Adams Creek and Helps Road Drain Catchment

Stormwater Management Plan

City of Playford and City of Salisbury

Client Ref 000554
27 June 2024
Ref: 20170712R001RevF

Building exceptional outcomes together

Document History and Status

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Contents

Project: Adams Creek and Helps Road Drain Catchment | Stormwater Management Plan
Client: City of Playford and City of Salisbury
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Tables

Figures

Appendices

Glossary

AAD	Annual average damages
ACHRD	Adams Creek and Helps Road Drain
ACQS	Adelaide Coastal Waters Study
ACWQIP	Adelaide Coastal Water Quality Improvement Plan
AEP	Annual exceedance probability
AMLR	Adelaide and Mount Lofty Ranges
ARI	Average recurrence interval
ARR	Australian Rainfall and Runoff
ARTC	Australian Rail Track Corporation
ASR	Aquifer storage and recovery
BCR	Benefit-cost ratio
CPI	Consumer price index
DCIA	Directly connected impervious area
DST	Department of Defence Science and Technology
EPBC	Environment Protection and Biodiversity Conservation
EY	Exceedances per year
GEP	Greater Edinburgh Parks
GP/GPT	Gross pollutants / gross pollutant trap
HGL	Hydraulic grade line
MAP	Epic Energy Moomba to Adelaide pipeline
MAR	Managed aquifer recharge
MOSS	Metropolitan Open Space System
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NAP	Northern Adelaide Plains
NEPM	National Environmental Protection Measure
NRM	Natural Resources Management
ODMG	Optimised decision making guidelines
PMF	Probable maximum flood
PFAS	Per- and poly-fluoroalkyl substances
RAM	Rapid appraisal method
SA EPA	South Australian Environmental Protection Authority
SEDMP	Soil erosion and drainage management plan
SMA	Stormwater Management Authority
SMP	Stormwater management plan

SSWFE	Southern and South-Western Flatlands East
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
WSUD	Water sensitive urban design

Report terminology

Typically, general practice has been to use the term Average Recurrence Interval (ARI) for design flood estimation. However, the new Australian Rainfall and Runoff (ARR) guidelines have adopted the term Annual Exceedance Probability (AEP) or Exceedance Year (EY) (depending on the event and use) to reduce ambiguity and confusion within the community.

Terminology in this report is used interchangeably between ARI and AEP depending on the context. Where this report refers to modelling or documents prepared prior to 2016 the use of ARI has been continued for consistency. For any new work or modelling the term AEP has been used, as recommended by ARR 2019.

There are some differences between ARI and AEP for events under the 5% AEP (20 year ARI). Where this report refers to these more frequent events, ARI is used for consistency with modelling previously carried out.

Executive summary

A Stormwater Management Plan has been prepared for the Adams Creek and Helps Road Drain catchment, an area of approximately 83 km^2 that is roughly evenly split across two Council boundaries (City of Playford and City of Salisbury). The plan provides a framework for the holistic management of stormwater within the catchment area. It summarises the current state of the catchment, identifies problems and opportunities, defines objectives and develops a list of prioritised strategies which seek to achieve Councils' goals and meet the multi-objective requirements of the SMP planning process. The strategies are aimed at:

- Providing an acceptable level of protection from flooding to the community and public and private assets
- Improving water quality to meet the requirements for protection of the receiving environment
- Maximising the economic reuse of stormwater for beneficial purposes
- Managing stormwater assets in a sustainable manner
- Achieving desirable planning outcomes associated with new development, open space, recreation and amenity
- Managing stormwater runoff in a manner that protects and enhances biodiversity and the natural environment

A multi-criteria analysis framework was used to rate the stormwater management strategies against a wide range of benefits including reduction in flood risk, water reuse and water quality improvements.

A combined one and two-dimensional hydraulic model was developed to identify key flood prone areas within the study area and assess the flood reduction effectiveness of the recommended structural measures. The benefits of the major flood management strategies have been quantified using calculations of the associated reduction in average annual damages (AAD). The modelling found that a 13% ($1.3 million) reduction in AAD can be achieved across the study area if all of the structural flood management strategies are implemented.

The SMP identifies a range of capital stormwater works and stormwater management measures to be undertaken within the catchment area over the coming years. This range of capital works and measures remain unfunded and need to be further considered against Council's other strategic plans and priorities prior to being delivered. This document will be used as a planning tool to inform both Councils' strategic directions and future Annual Business Planning process.

The SMP provides the framework for future stormwater initiatives and ensures that each Council is aware of catchment-wide stormwater impacts, to help inform future decision making.

A number of projects are identified within the SMP. These projects are conceptual only and require further planning, investigations, feasibility, design considerations and an approved funding pathway. Council will consult with the community on these projects as they are planned for delivery through future Annual Business Planning processes and through the design phase where appropriate.

1 Introduction

This draft Stormwater Management Plan (SMP) provides a framework for a coordinated, multi-objective approach for the management of stormwater within the Adams Creek and Helps Road Drain (ACHRD) catchment area. The process that has been undertaken during the development of the plan, and the contents of the plan itself comply with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007).

Consistent with the intent of the SMP Guidelines, this plan is founded on an integrated multi-objective approach to stormwater management on a whole of catchment basis. It provides an overview of the existing state of the catchment, including identification of problems and opportunities associated with the management of stormwater. It defines objectives for the management of stormwater and presents structural and non-structural strategies to address the objectives. The plan then defines the priorities, responsibilities and timeframes for the implementation of the works identified by the plan.

The plan has been prepared in consultation with staff from the City of Playford and the City of Salisbury and a dedicated Project Steering Committee including representatives from the Stormwater Management Authority (SMA) and Natural Resources Adelaide and Mount Lofty Ranges (AMLR), Department for Environment and Water.

The plan was written before creation of Green Adelaide and has been based on the natural resources management plan for what was the AMLR region.

2 Study area

2.1 Catchment description

The ACHRD catchment boundary covers an area of approximately 83 km^2, as shown in Figure 2.1. The catchment is located to the north of Adelaide CBD (an approximate distance of 20 km) and is roughly evenly split across two Council boundaries; the upstream portion of the catchment is located within the City of Playford while the downstream portion is located within the City of Salisbury. Three major roads (Port Wakefield Road, the Northern Connector (currently under construction) and Main North Road) pass through the catchment, in addition to the Adelaide-Gawler commuter railway line and the Australian Rail Track Corporation (ARTC) freight line.

Adams Creek is a minor watercourse with its headwaters originating in the hills face zone at the eastern end of the catchment. The main channel passes through the suburbs of Craigmore and Elizabeth Park before passing under the Elizabeth Shopping Centre through a set of large underground culverts. The main channel downstream of the shopping centre is known as the Helps Road Drain which has been heavily altered and redirected through the Department of Defence Science and Technology (DST) area and RAAF Base, Edinburgh. It then drains into the Kaurna Park wetland and suburban areas in Burton before ultimately discharging to Gulf St Vincent via a narrow constructed channel (the Gap) between the Bolivar Sewerage Treatment Works storage basins.

The catchment is rural and/or undeveloped in the upper reaches and to the west of Port Wakefield Road, residential to the east and south of the DST area and industrial in Burton, Direk and Edinburgh North. The catchment is unlikely to change significantly in the long term other than infill developments which will increase the impervious areas. The upstream portion of the catchment to the east of Main North Road is relatively steep, with the grade gradually flattening towards the coast.

In large flow events, runoff from the Little Para River is directed to the Helps Road Drain via the Little Para Overflow. While the areas contributing runoff to the Little Para River (such as Elizabeth Vale) have not been included within the ACHRD catchment boundary, the flows from the Little Para Overflow have been considered within this SMP.

A map showing the topography of the study area is provided in Figure 2.2.

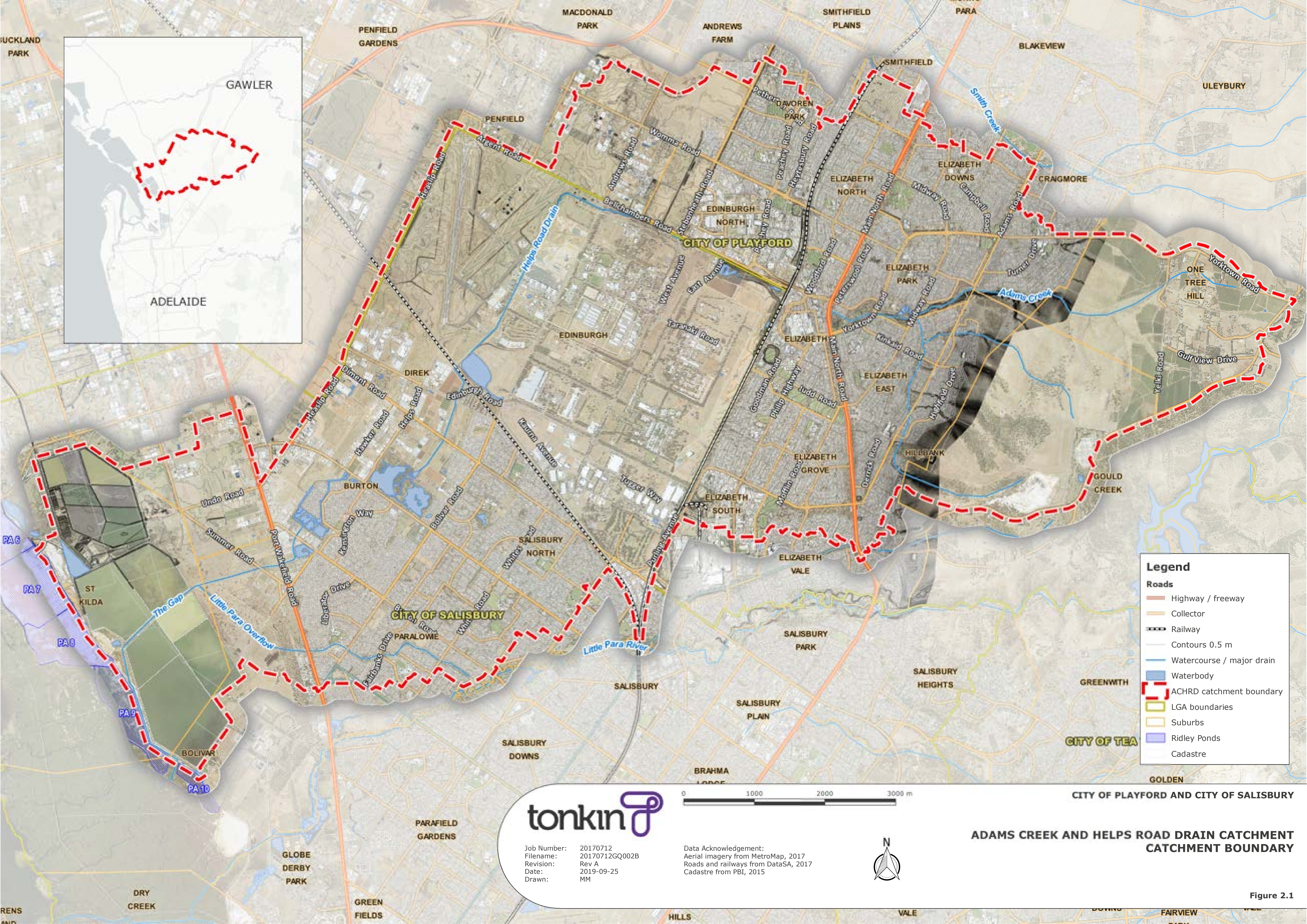
2.1.1 Land use

There are a variety of land uses within the catchment as shown in Figure 2.3 and summarised in Table 2.1.

Residential areas and the Edinburgh RAAF Base are the two predominant land uses representing 19% and 18% of the catchment area respectively. Agricultural and horticultural land uses comprise 17% and 7% of the catchment.

The generally open and undeveloped Hills Face Zone in the east, and open space scattered throughout the west and east is classified as reserve/recreation and represents approximately 9% of catchment.

Commercial (such as shopping precincts in Elizabeth City Centre), utility (such as the rail line) and industrial land uses represent 5%, 4% and 2% of the catchment respectively.



GAWLER
ADELAIDE
CITY OF PLAYFORD
CITY OF SALISBURY
CITY OF TEA
MACDONALD PARK
ANDREWS FARM
SMITHFIELD PLAINS
PENFIELD GARDENS
PENFIELD
SMITHFIELD
BLAKEVIEW
ULEYBURY
DAVOREN PARK
ELIZABETH DOWNS
CRAIGMORE
ELIZABETH NORTH
EDINBURGH NORTH
ONE TREE HILL
ELIZABETH PARK
EDINBURGH
ELIZABETH
DIREK
ELIZABETH EAST
HILLBANK
ELIZABETH GROVE
GOULD CREEK
BURTON
ELIZABETH SOUTH
ELIZABETH VALE
SALISBURY NORTH
ST KILDA
PARALOWE
SALISBURY PARK
SALISBURY
SALISBURY HEIGHTS
GREENWITH
SALISBURY PLAIN
SALISBURY DOWNS
BOLIVAR
BRAHMA LODGE
GOLDEN
PARAFIELD GARDENS
GLOBE DERBY PARK
DRY CREEK
GREEN FIELDS
HILLS
VALE
FAIRVIEW
BUCKLAND PARK
PA 6
PA 7
PA 8
PA 9
PA 10
Helps Road Drain
Adams Creek
Smith Creek
Little Para River
Little Para Overflow
The Gap
Yorktown Road
Gulf View Drive
Main North Road
Port Wakefield Road
Bellchambers Road
Womma Road
Edinburgh Road
Heaslip Road
Legend
Roads
Highway / freeway
Collector
Railway
Contours 0.5 m
Watercourse / major drain
Waterbody
ACHRD catchment boundary
LGA boundaries
Suburbs
Ridley Ponds
Cadastre
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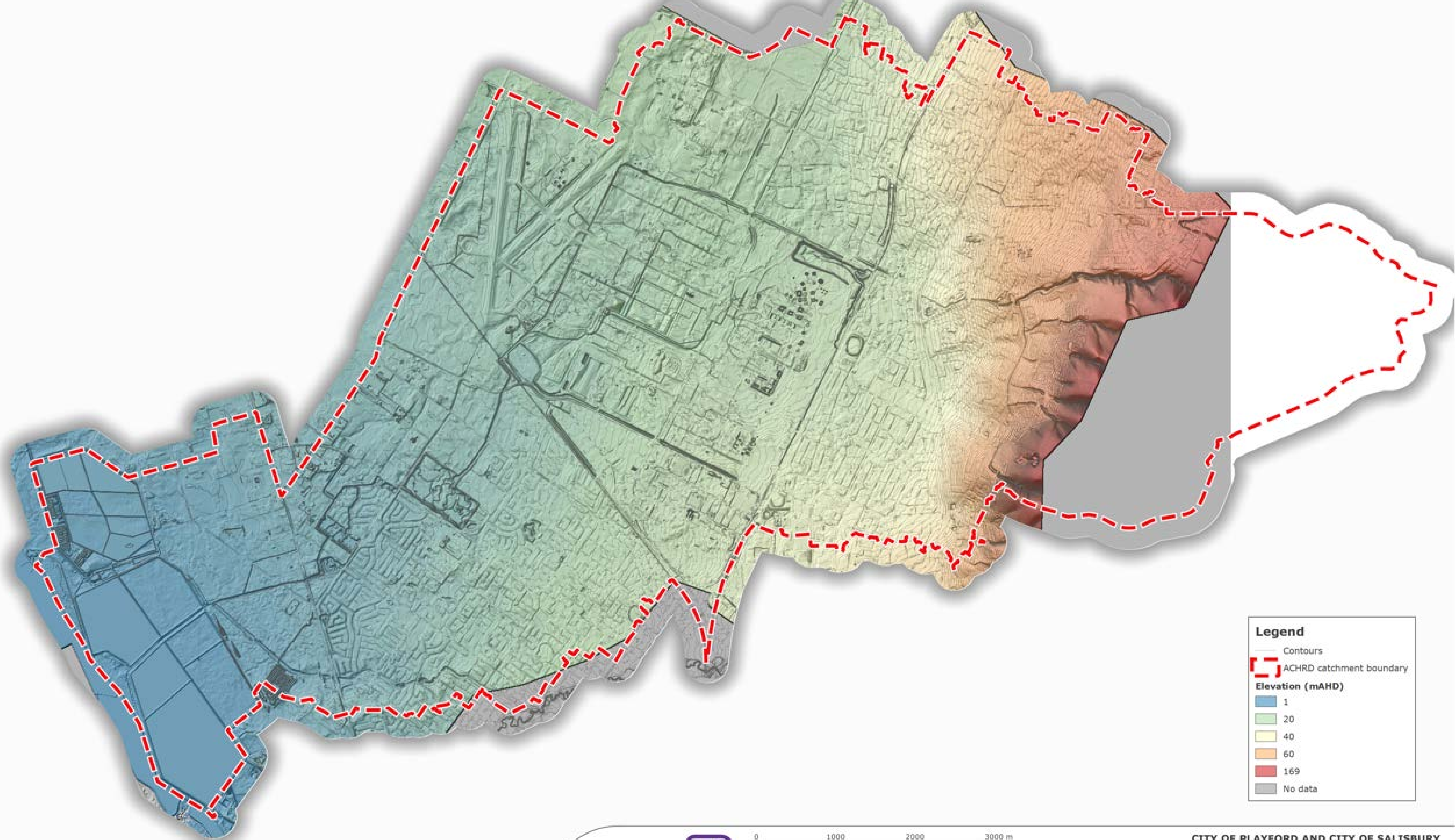
CITY OF PLAYFORD AND CITY OF SALISBURY
ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
CATCHMENT BOUNDARY

Figure 2.1



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
TOPOGRAPHY

Figure 2.2

Table 2.1 Land use proportions

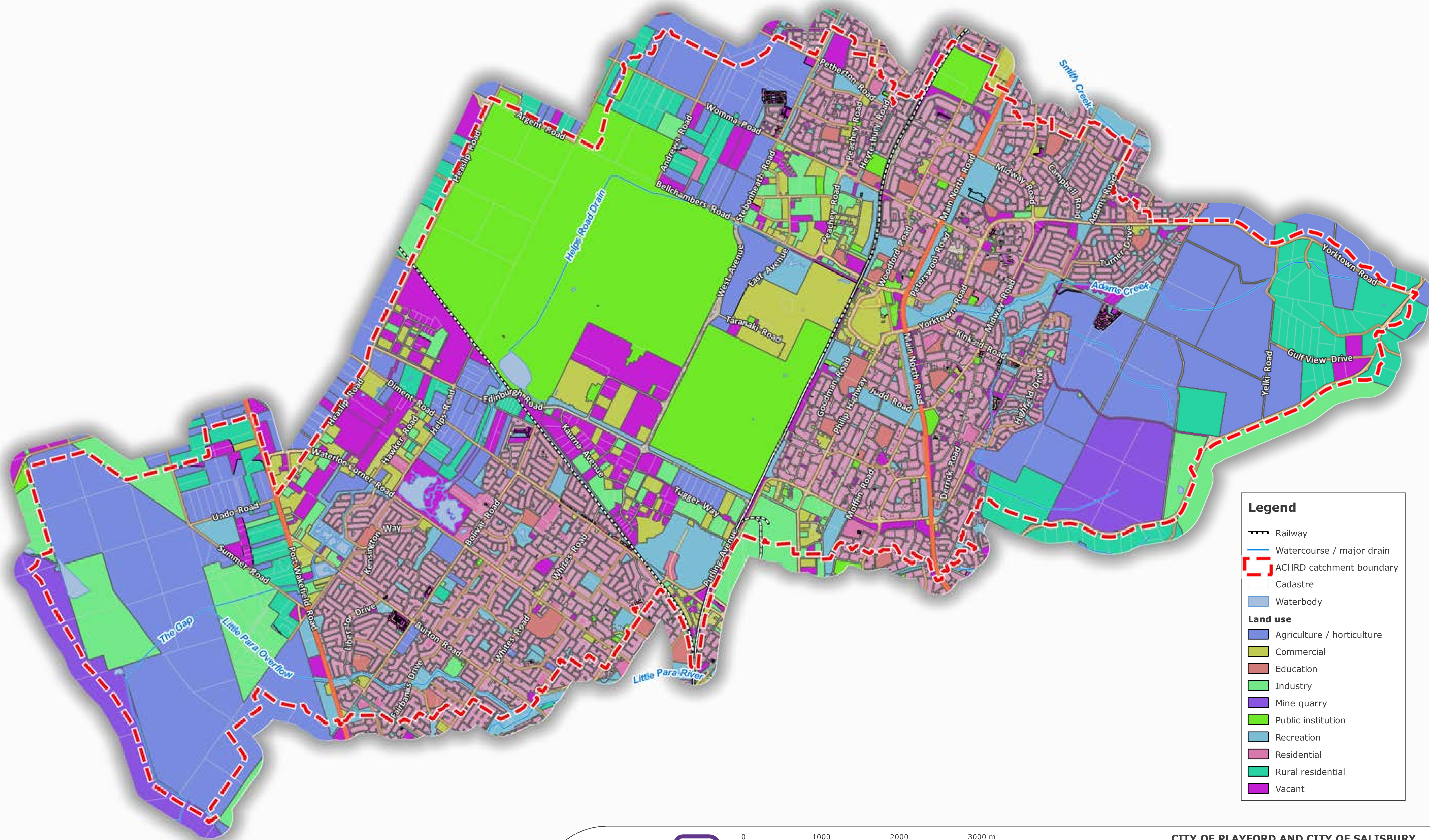
Land use (Source: Valuer General, 2015)	Area (ha)	Proportion of catchment (%)
Residential	1548	19%
Institutions	1462	18%
Agriculture	1394	17%
Reserve, recreation	751	9%
Horticulture	547	7%
Vacant	498	6%
Road reserve	488	6%
Utility	363	4%
Commercial	413	5%
Mining	349	4%
Industry	184	2%
Rural Living (without primary production)	153	2%
Other	169	2%
TOTAL	8319	100%

2.1.2 Soils

Data contained in the Data SA soils database was used to map the distribution of soils across the catchment area, as shown in Figure 2.4. However, no data is provided for the urban areas and therefore only the soils within the eastern and western extents of the catchment have been identified. A summary of the soils in the non-urban areas is shown below.

- D1 Loam over clay on rock
- D3 Loam over poorly structured red clay
- D5 Hard loamy sand over red clay
- E1 Black cracking clay
- L1 Shallow soil on rock

Other than a small strip along the coast line, the majority of the urban area is classified as Hindmarsh Clay which is comprised of sand and silt (loam) over red clays. Infiltration in these areas will typically be low, while runoff will be relatively high. The narrow coastal strip is within the St Kilda Formation, comprising calcareous sands and muds that have fairly high infiltration rates.



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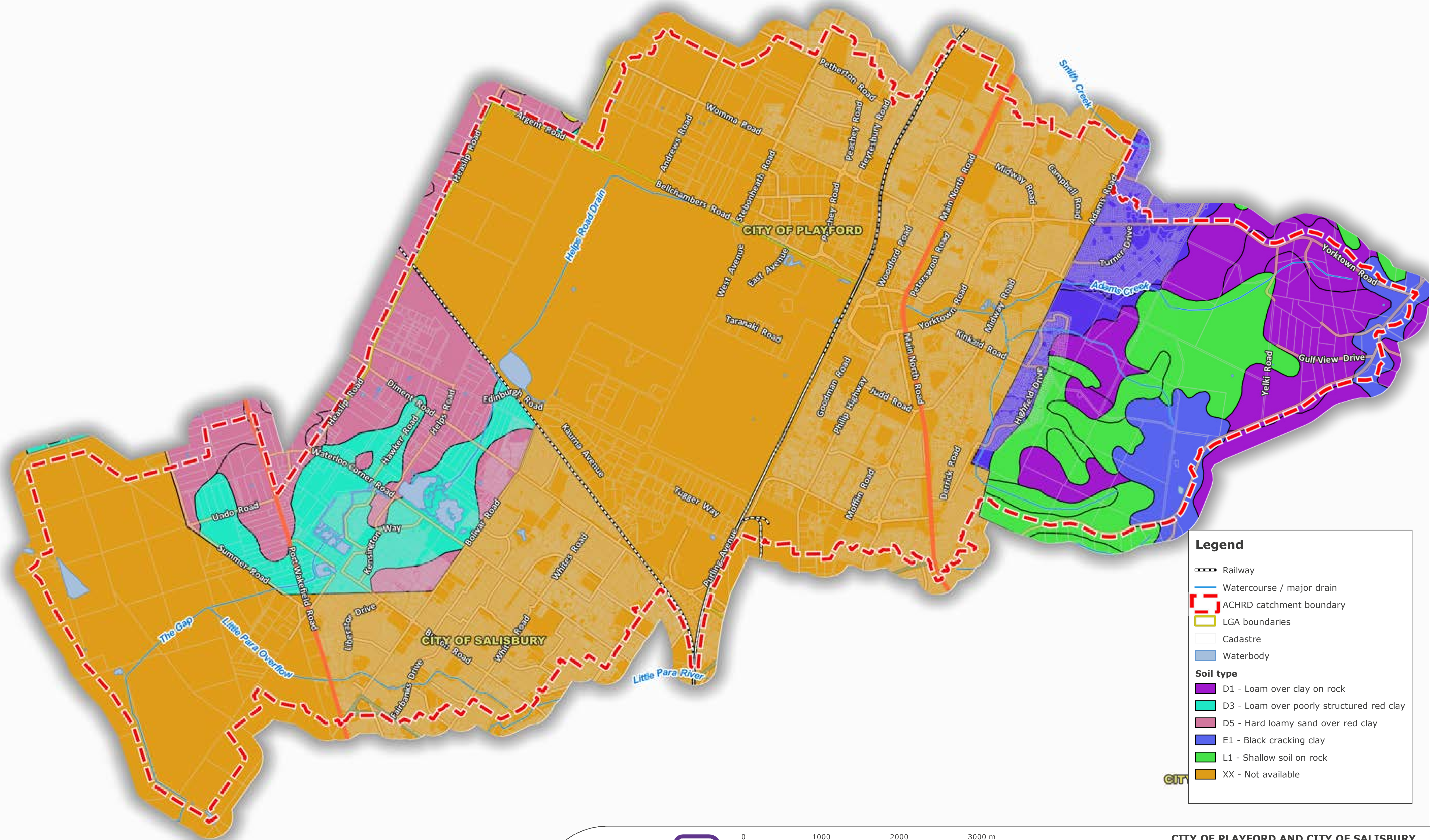
CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT LAND USE

Figure 2.3



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Soil type from DataSA, 2016

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT SOIL TYPES

Figure 2.4

2.1.3 Existing stormwater infrastructure

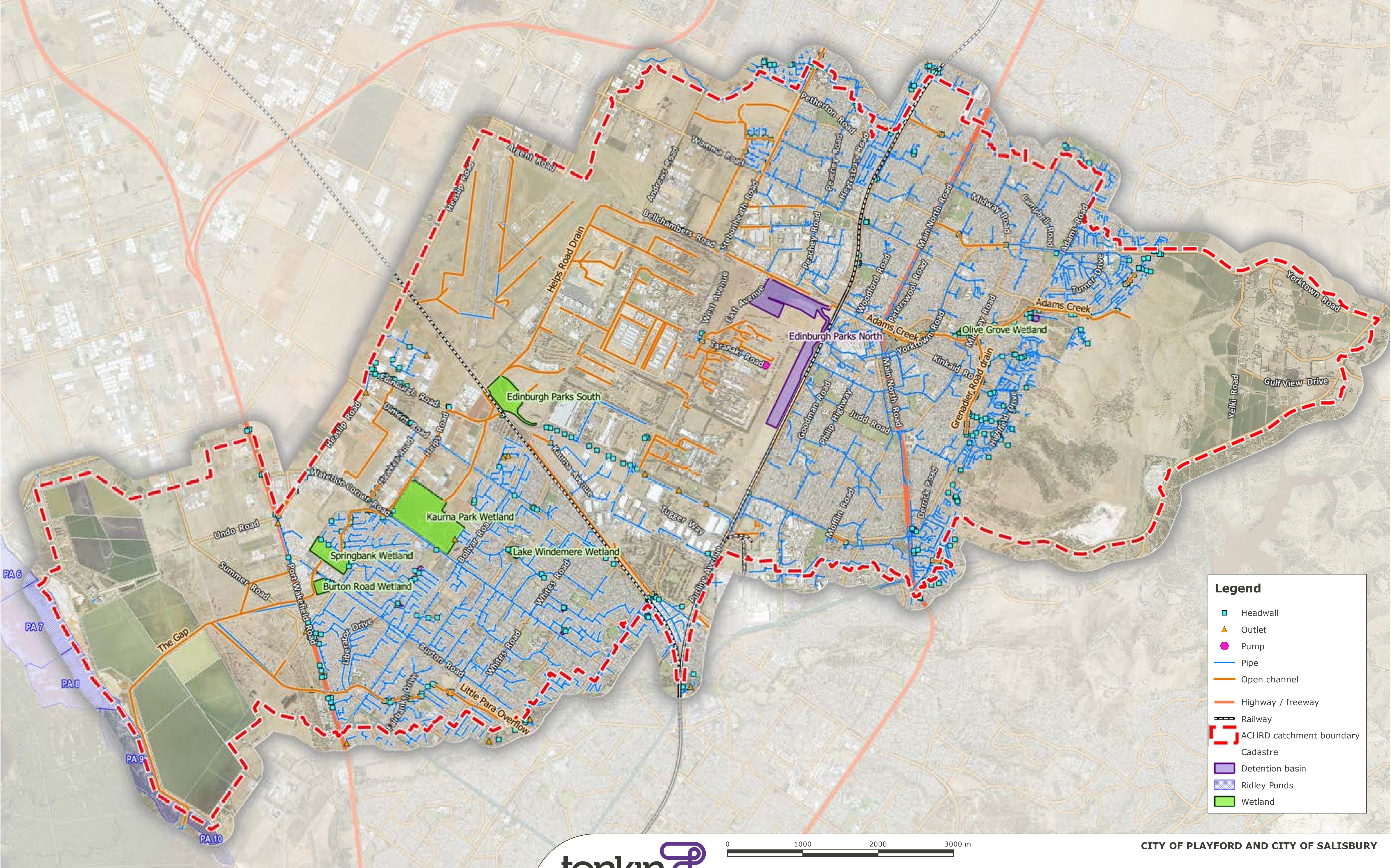
The ACHRD catchment is largely developed and as such underground and open channel stormwater infrastructure is already in place. Runoff is directed through the road network to underground drains which discharge to either Adams Creek, Helps Road Drain or lateral channels. A summary of the existing infrastructure is provided below, and shown in Figure 2.5.

Drainage

- Adams Creek which begins within the rural area to the east and traverses through urban areas to Fremont Park in Elizabeth Park.
- Adams Creek connection to the Helps Road Drain via twin 1350 mm trunk drains located to the north of the Elizabeth City Centre.
- Grenadier Road drain is mostly an open channel which traverses north-south (across the natural fall of the land) near the rural residential fringe. The drain discharges into the Olive Grove Wetland capture basin in Adams Creek. The drain is known to have restricted capacity in the underground section along Highfield Drive.
- Helps Road Drain which begins at the railway line adjacent Bellchambers Road and traverses south through the RAAF base to the Kaurna Park Wetland. The drain continues through to the Gap.
- A series of open channels within the DST site.
- A large open channel servicing the industrial area in Burton and Direk.
- The Gap is a section of open channel between two of the Bolivar treatment lagoons. The channel outfalls to the Barker Inlet between Ponds PA9 and PA10.
- The Little Para Overflow provides drainage for surrounding residential catchments and relief drainage for when the Little Para River exceeds its capacity.

Wetlands

- Olive Grove wetland on Midway Road, Elizabeth Park which takes water from Adams Creek for the purpose of treatment. Reuse was proposed for the wetland but is not currently operational.
- Kaurna Park wetland for stormwater treatment and harvesting (not currently operational). It also provides flood mitigation.
- Springbank Waters Linear Park further south-west of the Kaurna Park Wetland. It also provides flood mitigation.
- Burton Road wetland at the western end of Burton Road.
- Edinburgh Parks South wetland and water harvesting scheme on Edinburgh Road, Edinburgh (not currently operational).



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
EXISTING STORMWATER INFRASTRUCTURE

Figure 2.5

Flood mitigation

- Detention basin within Adams Creek at Whitford Road, Hillbank.
- Edinburgh Parks North detention basins along the local train line and Winterslow Road.
- Detention basin at the corner of Main North Road and Shandon Court, Elizabeth East.
- Detention basin at the corner of Main North Road and Stanley Street, Hillbank.
- Lake Windemere detention basin in Salisbury North.
- Detention basin adjacent Castle Drive in Burton.
- Detention basin adjacent Doncaster Terrace in Burton.
- Detention basin adjacent Port Wakefield Road and General Drive, Paralowie.
- Detention basin at the corner of Waterloo Corner Road and Harnham Road, Salisbury North.
- Detention basin adjacent Hyde Street, Salisbury North.

2.2 Previous studies and investigations

A number of previous studies of relevance to this SMP have been undertaken in recent years. In some cases the previous studies represent early developmental work on this SMP and have provided the basis for the modelling undertaken as part of this project. A brief description of the previous studies and their relevance to this SMP is provided below.

2.2.1 Adams Creek and Helps Road Drain catchments SMP – Stage 1 report

The Stage 1 report (Tonkin, 2018a) supports the development of this SMP. The following tasks/investigations were undertaken:

- Data collation
- Groundwater and soil investigations
- Assessment of receiving water habitats
- Assessment of current and future development levels
- Ecological assessment.

2.2.2 Playford CBD existing design review

A number of concurrent projects within the Playford CBD were being undertaken independently without consideration to broad scale strategic stormwater management in the area. This report (Tonkin, 2016a) identified stormwater management issues and opportunities that could be incorporated into the project designs. The projects included the Playford Tennis Centre, Lawn Bowls Centre upgrade, new buildings as part of the Stage 1 CBD development and Stage 1 of the Fremont Park upgrade.

2.2.3 Playford CBD strategic directions

The purpose of this study (Tonkin, 2016b) was to identify opportunities to reduce flood risk to businesses and residents within the Playford CBD and in particular the Elizabeth City Centre. The opportunities were sized using DRAINS and then modelled using the Adams Creek and Greater Edinburgh Parks (GEP) TUFLOW model such that an assessment of flood reduction could be made. There were a number of recommendations within the report that have been considered in this SMP.

2.2.4 Adams Creek and Greater Edinburgh Parks areas flood mapping, flood hazard mapping and flood damages assessment

The Adams Creek and GEP floodplain and flood hazard mapping and damages assessment (Tonkin, 2016c) was carried out for the City of Playford and City of Salisbury. It covered all of the study area for the ACHRD SMP.

The purpose of the study was to generate inflow hydrographs and define the extent of inundation and to categorise the potential hazard resulting from a series of design storm events.

The study identified areas of problem flooding at a number of locations. The flood damages assessment used the Rapid Appraisal Method (RAM) developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000).

An extract of this report, detailing the flood inundation modelling methodology (which is relevant to this SMP), is provided in Appendix A.

2.2.5 Little Para and Helps Road Drain catchments floodplain mapping and stormwater management strategy

This study (Tonkin, 2018b) was completed by Tonkin for the City of Salisbury. A significant portion of the northern suburbs of Adelaide drain to Gulf St Vincent via the Little Para River and the Helps Road Drain. The two systems are interlinked via the Little Para overflow channel which directs water from the Little Para River into the Helps Road catchment outfall.

Due to the interconnectivity of the Little Para River, Helps Road Drain, Adams Creek and GEP catchments, the individual TUFLOW models were combined into one large model such that the spill and accumulated flooding between catchments could be more accurately represented on the flood maps.

The floodplain mapping undertaken provides essential information on the drainage capacity restrictions through the Helps Road Drain outfall (the Gap). The Gap is located between the Bolivar Treatment plant ponds and discharges via a gap between the Ridley salt ponds. The Helps Road Drain and the Little Para overflow converge just upstream of the Gap, which is a pinch point in the system.

The study identified significant flooding within some areas for the 100 year ARI event. Potential high-level solutions to reduce the flooding in critical areas were explored. These solutions were revisited and included as potential opportunities for this SMP where appropriate.

An extract of this report, detailing the flood inundation modelling methodology (which is relevant to this SMP), is provided in Appendix B. The flood modelling undertaken as part of the SMP development has combined the models used in the Adams Creek and Greater Edinburgh Parks (Tonkin, 2016c) and Little Para and Helps Road Drain (Tonkin, 2018b) areas.

2.2.6 Nearshore marine habitats of the Adelaide and Mount Lofty Ranges NRM region

This report (Bryars, 2013) provides information to assist in prioritising land-based impacts to protect the coastal fisheries habitat within the Natural Resources AMLR region. Evaluation of existing information has identified that a diverse range of seagrass, reef and sand habitats exist within the AMLR region and these nearshore marine habitats have considerable value.

Stormwater and poor-quality runoff from catchments were recognised as threats to most of the coastal habitats within the AMLR region. Increased pollutant loads due to development within the catchment present a threat to these habitats. The report identified a number of local and regional actions to mitigate threats to the valuable habitats.

2.2.7 Northern Adelaide Plains water stocktake

This report (Goyder Institute for Water Research, 2016) assesses the current available water and potential for future expansion of water availability within the Northern Adelaide Plains (NAP). A number of different water sources, including recycling, groundwater, natural watercourses and stormwater, have been assessed to determine current availability and the potential for future increase in water supply to the NAP, taking into account historical and potential future risks.

2.2.8 Northern urban catchments: stormwater yield review

This report (Aqueon, 2016) models the mean annual discharge to sea and identifies the mean annual flow available for harvest from catchments within the City of Salisbury, City of Playford and City of Tea Tree Gully. It provides options for the expansion of the current managed aquifer recharge (MAR) systems and potential for future new MAR systems.

2.3 Development constraints

The following sections outline a number of considerations that may potentially act as constraints to the development of recommendations described within this SMP.

2.3.1 Major services infrastructure

A Dial Before You Dig search was carried out to identify existing major infrastructure within the catchment area. The identified services are shown in Figure 2.6 and include:

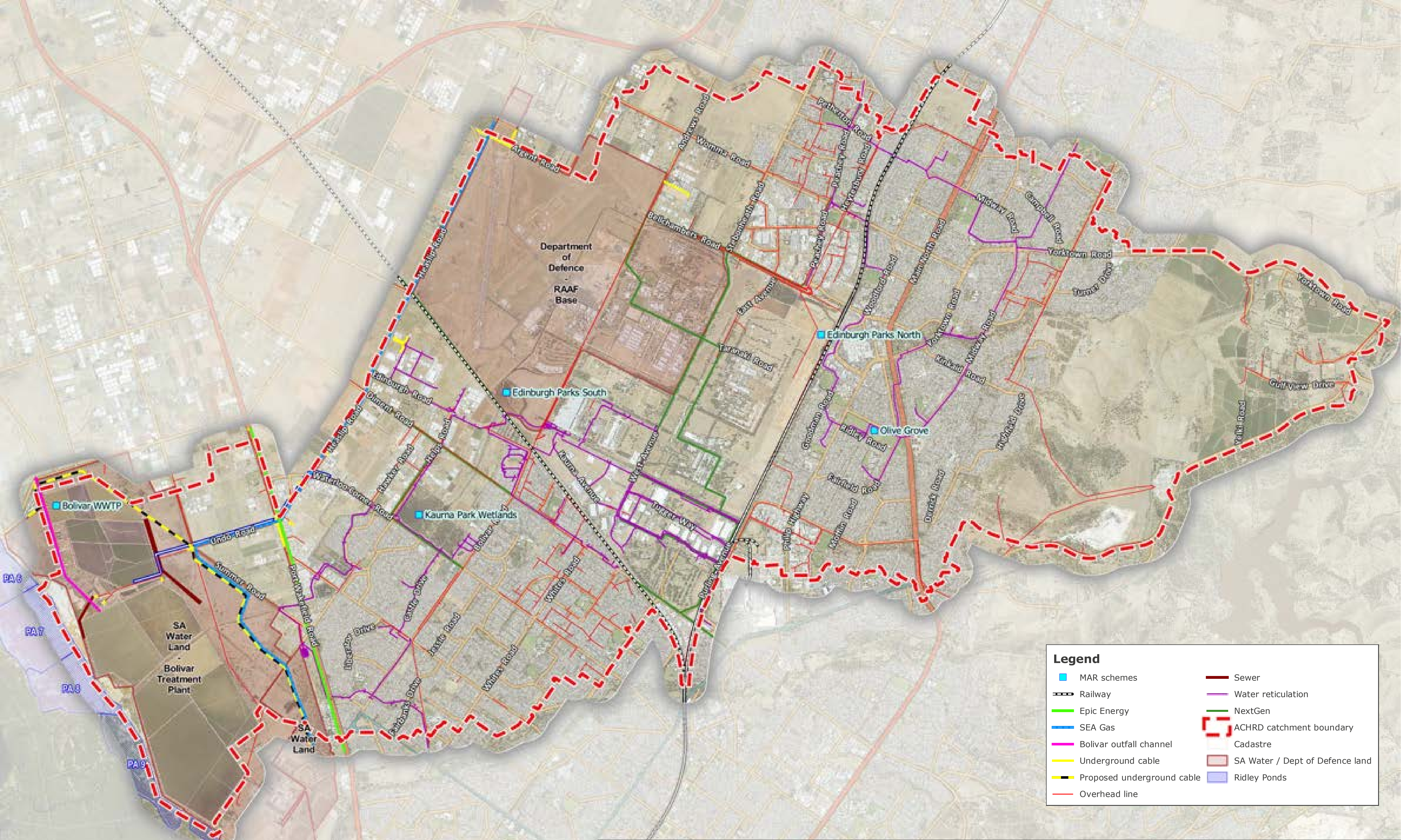
- Epic Energy Moomba to Adelaide pipeline (MAP) located along Port Wakefield Road.
- SA Water transmission water main from Bolivar Treatment Plant, along Undo Road and up to Waterloo Corner Road.
- Large banks of Telstra conduits along Main North Road, Yorktown Road, Kinkaid Road, Elizabeth Way, Waterloo Corner Road, Burton Road, within the RAAF base, Peachey Road and Womma Road.
- Proposed Ceres high voltage cable through SA Water Land (adjacent to the Bolivar Treatment Plant).
- SEA Gas located along Heaslip Road and through SA Water Land (adjacent to the Bolivar Treatment Plant).
- Water reticulation main by the Bolivar Lagoons.
- High voltage cables distributed throughout the catchment.
- SA Water supply mains.

2.3.2 Groundwater

The catchment is underlain by shallow, saline groundwater that ranges in depth typically between 4-7 m below ground level in the eastern portion of the catchment (Northern Adelaide Plains), to less than 1 m below ground level in the western portion of the catchment (Coastal Zone). The expected regional groundwater flow direction is west, towards the Dry Creek Saltfields and the Barker Inlet.

Near surface aquifers of the Northern Adelaide Plains are typically found within interbedded silt, sand and gravel layers of the Pooraka Formation sediments (upper Quaternary aquifers).

The salinity of groundwater within the Pooraka Formation aquifers are expected to range from 1,000 mg/L to greater than 15,000 mg/L. Differences in salinity and water table elevations are likely to be governed by local variations in surface recharge due to topography, soil texture, irrigation and vegetation type/density. Seasonal water table fluctuations of up to 1 m may occur due to winter recharge and summer evapotranspiration and proximity to existing drains, ponds or irrigated horticulture. Groundwater salinity will also vary seasonally in response to recharge and discharge characteristics of the shallow aquifers.



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
EXISTING CATCHMENT INFRASTRUCTURE

Figure 2.6

Groundwater extraction and use may occur from the upper Quaternary aquifer, where groundwater salinities are typically 3,000-6,000 mg/L and yields are higher. The vast majority of groundwater extraction wells (for domestic and or irrigation purposes) within the area are installed in the lower Quaternary (Q4) and Tertiary (T1 and T2) aquifers, which are separated from the surficial Quaternary aquifers by up to 10 m of Hindmarsh Clay.

The depth of groundwater may present a constraint on the effective depth of detention basins (or wetlands) that may be constructed within the study area due to inflows of shallow saline groundwater. In areas where the shallow aquifer is confined, the removal of overburden during construction of basins may locally reduce confining pressures, leading to vertical movement of groundwater. The rate of lateral or vertical seepage to the constructed basins would be dependent on the permeability (vertical and horizontal permeability) of the local geology/overburden. Where the groundwater potentiometric surface is intersected by the basins, seepage rates will influence the risk of saline inflows, surface water levels (pooling) and constructability (additional control measures may be required during construction to manage soil moisture and groundwater). Excavation during summer months would reduce the impact of groundwater inflows during construction.

Given the anticipated depths of the proposed basins described within this SMP, groundwater seepage rates (on average) are likely to be very low due to the low groundwater hydraulic gradient and low transmissivity of the upper Quaternary aquifers, however local variations will occur.

Walbridge Gilbert Aztec (WGA) were engaged by Tonkin to carry out an assessment of the groundwater, aquifer and soil conditions in the area. WGA (2018) identified where local shallow groundwater may limit the depth of stormwater infrastructure such as basins and also considered deep groundwater hydrogeology to identify opportunities for potential MAR schemes. An extract of the WGA report showing the extent of shallow groundwater is included in Appendix C.

It was determined that the deeper Port Willunga Formation (T2 aquifer) is the most suitable target aquifer for MAR in the catchment for the following reasons:

- Multiple active MAR systems currently target the T2 aquifer across the Northern Adelaide Plains and have been operating successfully for several years.
- The shallow Quaternary aquifers are not considered viable for recharge due to the relatively thin nature of the aquifer, shallow depth to water, high salinity and limited lateral extent.
- The overlying Tertiary (T1) aquifers have proved more difficult to target in the past, particularly in areas where there are low recharge rates.
- There is little known about the deeper T3 and T4 aquifers, but groundwater through these has been reported as highly saline.

The report identified that there is the potential for significant volumes of water to be harvested within the catchment area through both development of new MAR schemes and upgrades to existing schemes.

Evaluation of currently available data suggests that across some parts of the NAP, water levels in the perched aquifer and uppermost Quaternary (Q1) aquifer are rising at rates of up to 0.16 m/a. Water levels in the shallow Q1 aquifer are particularly high (less than 2 m below ground level) in areas west of Port Wakefield Road. Infrastructure installed in the area between the coast and approximately 6 km inland will need to consider impacts from shallow saline groundwater that may occur due to the rising groundwater table in the Q1 aquifer.

WGA (2018) estimated that if the rising trend in groundwater levels continues, within the next six years groundwater levels in the area extending 2 km to the east of Port Wakefield Road could be up to 1 m higher than the 2017 recorded groundwater levels. Consequently, any wetland or detention basin design will need to consider this to account for the potential rising groundwater levels. The footprint required to accommodate any below ground stormwater infrastructure is therefore likely to be large, as the depth available for construction will be limited by the shallow water table. Aquifer storage and recovery (ASR) may generate additional hydraulic loading on the shallow aquifer, exacerbating water logging risks. Additionally, wetlands or basins will need to be lined to prevent ingress of saline groundwater and prevent mounding beneath the wetland.

It has been identified that there is contamination associated with per- and poly-fluoroalkyl substances (PFAS) in stormwater runoff leaving the RAAF Edinburgh Airforce Base. The Kaurna Park and Springbank Park wetlands are downstream of the contaminant source site. In order to meet water quality criteria for PFAS limits (set by the EPA) there are options to introduce treatment at a MAR system to reduce PFAS concentrations, including the potential use of activated carbon.

2.3.3 Development potential

URPS was engaged by Tonkin to review runoff coefficients from a previous floodplain mapping study of the catchment (Tonkin, 2016c), based on the potential future (2050) catchment development.

URPS carried out a desktop assessment of current land use and development conditions, a desktop assessment of emerging policy directions outlined in State and Local Government Planning documents, and engaged with planning officers at local Councils.

Their study (URPS, 2018) identified a number of further changes to the types or intensity of land use in the catchment that superseded portions of the Tonkin study. These variances were used by Tonkin in determining projected future runoff for the catchment. The recommendations are summarised in Table 2.2, with the revised directly and indirectly impervious areas shown in Figure 2.7.

Table 2.2 Future catchment impervious proportions (%)

Land use	URPS impervious recommendation (2050)
All residential areas	Increase impervious area from 40% to 50%
High density residential properties	Increase impervious area from 50% to 60%
Windbreaks development along Main North Road	Increase to high density residential (60%) to allow for future residential development
Elizabeth (west)	Increase to high density residential (60%) to allow for the proposed development in this area
West of Port Wakefield Road	Increase to 35% impervious to allow for an increase in glass house development

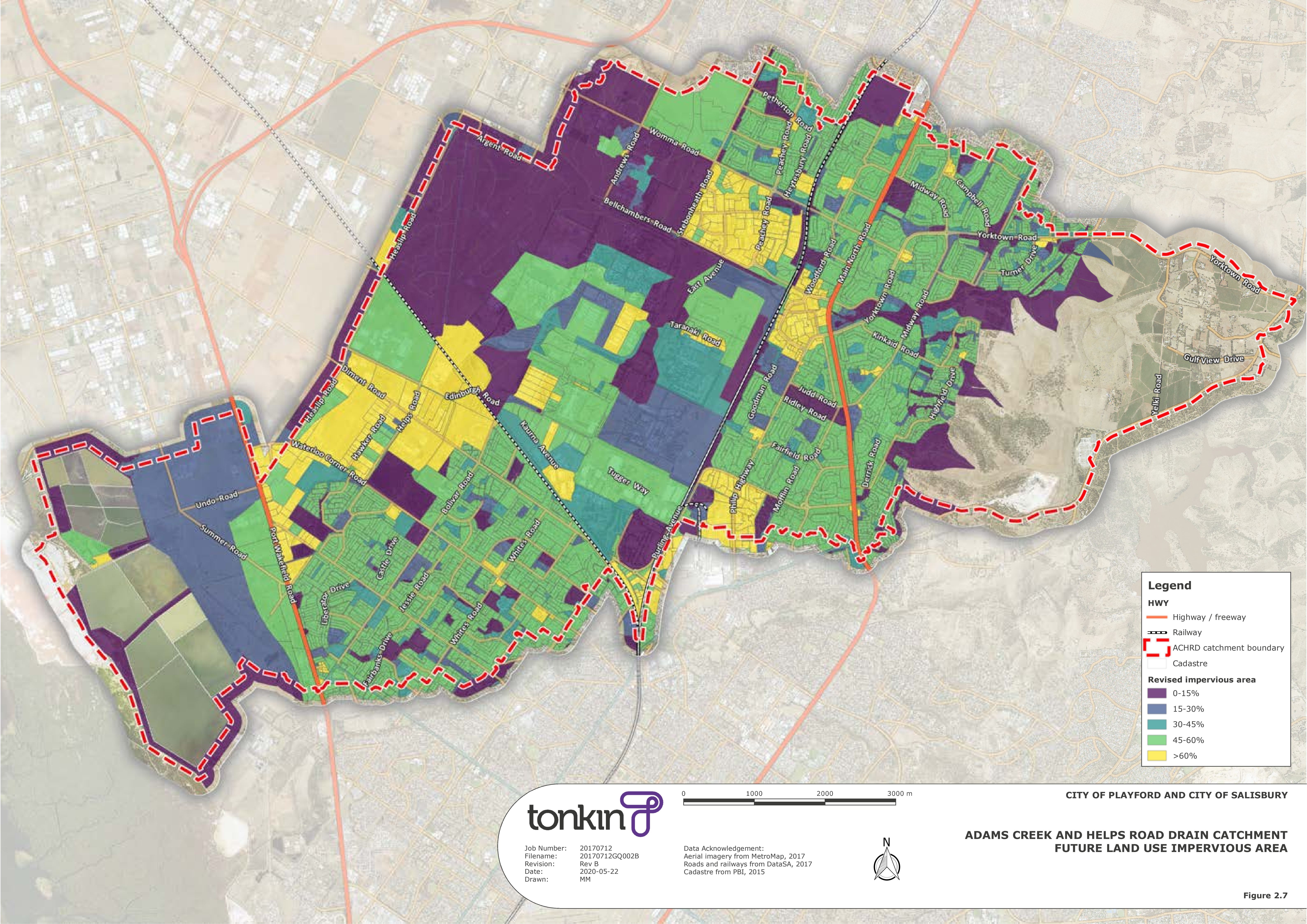
2.3.4 Climate change assessment

The latest available science indicates that the climate is changing. CSIRO and the Bureau of Meteorology preface the latest regional climate change summaries with the following statement:

"*Australia's changing climate represents a significant challenge to individuals, communities, governments, businesses and the environment. Australia has already experienced increases in average temperatures over the past 60 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising sea levels*."

Australian Rainfall and Runoff (ARR, 2019) states "*human induced climate change has the potential to alter the prevalence and severity of rainfall extremes, storm surge and floods*".

Despite global efforts to mitigate greenhouse gas emissions, the momentum of the climate system means that the observed climatic changes will continue with increasing magnitude, for many decades to come.



Job Number: 20170712
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Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
FUTURE LAND USE IMPERVIOUS AREA

Figure 2.7

Climate Change in Australia (CSIRO and BoM) provides regional summaries of projected climate change for Australia. The study area is within the Southern and South-Western Flatlands East (SSWFE) cluster. The key climate change projections relevant to the design of stormwater systems for the SSWFE cluster are as follows:

- A continuation of the trend of decreasing winter rainfall is projected with high confidence. Spring rainfall decreases are also projected with high confidence.
- Increased intensity of extreme rainfall events is projected, with high confidence.
- Mean sea level will continue to rise and the height of extreme sea level events will also increase (very high confidence).

With respect to the management of stormwater within the study area, the projected changes in climate represent the following risks:

- A reduced level of service (greater frequency of flooding) due to the higher intensity rainfall events resulting in higher peak flows.
- Higher downstream water levels as a result of rising sea levels.
- Rising groundwater levels as a result of rising sea levels.
- Lower volumes of water able to be harvested.

A methodology for modelling climate change has been developed with reference to the project brief, the latest climate change science and in collaboration with the Project Steering Committee. A full description of the methodology can be found in the climate change modelling memorandum dated 12 December 2017 (Tonkin ref. 20170712M003).

The climate variables that are considered directly relevant to the SMP modelling are average annual rainfall, rainfall intensity, evaporation and sea level rise. Two climate change scenarios were selected for modelling in TUFLOW and MUSIC. The scenarios are summarised in Table 2.3. The change in rainfall is relative to the current annual average rainfall for the region of 430 mm.

Table 2.3 Climate change scenarios

Year	RCP	Rainfall intensity increase	Sea level rise	Change in annual average rainfall
2050	8.5	9%	0.4 m	-30 mm (-7%)
2090	8.5	17%	1.0 m	-39 mm (-9%)

The MUSIC model will apply the 2050 and 2090 seasonal average annual rainfall and evapotranspiration scaling factors to historic data for the purpose of water balance modelling.

TUFLOW has been used to prepare flood maps for the 2050 and 2090 scenarios. Only the 2050 scenario has been used for the modelling of mitigation strategies.

Risk-based approach to climate adaptation

Recognition of the risks associated with climate change is required for better planning for new infrastructure and mitigating the potential damage to existing infrastructure (ARR, 2019). Despite advances in climate science there are still significant uncertainties associated with the projections of future climate, not least of which is patterns of global development and greenhouse gas emissions. A risk-based approach to climate change adaptation is therefore recommended.

Factors to be considered when developing an adaptation approach include:

- The design life of the asset – the impacts of climate change will be greater for assets with a long design life.

- The consequences of failure – if failure is catastrophic then design should be based on the worst-case climate change projection for the end of the asset life. If not catastrophic, design may be based on climate change projections for the middle of the design life of the asset with acceptance of increased risk of failure towards the end of the asset life.
- Impacts of the projections on system performance – a sensitivity analysis should be undertaken to provide an understanding of what the projected changes mean for system performance.
- Cost of the adaptation measures – no cost or low-cost options should be sought, particularly where the consequence of failure is not severe.

2.3.5 Environmental considerations

Receiving waters

Stormwater discharging to Gulf St Vincent has been identified as a contributing factor in the dieback of seagrasses and is causing an increase in the nutrient levels and turbidity of the marine environment (Commonwealth of Australia, 2000). The ACHRD catchment flows to the Barker Inlet via the Gap between the Bolivar treatment lagoons. These flows, which may increase due to infill development, have potential to modify salinity gradients and increase pollutant loads. If unmanaged, the increased discharges may threaten water quality in Gulf St Vincent and stress coastal ecosystems such as the intertidal mudflats, seagrass meadows, mangroves and tidal creeks, in addition to potentially substantial long term impacts on the samphire habitat at this location.

SMPs are required by legislation (refer Table 2.4) to consider stormwater quality and identify the environmental values of receiving waters to set minimum water quality objectives and to mitigate against harming the environment or human health (Myers et al., 2015).

Table 2.4 Relevant water quality legislation and guidelines

Legislation/guideline	Relevance to the Project
Landscape South Australia Act 2019 (SA)	The *Landscape South Australia Act 2019* is the legislative foundation for the sustainable management of water in South Australia. The study area is contained within the Green Adelaide region. Environmental outcomes and strategies of the SMP will need to consider the regional landscape plan. Permits may be required for certain SMP activities.
Section 25 of the *Environment Protection Act 1993* (SA)	Any development, including the construction of drainage, outfall channel or sedimentation basin, has the potential for environmental impact, which can result from vegetation removal, stormwater management and construction processes. The Act requires a 'duty of care' in relation to activities that have potential to cause serious or material environmental harm or an environmental nuisance by polluting the environment and failing to inform the South Australian Environmental Protection Authority (SA EPA) of an incident that has caused, or threatens to cause, serious or material environmental harm as soon as reasonably practicable. The Act is the overarching legislative tool used to evoke protection of the environment and is administered and enforced by the SA EPA.
Environment Protection (Water Quality) Policy 2015	Water quality in South Australia is protected using the *Environment Protection Act 1993* and the associated *Environment Protection (Water Quality) Policy 2015*. The principal aim of the Water Quality Policy is to achieve the sustainable management of waters by protecting or enhancing water quality while allowing economic and social development. In particular, the policy seeks to ensure that pollution from both diffuse and point sources does not reduce water quality and promotes best practice environmental management.

Legislation/guideline	Relevance to the Project
Stormwater Management Authority (SMA)	The Stormwater Management Authority (SMA) was established on 1 July 2007 as a consequence of the *Local Government (Stormwater Management) Amendment Act 2007*. The SMA operates as the planning, prioritising and funding body in accordance with the Stormwater Management Agreement between the State of South Australia and the Local Government Association. A key element is the development of stormwater management plans for catchments or specified areas. The purpose of these plans is to ensure that stormwater management is addressed on a total catchment basis. The relevant NRM board, various local government authorities and state government agencies responsible for the catchment work together to develop, implement and fund a coordinated and multi-objective approach to management of stormwater for the area. The state released a Stormwater Strategy in 2011 (Government of South Australia, 2011), as a road map for achieving the stormwater-related actions in Water for Good.
Stormwater Pollution Prevention Code of Practice for Local, State and Commonwealth Government (EPA 1998)	This Code of Practice is intended to inform government agencies and their contractors of their 'general environmental duty' with respect to stormwater under the *Environment Protection Act 1993*. The code provides for the preparation of a soil erosion and drainage management plan (SEDMP) where there is a risk of significant sediment pollution to adjoining lands or receiving waters.
Water for Good (Government of South Australia 2009)	Underpinning the state's legislative requirements, the government's water security plan to 2050, Water for Good, outlines 94 actions to ensure the future availability of water. Released in 2009, the plan was developed during a time of severe drought. While having a focus on water quantity, it also addresses water quality and supports other state initiatives; these include the recommendations of the Adelaide Coastal Waters Study for improving the quality of water discharged into Gulf St Vincent from Adelaide's urban and peri-urban areas.
National Environment Protection (Assessment of Site Contamination) Measure (NEPM) 1999	This Measure provides a national approach to site contamination assessment and forms an Environment Protection Policy under the *Environment Protection Act 1993*. Assessment of site contamination requires comparison to NEPM guidelines to determine the contamination status of a site.
Native Vegetation Act 1991	The Act controls the clearance of native vegetation and provides incentives and assistance to land owners for the enhancement and preservation of native vegetation. Clearance of native vegetation will require a management plan, endorsed by the Native Vegetation Council, that demonstrates the Project will result in a significant environmental benefit.
Aboriginal Heritage Act 1988	The *Aboriginal Heritage Act 1988* provides for the protection and preservation of the Aboriginal heritage.
Heritage Places Act 1993	The Act makes provision for the identification, recording and conservation of places and objects of non-Aboriginal heritage significance and establishes the South Australian Heritage Council.
Adelaide Coastal Water Quality Improvement Plan (ACWQIP) (EPA, 2013)	The ACWQIP, developed by the SA EPA, provides a long-term strategy to achieve and sustain water quality improvement for Adelaide's coastal waters and create conditions to see the return of seagrass along the Adelaide coastline.
Other legislation potentially relevant to the Project may include:	- *Mining Act 1971* and *Mining Regulations 2011* - *Environment Protection and Biodiversity Conservation Act 1999* - *Fisheries Management Act 2007*

Legislation/guideline	Relevance to the Project
	- *Adelaide Dolphin Sanctuary Act 2005* - *Coast Protection Act 1972* - *Occupational Health Safety and Welfare Act 1986* - *National Parks and Wildlife Act 1972*

Potential pollutants

Historically, stormwater has been managed as a drainage issue, essentially to minimise nuisance inundation across developed areas. However, the quality of stormwater runoff has implications for receiving waters due to pollutants such as nutrients, fertilisers, herbicides and pesticides. In addition, groundwater seepage to drains, or runoff from drain batters, has potential to further impact the quality of stormwater discharges.

PFAS contamination has been identified in stormwater runoff from the RAAF Edinburgh Airforce Base, which enters the lower Helps Road Drain catchment. PFAS is used in a range of common household products, but occurs in higher concentrations in some types of fire-fighting foam commonly used at airports, and can persist for a long time both in the environment and in humans.

A list of potential stormwater pollutants is provided in Table 2.5.

Table 2.5 Potential stormwater pollutants

Potential stormwater pollutants	Potential exposure routes	Key receptors
Salinity	Leaching of salts from soil, surface water and groundwater seepage to drains	Aquatic ecosystems (fresh) and freshwater aquifer(s)
Acidity	Disturbed acid sulfate soils - widespread at depth within the Coastal Zone sediments	Aquatic ecosystems (fresh and marine) and aquifer(s) Excavation / maintenance workers
Nutrients and metals	Runoff from urban catchment, soils and groundwater in the vicinity of the wastewater lagoons or service easements, horticultural irrigation (reclaimed water or direct application) and outfall channel	Aquatic ecosystems (fresh and marine) and aquifer(s)
Suspended solid / soil erosion	Runoff from urban catchment, sodic / erodible soils within the drain (distribution unknown) During construction activities there is potential for large amounts of sediment to be washed into the drainage system	Aquatic ecosystems (fresh and marine) and aquifer(s)
Discrete site contamination (e.g. PAHs, petroleum hydrocarbons and PFAS)	Roads, runoff or groundwater seepage from potentially contaminating sites, including the Edinburgh RAAF site	Aquatic ecosystems (fresh and marine) and aquifer(s) Excavation / maintenance workers

Additionally, stagnant water (for example shallow pools of water) may become a breeding ground for mosquitos, causing nuisance to humans and terrestrial and marine ecosystems.

Environmental receptors

Environmental values in this region include both those that relate to beneficial use as well as those independent of human need. In broad terms environmental values for the Gulf include the commercial, cultural and aesthetic uses of the area but also extend to the preservation or conservation of biodiversity and ecosystem function. Waters that are classified as having an ecosystem protection value should have ambient water quality that meets or exceeds the requirements of Schedule 2 of the *Environment Protection (Water Quality) Policy 2015* or the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) Tables 3.3.8 and 3.4.1.

The level of risk to the receiving marine environment will depend on the likelihood of an incident occurring and the consequence of that incident.

The greatest risks presented by stormwater quality within northern Adelaide catchments are considered to be turbidity generated from urban runoff and nutrients from wastewater leakages. Hydrocarbons and trace metals from roads, marinas and boat ramps are considered a lesser risk to maintaining water quality for all environmental values. Increased freshwater inflows also have potential to impact marine organisms. When salinity changes to above or below an optimum range, an organism may become stressed and can succumb to predation, competition, disease or parasitism (ANZECC 2000). The magnitude and duration of salinity changes will be somewhat dependent on the drainage catchment and outfall design.

Adelaide's coastal waters are part of the waters of Gulf St Vincent and include areas of seagrass and subtidal reef environments supporting important feeding grounds and nurseries for fish, crustaceans, molluscs and marine mammals. Maintaining good water quality is essential for the maintenance of these marine habitats and important for industry and the recreational uses of Adelaide's coastal waters and metropolitan beaches.

Discharges of high levels of suspended solids into the Adelaide coastal waters increase turbidity levels contributing to challenges for re-establishing seagrass, poor recreational water quality and may result in beach closures at times after rain events.

Seagrass loss in Gulf St Vincent has historically shown a clear correlation with sewage outfalls and stormwater inputs. The Coastal Waters Study (EPA SA, 2007) investigated the possible impacts of pollutants, decreased salinity, light availability and nutrient loads, and presented convincing evidence that the primary factor in seagrass loss is nutrient loading.

Loss of seagrass has implications in terms of sediment instability for the management of Adelaide's beaches and loss of seagrass results in more carbon released into the atmosphere.

Stressors to seagrass are listed below in order of impact rating (highest to lowest):

- Nutrient loads leading to eutrophication – caused by increased nitrogen and phosphorous concentrations in effluent and/or stormwater discharges
  - Eutrophication is the most widely reported cause of seagrass loss
  - High nutrient loads have a direct toxic effect on seagrasses
  - Nutrient inputs encourage growth of epiphytes which can create barriers to light absorption, gas exchange and nutrient absorption
- Nitrogen/phosphorus (N:P) ratios – important in determining the dominant plant community
- Turbidity – decreased light availability average resulting in decreased productivity – measurable impacts over longer term.
- Turbidity – plume events reducing light – minimal impacts for events lasting less than 6 weeks.
- Salinity increases or decreases – under marine influences the salinity is relatively stable and never gets diluted enough to impact mature plants (<1 ppm), seedlings or seeds (<10 ppm).
- Temperature – temperature extremes impacts (outside optimums).

Vegetation and fauna habitat

EBS Ecology was engaged by Tonkin to undertake a field assessment of the watercourses within the ACHRD catchment. From a vegetation and fauna habitat perspective, the assessment (EBS Ecology, 2019) determined that the areas of highest value are the western and eastern extremities of the study area, being the intact remnant samphire shrubland near Barker Inlet and the *Eucalyptus porosa* (Mallee Box) Woodlands on Boral-managed land and private property.

The report recommended the protection and enhancement of vegetation in these areas. The samphire shrubland is of high conservation value and is a likely habitat for migratory bird species listed in the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (an EPBC referral may be required if the vegetation is to be impacted).

Mine site within the catchment

The Boral quarry on Black Top Road, Gould Creek, is located within the catchment area. It is unknown whether the quarry operations are impacting the water quality of downstream waterways, however it is assumed that appropriate water quality management measures are in place as a part of the quarry's licencing requirements.

2.3.6 System outlet constraints

There are limited opportunities for discharging stormwater runoff to the Barker Inlet/Gulf St Vincent. An existing coastal channel (the Gap) forms the outfall for the ACHRD catchment. This channel is currently under capacity with large amounts of flooding observed to the east of the Bolivar site (Tonkin 2018b).

Increasing the capacity of the outlet all the way to the coast (to alleviate this flooding) would be challenging given the limited space between the Bolivar lagoons. Were the outlet to be upgraded, it is likely that increased flow rates would be discharged to the coast.

Additionally, the vegetation (Samphire shrubland) within the downstream portion of the Gap outfall is of high conservation significance. Disturbance to this vegetation would be required to facilitate upgrade of the channel.

3 Stormwater management objectives

The Stormwater Management Planning Guidelines published by the SMA includes the following in relation to stormwater management objectives:

Catchment specific objectives for the management of stormwater within the area are to be set and are to be based on the problems and opportunities identified. The objectives should provide measurable goals for the management of stormwater in the catchment.

The stormwater management guidelines (SMA, 2007) stipulate that:

"As a minimum, the 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 watercourse and riparian ecosystems;*
- *desirable planning outcomes associated with new development, open space, recreation and amenity;*
- *sustainable management of stormwater infrastructure, including maintenance and resilience against climate change*".

3.1 Stormwater management service attributes

The key issues to be addressed in the development of the SMP for the management of stormwater runoff from an urban catchment are:

- Flooding
- Water quality and reuse
- Amenity, recreation and environmental protection and enhancement
- Asset management.

Arising from these issues, broad objectives for management of urban stormwater runoff can be developed and are commonly identified as follows:

Service attribute 1: Flood management

Provide and maintain an adequate degree of flood protection to existing and future development.

Service attribute 2: Water quality improvement and reuse

Improve water quality to meet the requirements for protection of the receiving environment and downstream water users where possible.

Maximise the use of stormwater runoff for beneficial purposes while ensuring sufficient water is maintained in creeks and rivers for environmental purposes.

Service attribute 3: Amenity, recreation and environmental enhancement

Where possible, develop land used for stormwater management purposes to facilitate recreation use, amenity and environmental enhancement.

Service attribute 4: Asset management

Ensure the condition of existing stormwater infrastructure is suitable for its intended purpose. Ensure that proposed stormwater infrastructure is sustainable.

The development of a SMP for the ACHRD catchment requires these broad objectives to be further refined to identify catchment specific management objectives. These specific objectives have enabled targeted management strategies to be identified and assessed.

3.2 Catchment specific objectives

The following catchment specific objectives and levels of service have been developed by the City of Playford and the City of Salisbury in collaboration with the project steering committee.

3.2.1 Service attribute 1: flood management

Existing drainage standard

Components making up the existing drainage system can be broadly categorised into three components:

Lateral or Feeder Drains

These drains collect runoff from streets within the catchment and have the primary function of preventing nuisance flooding of roadways.

Main or Trunk Drains

These drains form the main spines of the underground drainage system and act as the discharge point for the lateral drainage systems. The main drains can carry substantial flows and have the primary purpose of preventing property damage due to concentrated flood flows.

Open Channels and Gullies

The open channels and gullies collect flows from the main drains and have the primary purpose of transferring floodwaters to the catchment outlet without damage to property.

The existing standard for each of these components varies across the catchment. The following standards are generally accepted by Council and the community:

- Lateral Drains 2-5 yr ARI (0.5 EY – 0.2 EY)
- Main Drains 5 yr ARI (0.2 EY)
- Open Channels and Gullies 100yr ARI (1% AEP)

It is important to review the design standard of existing stormwater infrastructure to ensure it is 'fit for purpose'.

Currently accepted design standards

ARR (2019) provides some guidance on design standards for urban stormwater drainage. The design standard is embodied in the major-minor principle, which aims to ensure that development is protected from inundation in a 1% annual exceedance probability (AEP) event. Under the major-minor principle, the drainage system is considered to be comprised of a minor (generally underground) component that prevents nuisance flooding of roadways resulting from relatively frequent storm events, and a major component (generally along surface flow paths such as roads and reserves) that carries excess runoff during more substantial storm events. The combined capacity of the minor and major system components should be sufficient to carry the peak flow produced by a 1% AEP event. A design standard of 0.5 exceedances per year (EY) to 0.2 EY is generally adopted for the minor system. This is consistent with the Playford Council Development Plan and Salisbury Council Development Plan which state that new developments are to be protected from the 100 year ARI event.

Proposed drainage system design standard

Main drains and outfall

The ACHRD catchment is largely developed with trunk drainage systems already in place. Any new or upgrade works to these drainage systems should aim to meet the 1% AEP design standard with consideration to the physical constraints, construction costs and the consequences of the drainage system surcharging.

Lateral drains

In accordance with generally accepted practice, the historical use of a 5 year ARI (0.2 EY) design standard for new lateral drainage systems in the catchment should be continued.

Where property is likely to be inundated as a result of overflow of the underground drainage system (for example at a trapped low point), a higher design standard (up to 1% AEP) is appropriate. However, in some instances it may not be economically viable to provide a 1% AEP level of protection if the cost of the works would greatly exceed the likely magnitude of the flood damages.

Flood management levels of service

Based on the above, the following catchment specific objectives for management of flooding within the ACHRD catchment have been set.

For new development undertaken within the catchment the flood management objectives shown in Table 3.1 apply.

Table 3.1 Flood management objectives, measures and performance targets

Objective		Customer performance measure and target	Technical performance measure and target
1.1 Protect habitable buildings from inundation	a	1% AEP modelled protection for habitable floor levels with 300 mm freeboard **Target:** 99% of habitable floors within catchment by 2040	Annual capital value modelled flood losses **Target:** less than 0.1% of property capital value by 2040
1.2 Protect primary production land from inundation	a	5% AEP protection for primary production land with zero freeboard **Target:** 75% of land area within catchment by 2040	Annual average modelled produce/stock losses to floods (indexed 2020) **Target:** less than $4 million per annum
1.3 Flood hazard to the community	a	Proportion of residential properties subject to no more than low flood hazard during a 1% AEP flood **Target:** 95%	Proportion of minor[1] drainage network that has capacity of at least 20% AEP flow **Target:** 80% by 2030
	b	Proportion of road reserves that have flood hazard less than high during a 1% AEP flood **Target:** 98% by 2040	New development does not increase flood hazard to other properties for all events up to a 1% AEP **Target:** 100% of developments

[1] As defined in ARR 2016, Book 9, Section 3.4.

Objective		Customer performance measure and target	Technical performance measure and target
	c	Proportion of residential habitable floors that remain dry or have safe[2] exit routes for all floods **Target:** 99.99% by 2040	Proportion of infrastructure designed after 2020 to take account of RCP 8.5 climate change scenario, including sea level rise predictions **Target:** 95%
	d	N/A	Engage with critical engineering 'lifelines' infrastructure providers and complete flood hazard vulnerability assessment **Target:** initial 'Lifelines Project' completed by 2025

3.2.2 Service attribute 2: water quality improvement and reuse

Existing water quality

Stormwater from the ACHRD catchment ultimately discharges into Gulf St Vincent. There are existing water quality treatment schemes in place (such as the Kaurna Wetlands) that currently assist with the reduction in volume and pollution loading to Gulf St Vincent. However, opportunities for further improvement should be investigated.

Currently accepted design standards

To ensure that this stormwater management plan aligns with other strategies and guidelines, stormwater quality targets from other documents have been reviewed. These include the recommendations made in:

- Adelaide Coastal Waters Study (ACWS) (EPA SA, 2007) and Adelaide Coastal Water Quality Improvement Plan (ACWQIP) (EPA SA, 2013).
- Australian Runoff Quality: A Guide to Water Sensitive Urban Design (Engineers Australia, 2006).
- Water Sensitive Urban Design – Creating more liveable and water sensitive cities in South Australia (DEWNR, 2013).

ACWS and ACWQIP

Based on the outcomes of the ACWS, the EPA has developed strategies to assist with achieving their target of reducing nitrogen loads by approximately 75% from 2003 levels to halt seagrass loss and create conditions that support seagrass restoration. The strategies that apply to stormwater management include reducing nutrient, sediment and organic matter discharges through the uptake and implementation of water sensitive urban design (WSUD) and promote integrated reuse of wastewater and stormwater (EPA SA, 2013). The strategies include:

- The total load of nitrogen discharged to the marine environment should be reduced to around 600 tonnes/year (representing a 75% reduction from the 2003 value of 2,400 tonnes). The ACWQIP target for the stormwater contribution is 50 tonnes/year by 2028 including population growth.
- Commensurate with efforts to reduce the nitrogen load, steps should be taken to progressively reduce the load of particulate matter discharged to the marine environment. A 50% load reduction (from

[2] 'Safe' means not subject to FIS class hazard and has a rising egress route, of maximum H2 hazard, to dry ground beyond the PMF (Ref. Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, AIDR 2017).

2003 levels) would be sufficient to maintain adequate light levels above seagrass beds for most of the time. The reduced sediment load will also contribute to improved water quality and aesthetics.

- The ACWQIP target for the stormwater contribution of suspended solids is 730 tonnes/year by 2028 for discharges into the Barker Inlet. One means of reaching this target is to reduce the volume of stormwater discharging to the Barker Inlet.
- To assist in the improvement of the optical qualities of Adelaide's coastal waters, steps should be taken to reduce the amount of coloured dissolved organic matter in waters discharged by rivers, creeks and stormwater drains.

Australian runoff quality

Guidelines on the reduction of pollutant loads for new developments are set out for Victoria and New South Wales in the Australian Runoff Quality Guidelines (Engineers Australia, 2006). Stormwater treatment objectives are as follows:

- Total suspended solids (TSS) – 80% reduction of the developed catchment average annual load
- Total phosphorus (TP) – 45% reduction of the developed catchment average annual load
- Total nitrogen (TN) – 45% reduction of the developed catchment average annual load
- Litter – Retention of litter greater than 50 mm for flows up to the 3 month ARI peak flow
- Coarse sediment – Retention of sediment coarser than 0.125 mm for flows up to the 3 month ARI peak flow
- Oil and grease – No visible oils for flows up to the 3 month ARI peak flow.

WSUD – creating more liveable and water sensitive cities in South Australia

This document (DEWNR, 2013) provides a comprehensive and consistent approach to WSUD for State and Local Governments, the private sector and the community. It stems from both the Water for Good and Planning Strategy which recognises WSUD as an important element in creating more liveable urban environments. The state-wide performance target for runoff quality are as follows:

- Total suspended solids (TSS) – 80% reduction of the developed catchment average annual load.
- Total phosphorus (TP) – 60% reduction of the developed catchment average annual load.
- Total nitrogen (TN) – 45% reduction of the developed catchment average annual load.
- Litter/gross pollutants (GP) – 90% reduction of the developed catchment average annual load.

Water reuse

The NRM Board's target for reuse of stormwater is 75%. This is an ambitious target that will be difficult to achieve in the study area because of shallow ground water levels and limited suitable locations for harvesting schemes. Notwithstanding this, opportunities exist for capture and beneficial reuse of runoff.

It should be noted that there are synergies between objectives for reuse and water quality. For example, streetscape WSUD devices for water quality improvements will also provide a source of water for street tree and streetscape improvement. Also, reducing discharge volumes reduces pollutant loadings on the receiving environment.

Water quality improvement and reuse levels of service

With infill development likely to occur within the catchment, it is imperative that pollution loadings are not increased to a level that would be harmful to the receiving environments. The catchment specific objectives shown in Table 3.2 have been set to ensure that water quality and reuse targets are met.

Table 3.2 Water quality improvement and reuse objectives, measures and performance targets

Objective		Customer performance measure and target	Technical performance measure and target
2.1 Water sensitive urban design (WSUD)	a	Relevant new developments feature at least 6 different key WSUD measures that reduce pollution and/or make beneficial use of stormwater[3] **Target:** by July 2021	Pollution reduction from new developments after July 2021 **Target:** TSS 80% TP 60% TN 45% GP 90%
	b	Percentage of all urban streets retrofitted with WSUD devices **Target:** 10% by 2040	N/A
2.2 Quality of stormwater outflows at the coast	a	Coastal discharges do not exceed National Water Quality Management Strategy 'slightly disturbed' ecosystem default trigger levels **Target:** 95% of time by July 2034	By July 2034, released water is of concentration equal to or better than the following targets 95% of the time **Target:** TP = 0.1 mg/L TN = 1 mg/L Turbidity = 50 NTU Faecal coliforms = 1000 faecal coliform organisms / 100 mL
	b	N/A	For system effectiveness monitoring purposes only, main channel flow water quality is measured mid catchment against the same parameters as for outflows at the coast **Target:** by July 2025
2.3 Water reuse	a	Cost effective household stormwater reuse options are promoted and available **Target:** For at least 20% of average daily demand by 2034	Proportion of overall stormwater runoff volume that is reused **Target:** 75% by July 2034

3.2.3 Service attribute 3: amenity, recreation and environmental enhancement

Development of multiple use drainage open space requires a careful consideration of the interaction between drainage provision, environmental enhancement, water quality and recreation provision. By application of appropriate principles and implementation of suitable guidelines it is possible to serve a range of needs while at the same time providing a suitable drainage system. In doing so, advantages

[3] Refer Table 1.1, Chapter 1, Department of Planning and Local Government, 2010, *Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region*, Government of South Australia, Adelaide.

can be compounded beyond those which may be achieved if each component were considered in isolation.

Objectives for amenity, recreation and environmental enhancement are provided in Table 3.3.

Table 3.3 Amenity, recreation and environmental enhancement objectives, measures and performance targets

Objective		Customer performance measure and target	Technical performance measure and target
3.1 Beneficial use of drainage reserves	a	Proportion of total stormwater management reserve area that provides community amenity or recreation opportunities **Target:** 90% by 2029	N/A
3.2 Environmental enhancement of drainage reserves and watercourses	a	N/A	Ten year change in weighted average Bushland Assessment Method Total Biodiversity Score for all drainage reserves **Target:** 2% improvement per annum

3.2.4 Service attribute 4: asset management

Stormwater drainage forms a considerable financial asset for the City of Playford and the City of Salisbury, which is likely to be at varying ages and conditions. Degraded infrastructure will reduce the ability of the drainage system to act as per its original design intent.

Without careful planning structural failure of existing infrastructure may necessitate immediate and expensive rectification. Careful asset management will allow for future planning to determine the timeline for replacement of assets.

Objectives for asset management are provided in Table 3.4.

Table 3.4 Asset management objectives, measures and performance targets

Objective		Customer performance measure and target	Technical performance measure and target
4.1 Total service	a	Proportion of all levels of service targets being met **Target:** 80% by 2024	Asset Management Maturity Index Score for Stormwater at City of Playford **Target:** average score 3.5 by June 2023
4.2 Renewing assets at the rate required	a	Number of asset structural failures that affect level of service **Target:** no more than 5 per annum after 2023	Variance of renewal expenditure to AMP forecast **Target:** maximum +/- 30% each year after 2023

4 Problems and opportunities

4.1 Key flood prone areas

Flood models of the catchment area have been developed as part of this SMP (refer Appendix A and Appendix B for details of the flood inundation modelling methodology, and Section 5 for details of the scenarios modelled). The floodplain mapping of the area has identified a number of flooding hot spots. These are described below along with potential mitigation opportunities. The flood inundation map for the long term 2050 scenario, 1% AEP event is shown in Figure 4.1.

4.1.1 Ridley Road – Bubner Street – Goodman Road, Elizabeth South

Description of flooding

Water spills over the Philip Highway into Richardson Road and Goodman Road approximately 300 m east of the Gawler Railway; this is a natural low spot in the local topography. Ponding of water up to 0.8 m deep in Bubner Street occurs in the 1% AEP event due to a small ridge line on the western side of the street (refer Figure 4.2). Once water has overtopped this ridge line it continues to flood west towards Ridley Road and the Gawler Railway and adjacent open drain.

This area is the most severely flooded residential area within the model extents due to the trapped low spots on Bubner Street and Goodman Road. The maximum depth of ponding in these low spots is effectively unchanged in the 5% and 2% AEP events because the depth of ponding must exceed approximately 0.5 m before it can escape further to the west.

Potential opportunity

Acquisition of properties would allow for the creation of a formal flood flow path through the area. Culvert upgrades would also be required to allow the flows to pass under the rail line.

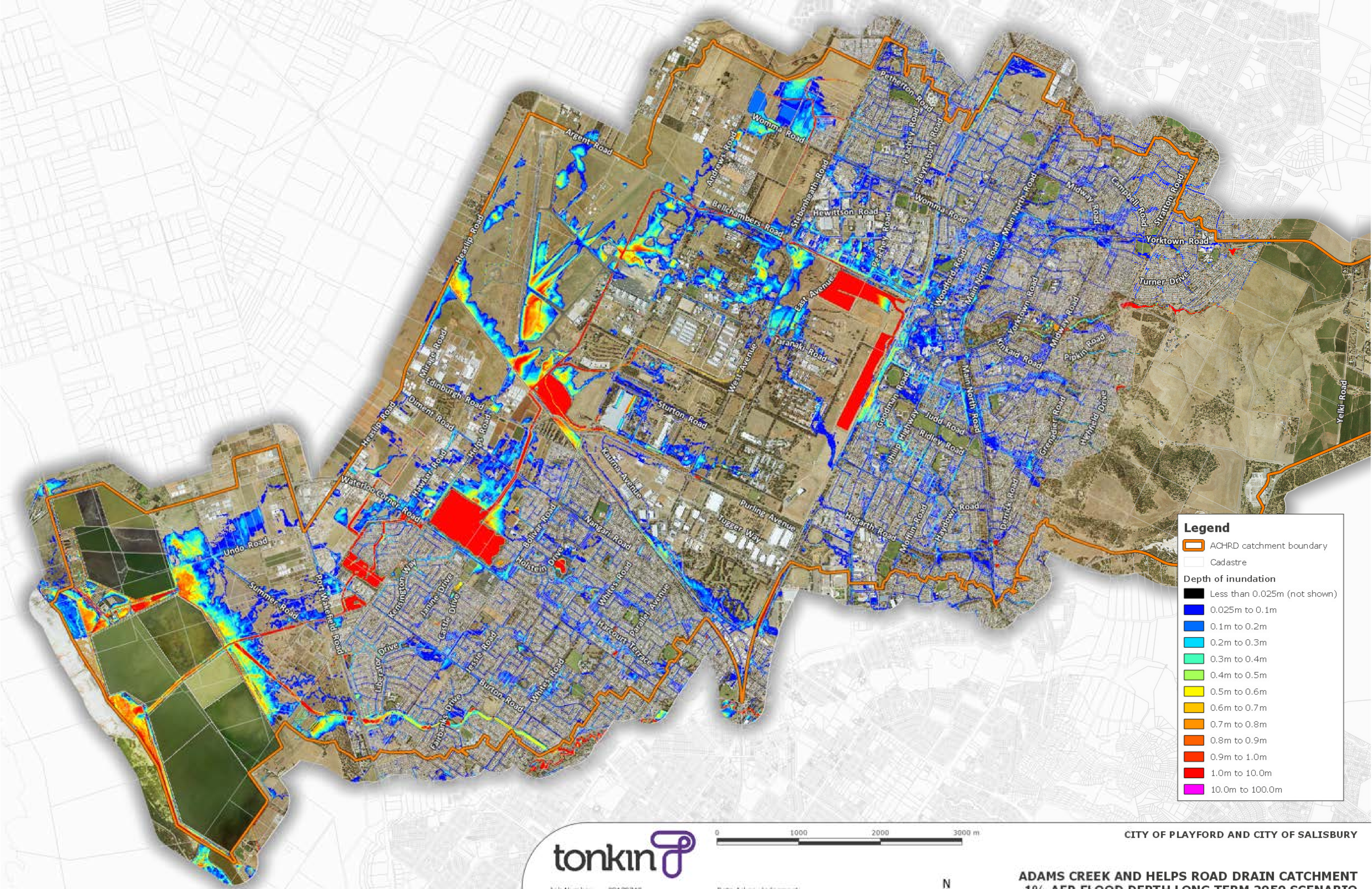
4.1.2 Main North Road, Elizabeth East

Description of flooding

Between Fletcher Road and Midway Road there is a significant amount of ponding on Main North Road during the 1% AEP event (refer Figure 4.3). Flood depths in this area are typically 0.1 m to 0.2 m, with depths of up to 0.3 m also observed. The floodwater spills over the reserve area to the west and floods Ashfield Road to a depth of 0.4 m. Flooding in the 2% AEP event is very similar. In the 5% AEP event less water floods through the reserve and consequently the depth of flooding in Ashfield Road is much reduced being only about 0.2 m deep.

Potential opportunity

There are pockets of open space in the area that could be used for detention storage. There are also options to detain rural catchments through the construction of embankments across existing valleys.



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Figure 4.1

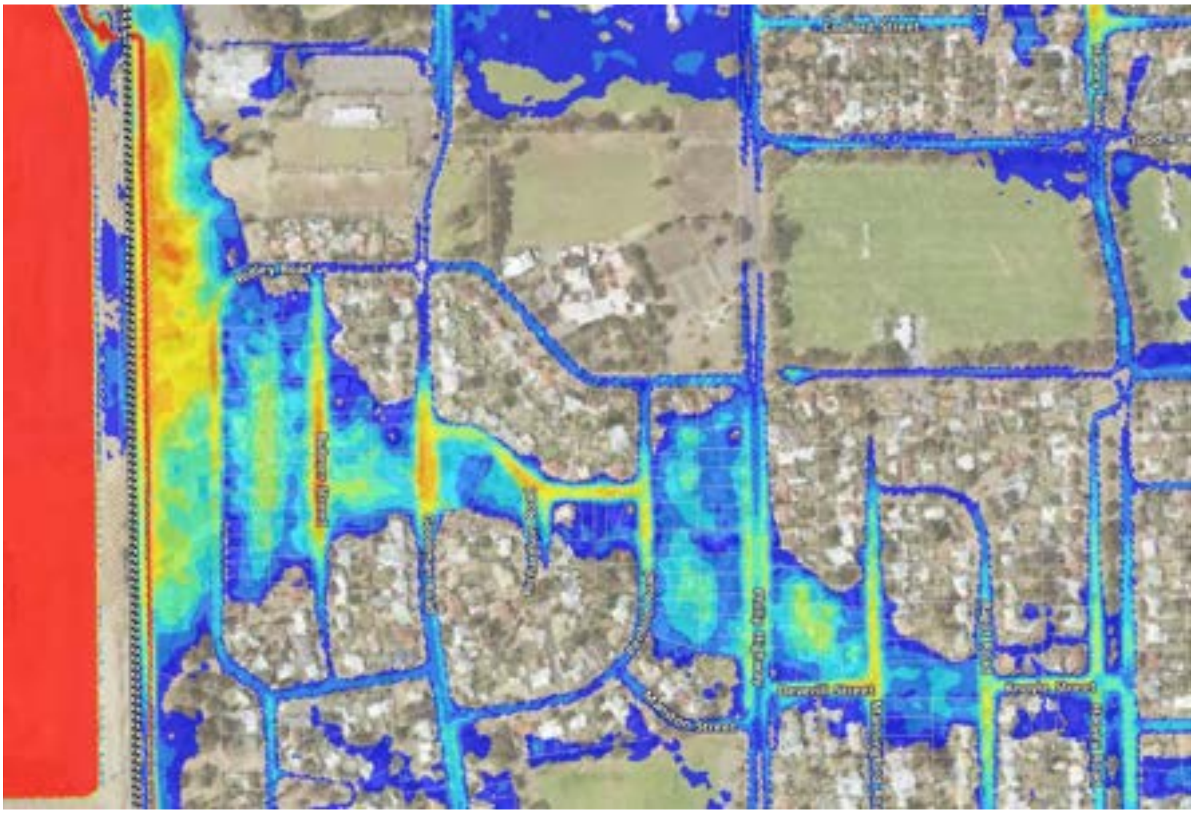


Figure 4.2 1% AEP flooding in Elizabeth South

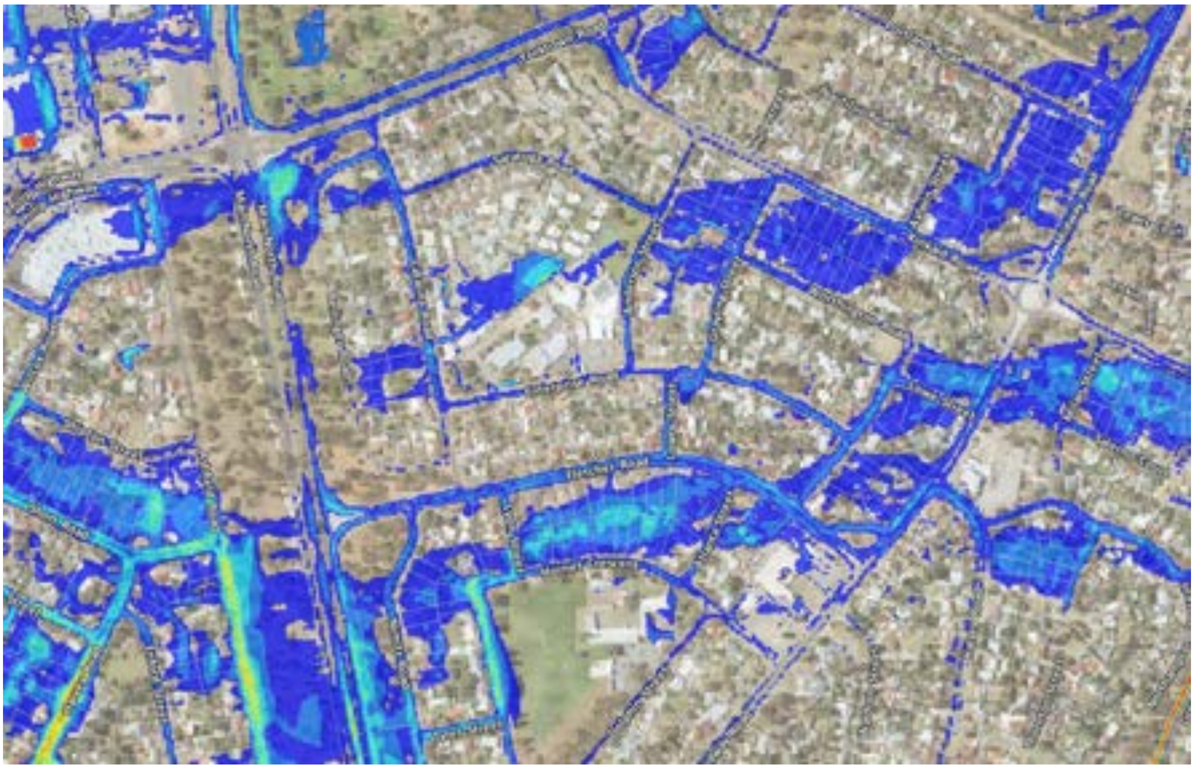


Figure 4.3 1% AEP flooding in Elizabeth East

4.1.3 Main North Road and Elizabeth Shopping Centre, Elizabeth Park

Description of flooding

A significant amount of flooding occurs on Main North Road between Yorktown Road and Ifould Road due to floodwaters breaking out from Adams Creek (refer Figure 4.4). Flooding is typically 0.3 m deep but is up to 0.6 m deep in some areas. During the 2% AEP event there is less ponding but still some overflow into the Elizabeth Shopping Centre.

There is some flooding throughout the Elizabeth Shopping Centre complex that is caused by overflows from Adams Creek as well as locally generated runoff. The severity of flooding depicted could be worse than in reality because some privately owned drains have not been modelled in this location due to unavailability of data.

Potential opportunity

There is an opportunity to construct a new underground drain between Main North Road and the Gawler rail line to reduce surface flood flows as well as detain flows upstream of the site.

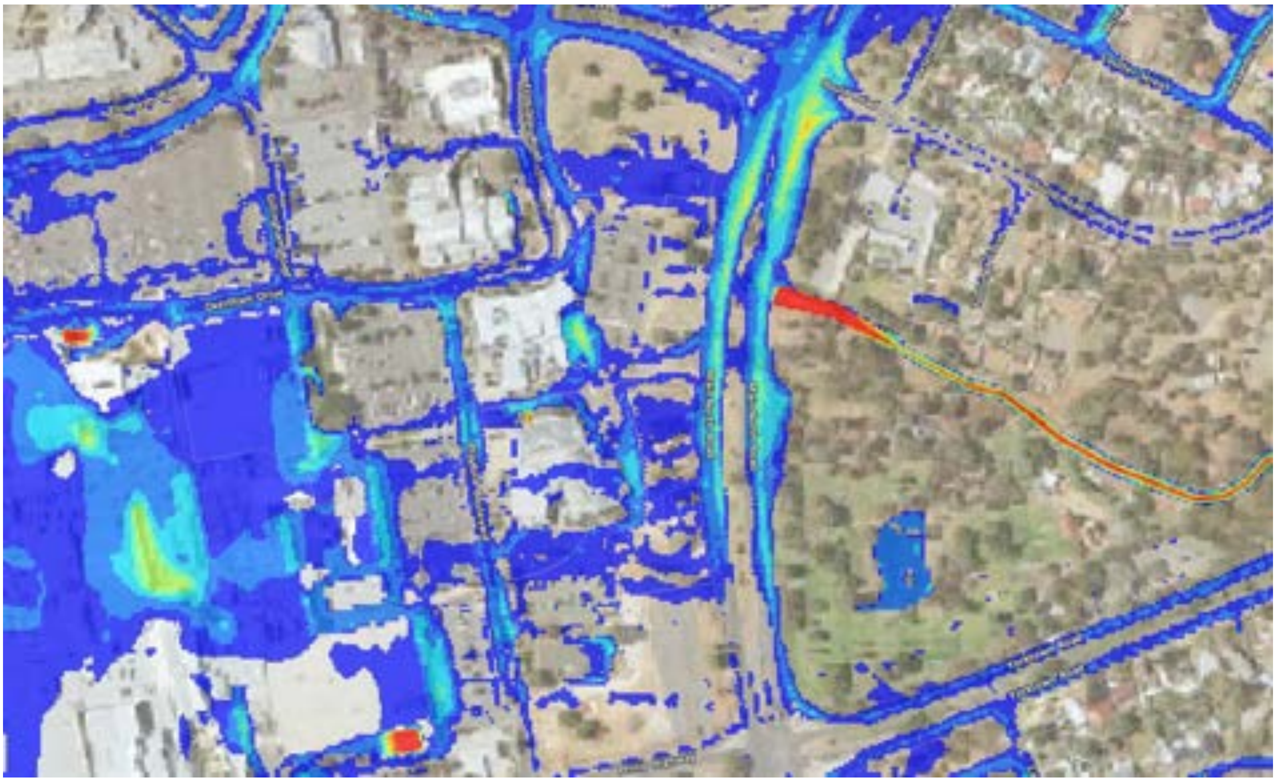


Figure 4.4 1% AEP flooding in Elizabeth Park

4.1.4 Adams Creek

Description of flooding

The flooding along Adams Creek is generally contained to the main channel of the creek in all events. However, there is significant overtopping of road crossings in all events modelled. The worst location for road flooding due to Adams Creek occurs at Yorktown Road (refer Figure 4.5); this location floods even in the 5% AEP event. During the 5% AEP event, the ponding is contained within the road corridor. Midway Road and Main North Road are also overtopped during the 2% and 1% AEP events.

Significant flood depths occur in the flood detention basins in the upper reaches of the creek—up to 7.5 m deep in the 1% AEP event. The detention basin near Indee Crescent begins utilising its spillway in the 5% AEP event. Further downstream, the basin near Turner Drive has significant detention storage. In the 0.2% AEP event the depth of flooding exceeds 10 m and the spillway is heavily utilised with water up to 1 m deep at the spillway crest.

Potential opportunity

There is an opportunity to construct larger culverts under the road crossings. Alternatively, increasing the volume of detention storage available upstream, or providing flood storage upstream of Main North Road through the construction of a new embankment, may alleviate some of the flooding.

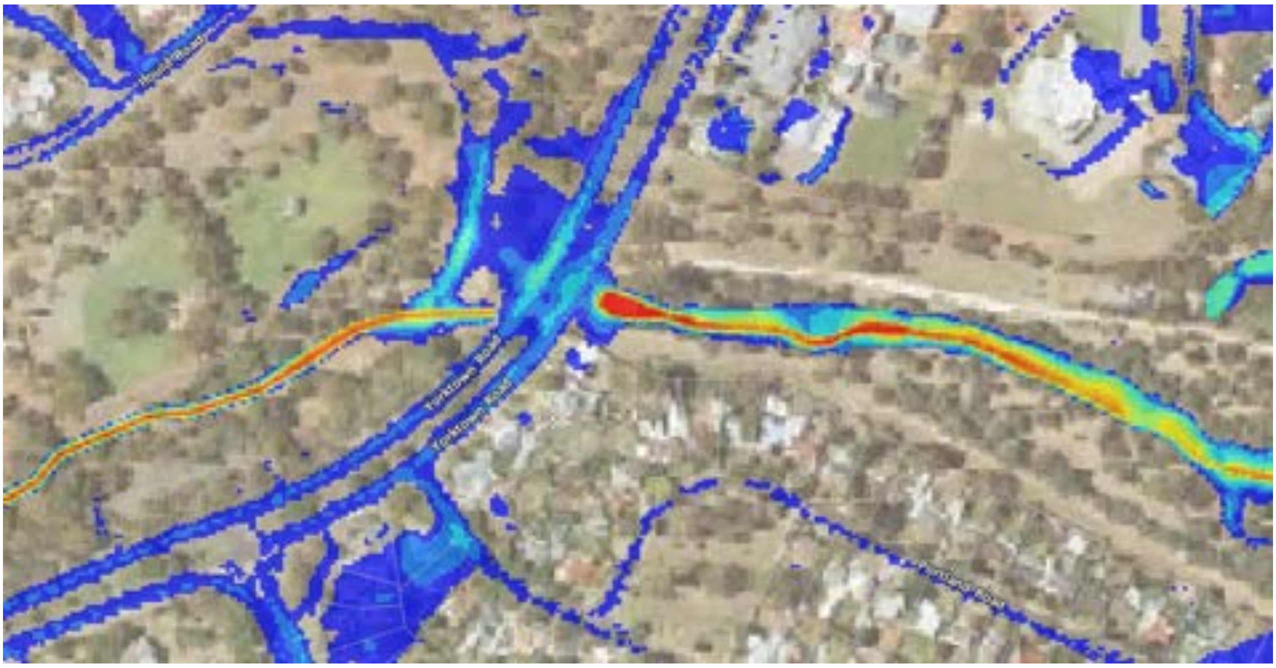


Figure 4.5 1% AEP flooding from Adams Creek over Yorktown Road

4.1.5 Elizabeth West

Description of flooding

The high imperviousness of this industrial area causes significant local flooding of the streets and lower lying properties in all events. Ponding in the 5% AEP event is predominantly confined to the road network, whilst the 2% and 1% AEP events cause widespread flooding throughout the area reaching depths up to 0.4 m (refer Figure 4.6).

Floodwaters spilling over the Gawler Railway near Winterslow Road compound the local flooding in the area because almost all floodwater that spills over the Gawler Railway is directed to the intersection of Winterslow Road, Bellchambers Road and Peachey Road and not towards the large flood detention basins to the south.

In all events modelled the flood basins are utilised, reaching full capacity in the 1% AEP event. In the 0.2% AEP event the basin walls are overtopped and surface flows move west into the DST precinct.

Potential opportunity

There is limited available open space to provide any regional scale detention storage in the area. The main opportunity to reduce flood risks would be to upgrade the local underground drainage network that discharges into either the main Helps Road open channel or the Stebonheath Road open channel.

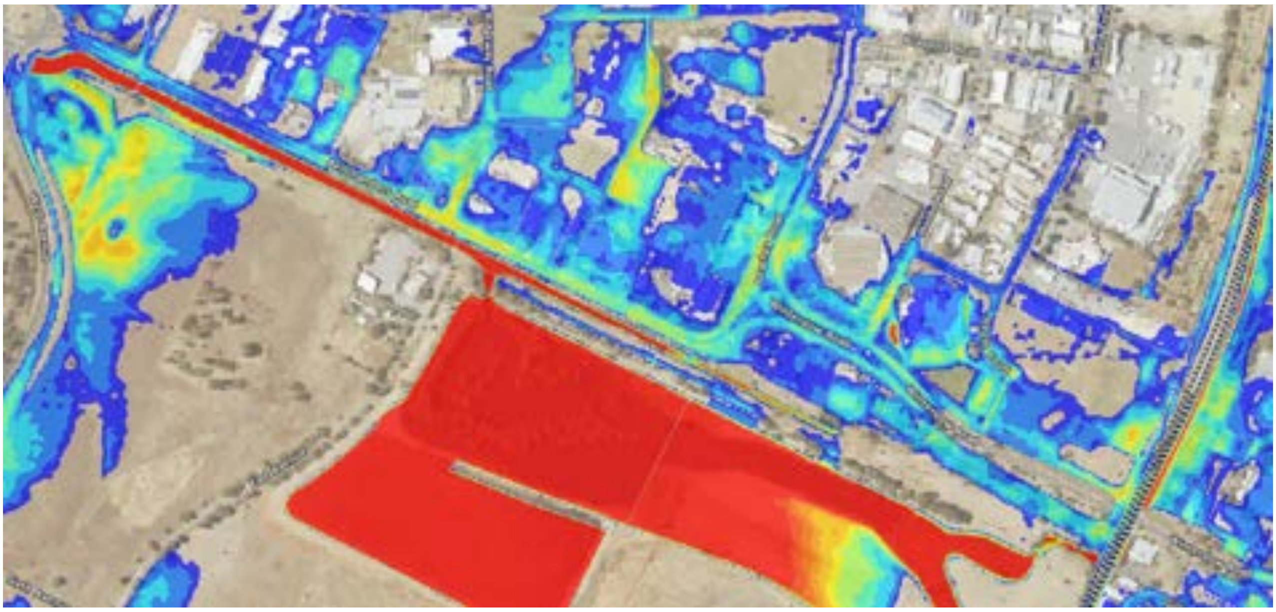


Figure 4.6 1% AEP flooding in Elizabeth West

4.1.6 RAAF Base Edinburgh

Description of flooding

Water ponds behind the natural barrier formed by the ARTC rail line and Heaslip Road in the south western corner of the RAAF base (refer Figure 4.7). There is some uncertainty regarding the internal drainage of the RAAF base so flooding may be less severe than predicted by the model. These waters have the potential to overtop the rail line and may take a long time to drain away as there is limited drainage infrastructure in the area.

Potential opportunity

Some of this flooding is exacerbated by overflows from Smith Creek. Managing this overflow would help to reduce flooding in this area, as outlined in Section 4.1.7. The Burton West industrial estate drain has been extended up to the rail line to provide an outlet for the area. The City of Salisbury is allowing the City of Playford to discharge flows up to 2.3 m^3/s from the GEP catchment into the upstream sections of the Burton West Drain.

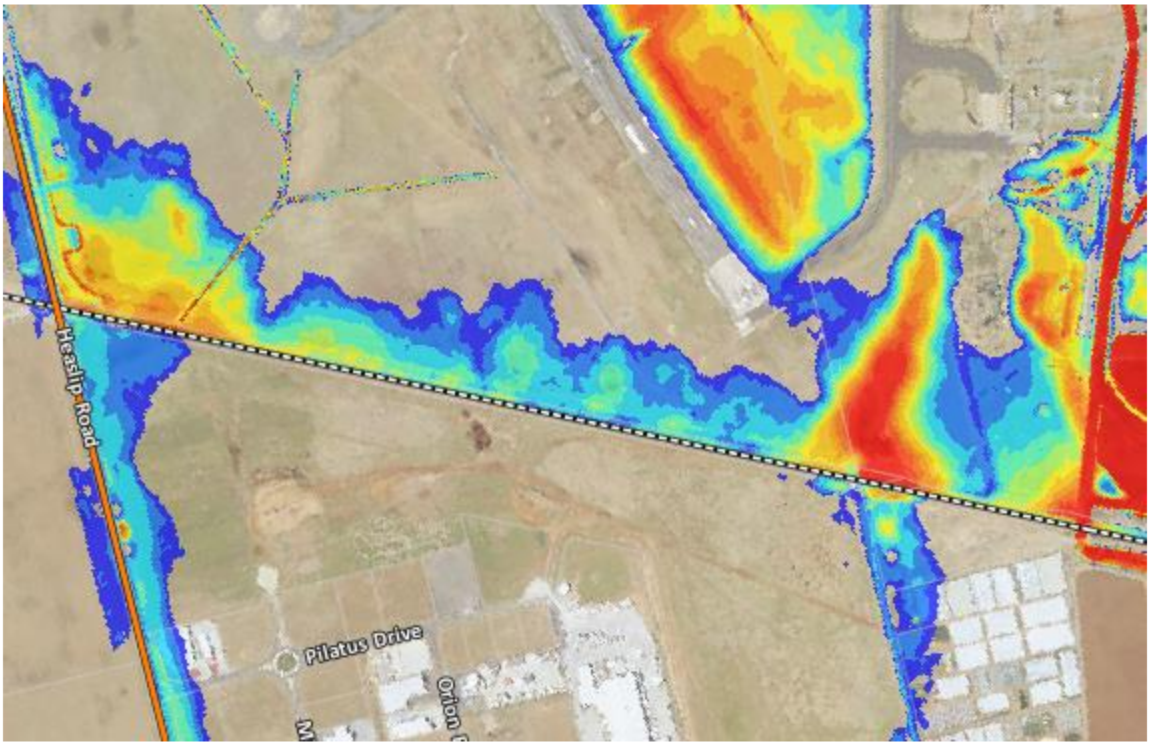


Figure 4.7 1% AEP flooding in RAAF base

4.1.7 Eyre Development, Penfield

Description of flooding

It should be noted that the final topography of this area is not known and only an approximation of final elevations has been used in the modelling. Therefore, assessment of the flooding in this location is limited.

Overflows from Smith Creek (as provided by Water Technology) into the proposed Eyre Development cause widespread flooding with depths up to 0.5 m in the 1% AEP event (refer Figure 4.8). Modelling shows that the proposed open channels within the development are unable to manage the flooding caused by the Smith Creek overflow in the 1% AEP event. During the 2% and 5% AEP events the proposed channels and culverts appear to satisfactorily manage flows and consequently the flooded area within the development is substantially less.

A low spot midway along Andrews Road on the western boundary of the development causes minor flooding (0.1 to 0.2 m deep) into the Eyre Development during all the events modelled.

Potential opportunity

There is an opportunity to undertake works within the Smith Creek catchment. The Smith Creek SMP (Water Technology, 2019) proposes to incorporate mitigation measures such that there is no spill from Smith Creek into the Eyre Development during a 1% AEP event.

If the breach point from the channel is relocated further downstream of the development, the flood flows could be directed to a large detention basin to the west of the development. This basin would then be used to release the flows at a controlled rate back into the Helps Road outfall channel.

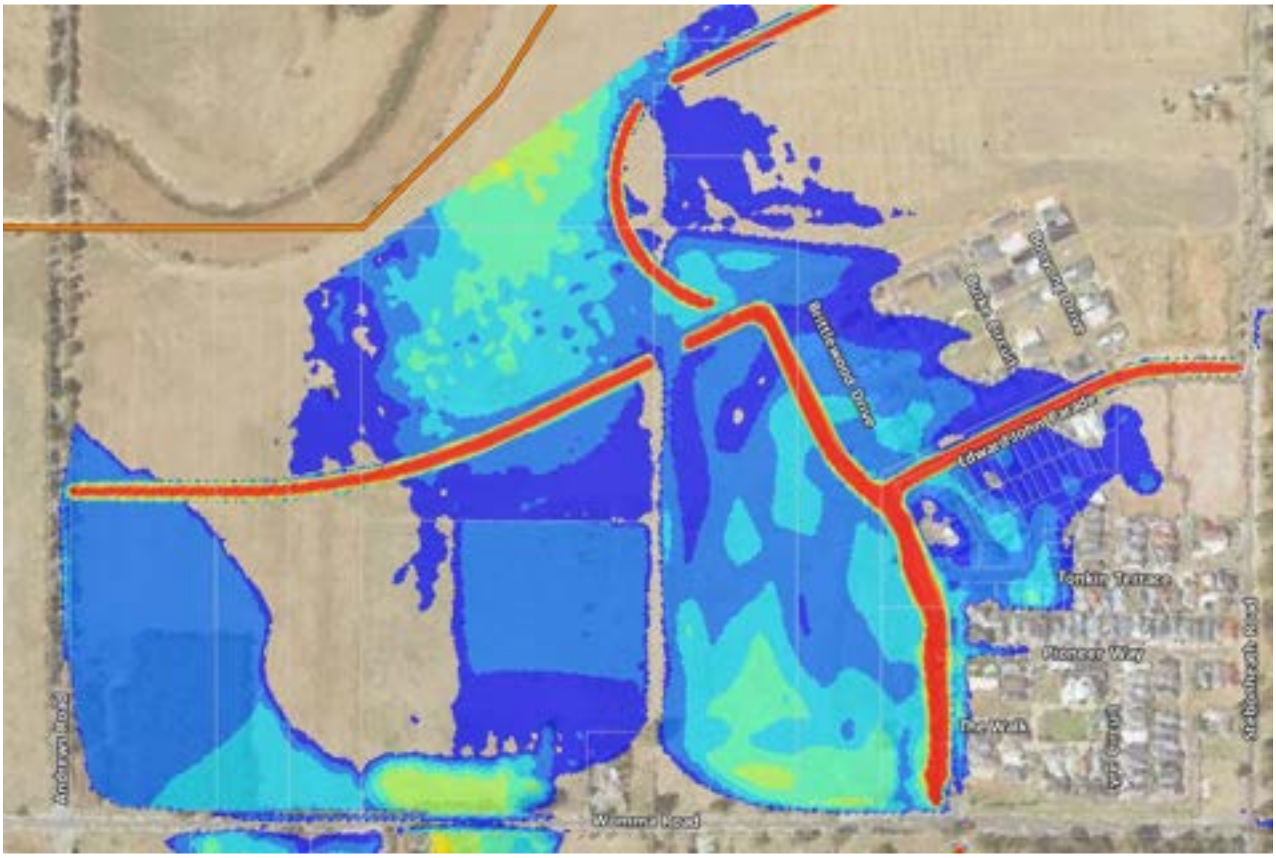


Figure 4.8 1% AEP flooding in Eyre development

4.1.8 Paralowie / Burton

Description of flooding

A strip of relatively shallow flooding (typically 0.2 m deep) is located in the vicinity of Burton Road to the east and west of Bolivar Road (refer Figure 4.9).

Potential opportunity

The main outfall drain along Burton Road has less than a 2 year ARI standard. While it would be an expensive exercise, the upgrading of the drain is the only solution that is likely to provide for a broad reduction of flooding in the area.

A relatively large amount of open space is located to the south east of the Burton Road / Bolivar Road intersection. A new detention basin at this location could be considered. However, it is towards the downstream end of the majority of the flooding in the area so will not do much to improve flood risk for upstream areas.

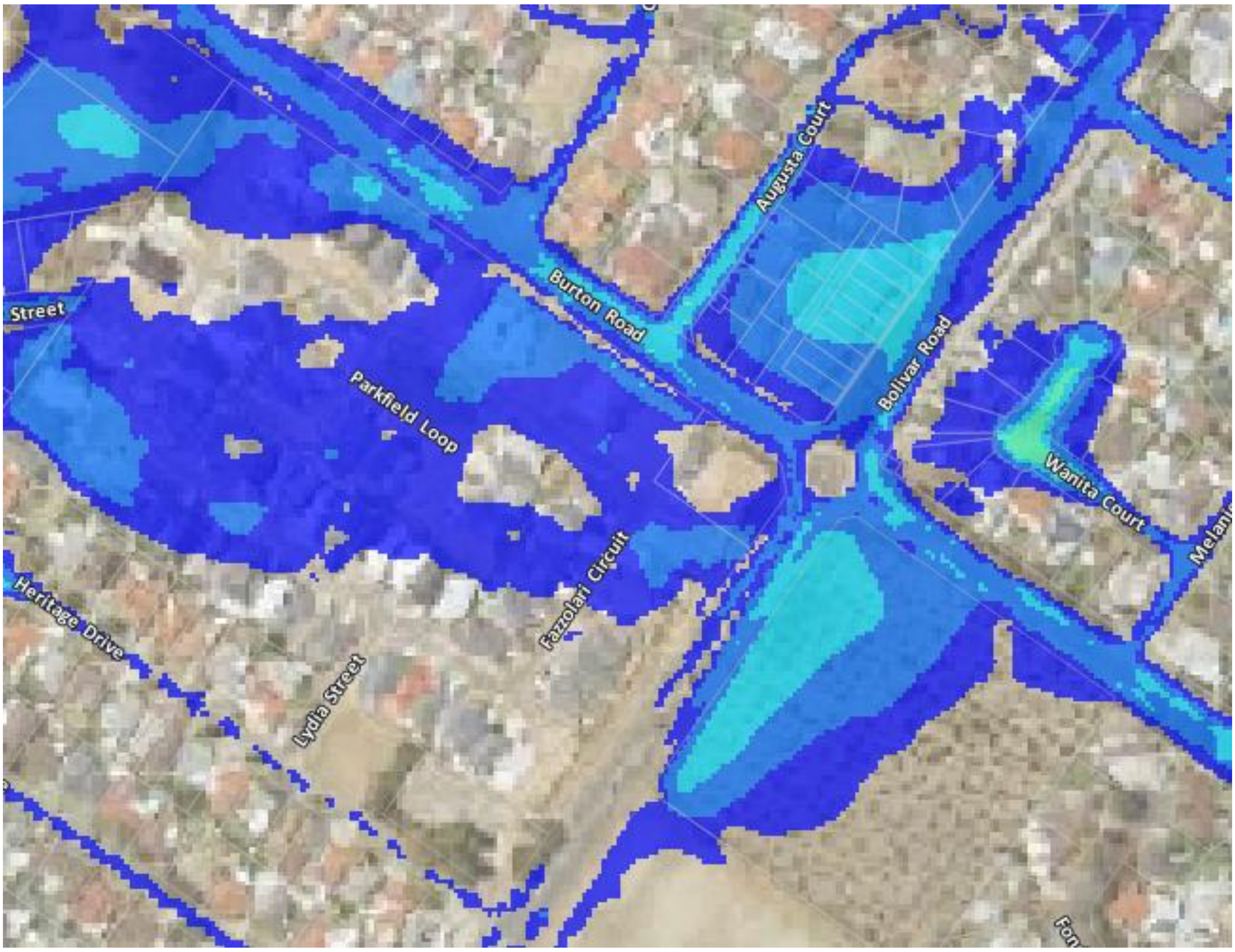


Figure 4.9 1% AEP flooding in Paralowie/Burton

4.1.9 Salisbury North / Kaurna Park Wetlands

Description of flooding

There is broad scale relatively shallow (up to 0.2 m deep) flooding through this area with localised deeper areas of up to 0.4 m to 0.6 m deep along Bolivar Road, Garrin Street, Holstein Drive and Witonga Avenue (refer Figure 4.10). Deep ponding of over 1.0 m is located behind the bund that is created by the Kaurna Parks wetland embankment. There is currently no development in this area but it may become developed in the future.

Potential opportunity

The main outfall drain along Waterloo Corner Road has less than a 2 year ARI standard. While it would be an expensive exercise, the upgrading of the drain is the only solution that is likely to provide for a broad reduction of flooding in the area.

It is understood that there is no outlet to the low lying area upstream of the Kaurna Park embankment. There is the potential to construct a new pipe through the wall of the embankment to allow the area to drain into Kaurna Park. Flood gates would potentially be required to ensure that water levels in the wetlands aren’t able to backwater into the low lying area. Future development in the area would need careful management, such as floor level controls, to ensure it is not flood prone.

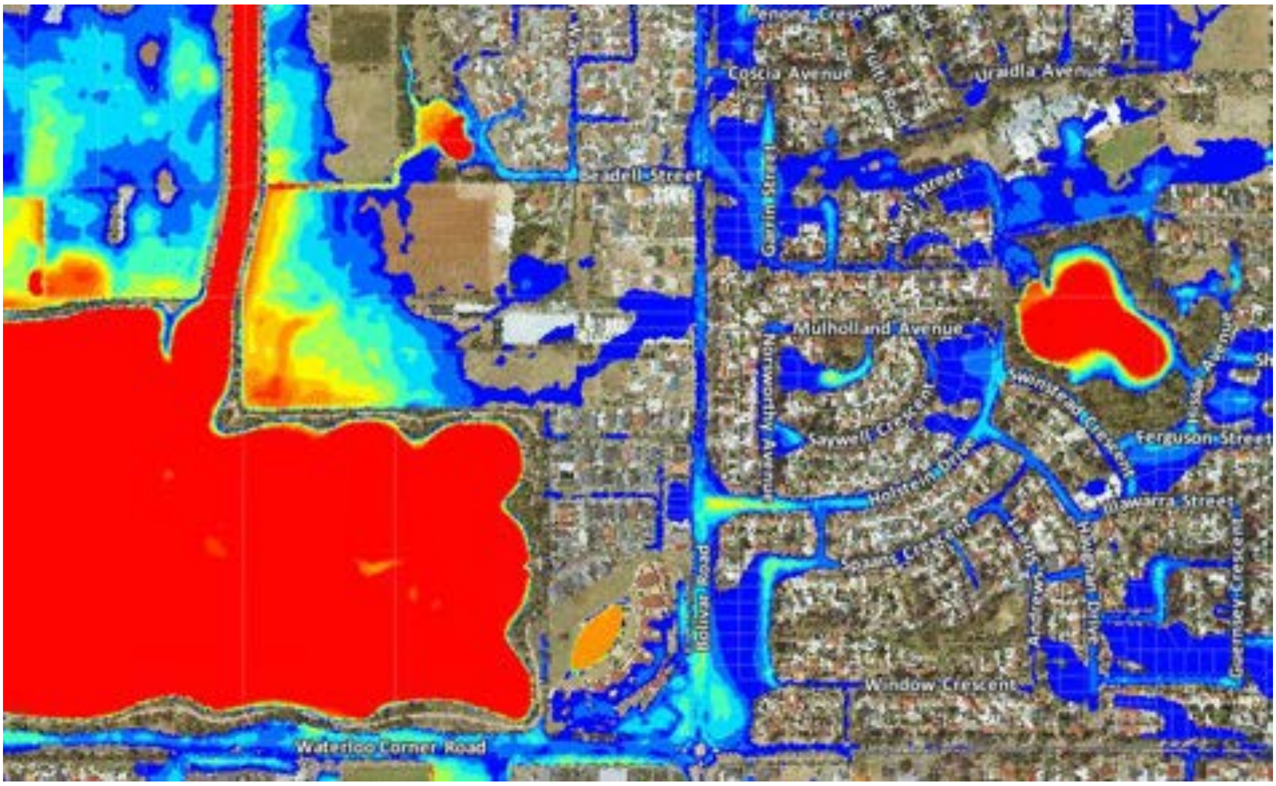


Figure 4.10 1% AEP flooding in Salisbury North

4.1.10 DST

Description of flooding

The main Helps Road channel spills into the northern portion of the DST in the vicinity of West Avenue and spills towards the south (refer Figure 4.11).

Potential opportunity

The Helps Road channel could potentially be upgraded, or additional storage provided to the large detention basin in the north-eastern corner of the DST, to reduce the peak discharge rate from the basin. There is also the opportunity to construct a new channel to the east of the RAAF base along the eastern side of West Avenue.

4.1.11 Helps Road Outlet, St Kilda

Description of flooding

The capacity of the outlet (the Gap) through the Bolivar wastewater treatment lagoons is relatively narrow and is restricting flows from passing along the outlet. As a result, large areas of flooding are occurring in the 300 m or so to the east of the lagoons with depths typically in the range of 0.3 m to 0.8 m (refer Figure 4.12).

Potential opportunity

The capacity of the Gap could potentially be increased by either encroaching into the lagoons or making better use of the current space between the lagoons. Channel widening upstream of the restricted section between the lagoons may also be required.

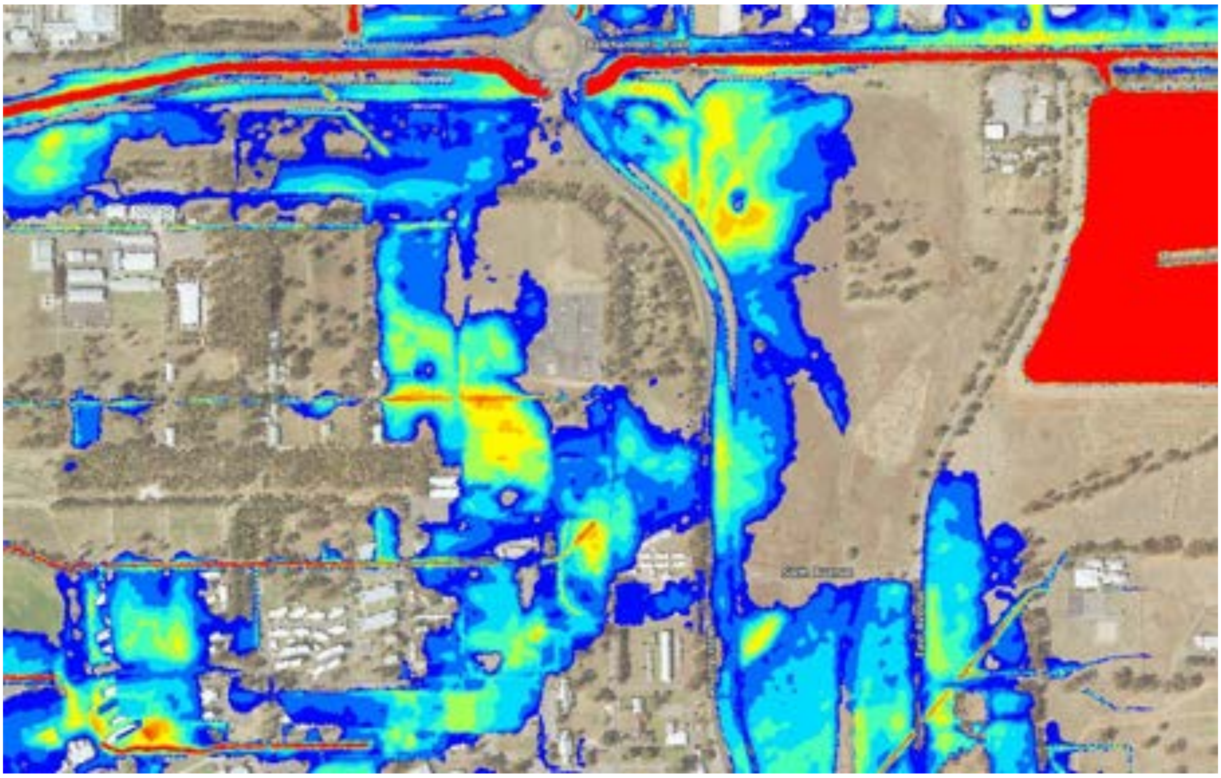


Figure 4.11 1% AEP flooding in the northern portion of the DST

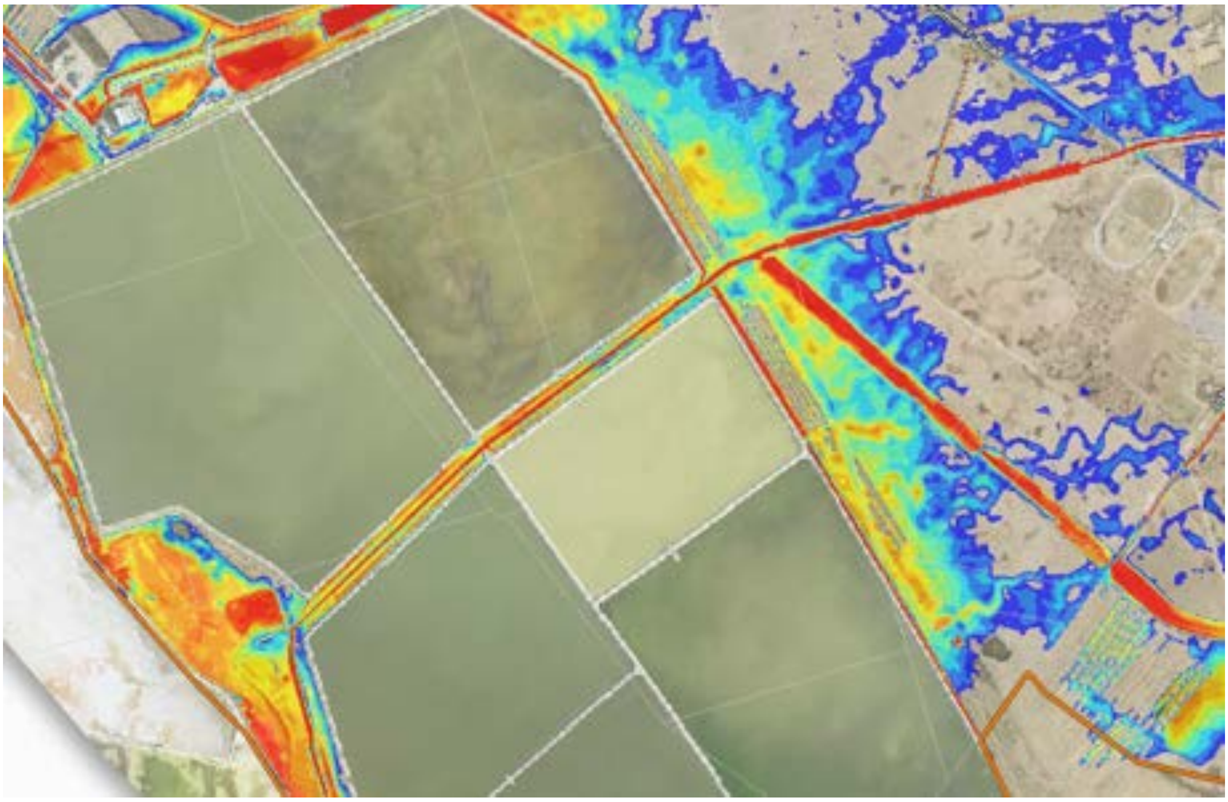


Figure 4.12 1% AEP flooding upstream of the Gap outlet

4.2 Water reuse

Each Council is currently licenced to inject harvested stormwater into the aquifer, and extract it for reuse. The injection limit is set by the EPA while the extraction limit is set by DEW. The ACHRD catchment area is located within both the Northern Adelaide Plains prescribed wells area and the Central Adelaide prescribed wells area. Discharging water into a well is subject to the conditions specified in the relevant water allocation plan.

The WGA hydrogeological assessment (WGA, 2018) identified potential for a significant increase in harvested yield from new or existing MAR schemes within the study area. These are described in the following sections. The additional harvest volumes will not exceed Councils' licence conditions.

4.2.1 Olive Grove wetlands

The Olive Grove MAR system (City of Playford) was constructed in 2006 with a design yield of 80 ML/a of treated stormwater for distribution to the recycled water network and community bores. Review of the scheme as part of the Northern Urban Catchments Stormwater Yield Review (Aqueon, 2016) indicated that the yield would be closer to 55 ML/a.

The scheme has been continually affected by turbidity issues preventing suitable injection water quality, attributed to the upstream catchment conditions and carp infestation within the wetlands. On this basis, the City of Playford decided to abandon the scheme as a MAR site and maintain the wetlands only as a treatment/aesthetic waterbody.

4.2.2 Edinburgh Parks North

The Edinburgh Parks North stormwater capture and MAR scheme has been partially constructed but is not currently operational as a water harvesting site. The design yield for the scheme is 600 ML/a.

The City of Salisbury does not consider the Edinburgh Parks North scheme as a viable standalone water harvesting scheme due to lack of local demands. The scheme could be brought online (with associated capital costs) if suitable demands are identified. The site is currently used for detention purposes only.

4.2.3 Edinburgh Parks South

The design yield for the Edinburgh Parks South wetlands (City of Salisbury) is 1,360 ML/a. It is not currently operational as a water harvesting site due to PFAS contamination concerns (refer Section 4.3.1).

4.2.4 Kaurna Park

The design yield for the Kaurna Park wetlands (City of Salisbury) is 600 ML/a. It is not currently operational due to PFAS contamination concerns (refer Section 4.3.1). There is the opportunity to expand the existing system to increase yields to close to 690 ML/a.

4.2.5 Springbank Park wetlands

A new MAR scheme incorporated into the existing Springbank Park basin has the potential to yield approximately 600 ML/a. This value is based on the Urban Stormwater Harvesting Opportunities Study (W&G, 2009).

4.2.6 Smith Creek overflows

A new basin is being considered as an option to treat overflows from Smith Creek (refer Section 4.1.7). If base flows were to be diverted into the basin, harvesting opportunities could be explored. However, the basin would be a relatively short distance upstream from the NEXY harvesting basin, so it may result in less volume being harvested at that existing scheme, which has room for expansion.

4.3 Water quality

4.3.1 PFAS contamination

PFAS contamination has recently been identified within the RAAF base. Stormwater flows passing through the base are mobilising PFAS contaminants which have been detected within the downstream Kaurna Park wetlands. As a precautionary measure and to manage community expectations, the harvesting scheme at the Kaurna Park wetlands has been taken offline. This is resulting in a significant financial cost to the City of Salisbury water supply business.

Preventing PFAS contamination from getting into the Kaurna Park wetlands would allow for harvesting to recommence within the wetlands. This could only be viable if runoff from the RAAF base could be treated on-site such that it limits off-site flows. To facilitate this the diversion of the Helps Road Drain to the east of the RAAF base would be required.

4.3.2 Smith Creek overflows

If base flows were diverted into the proposed basin to deal with flooding from Smith Creek (refer Section 4.1.7), the opportunity for the creation of a wetland could allow for improvement in water quality.

4.3.3 Inline treatment along existing outfall channel

Providing inline sedimentation basins and linear wetlands, where space permits and access for maintenance is feasible.

4.3.4 Integrating WSUD into established areas

Encourage implementation of WSUD for infill development. Incorporate WSUD features, such as raingardens, into road reconstruction projects.

5 Stormwater management strategies

5.1 Flood management

The management strategies presented here are targeted towards managing flooding within the key flood prone areas described in Section 4.1. The strategies do not exhaustively address all problems across the study area, but rather are targeted at reducing the largest flooding issues affecting the community. Both structural (such as construction works or drain upgrades) and non-structural strategies are discussed.

Flood models were developed for three scenarios:

- Estimated long-term development within the catchment with 2050 climate change (9% rainfall intensity increase).
- Estimated long-term development within the catchment with 2050 climate change (9% rainfall intensity increase), including selected structural flood management strategies.
- Estimated long-term development within the catchment with 2090 climate change (17% rainfall intensity increase).

The results of the flood modelling were used to identify opportunities for structural flood mitigation strategies. The location of these strategies is shown in Figure 5.1. The improvement to the extent and severity of flood inundation was assessed for each strategy.

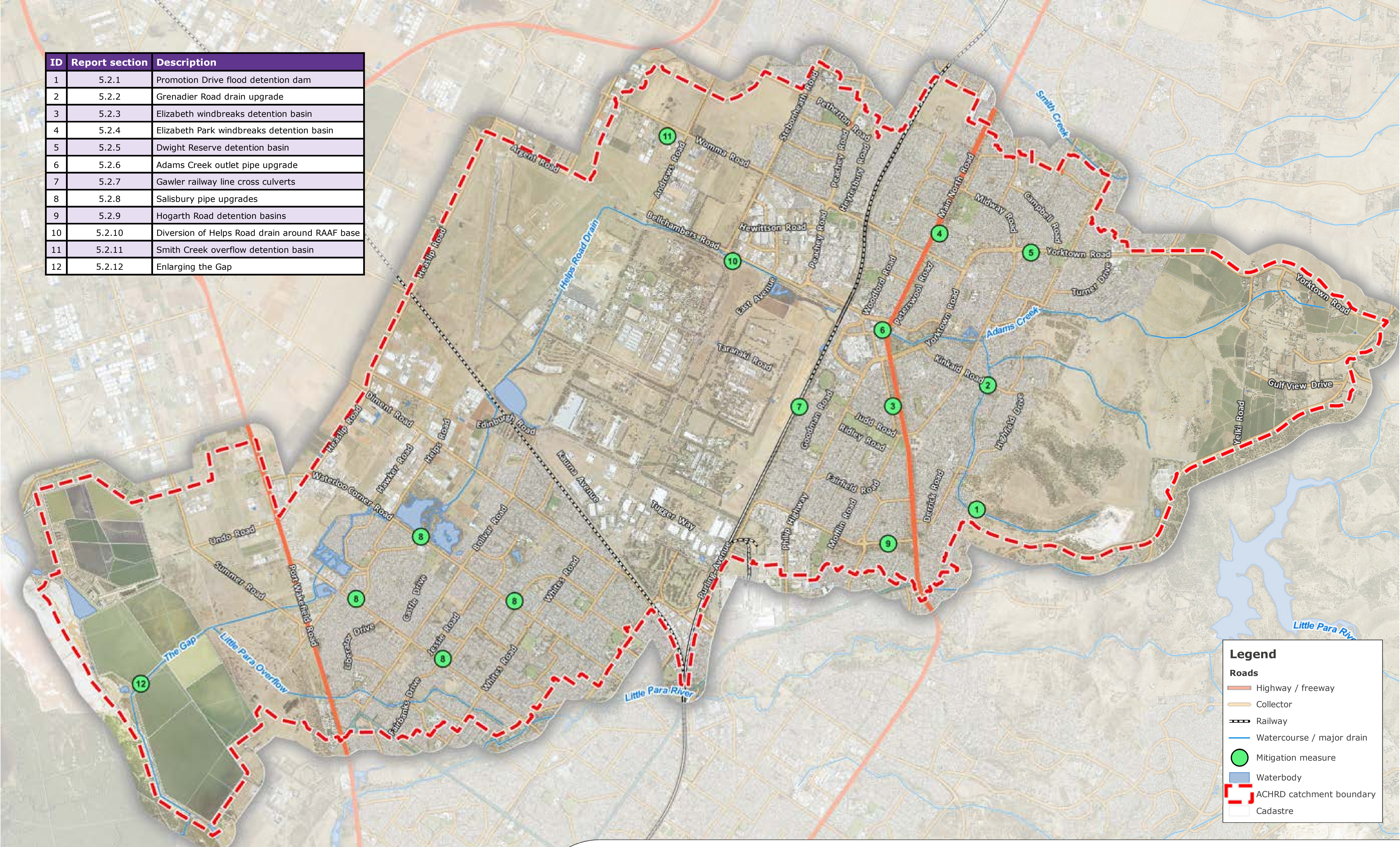
A set of maps showing the depth of inundation for all modelled scenarios is provided in Appendix D. RORB was used to estimate the runoff from the upper portion of the catchment. The hydrographs generated within RORB were then used to apply flows within the urbanised areas. As such, flood depths for the rural hills face catchments have not been calculated. This is discussed further in Appendix A.

The post-mitigation maps show the effects of implementing the structural mitigation options described within this section. Change maps showing the difference in flood depth between the pre- and post-mitigation scenarios are included.

Hazard maps are also provided, categorising the potential loss of life, injury and economic loss caused by future flood events. The hazard mapping is consistent with the flood hazard vulnerability curves derived by Smith et al. (2014). Interrogation of the flood maps for the pre-mitigation scenario was undertaken to identify the number of residential properties currently subject to inundation from flooding during a 1% AEP event. Of the approximately 24,500 rural/rural residential properties within the catchment area, 80% are free from inundation (at the cadastre centroid), while a further 19% are defined as hazard category 'H1' (safe). As such, the catchment is already exceeding the flood hazard target that 95% of residential properties are not subject to more than a low flood hazard.

For reference, Tonkin (2020) has also undertaken modelling of both the ACHRD and GEP catchments for the existing development scenario, to represent the current level of flooding across the catchments. The results of this modelling are shown in Appendix E.

ID	Report section	Description
1	5.2.1	Promotion Drive flood detention dam
2	5.2.2	Grenadier Road drain upgrade
3	5.2.3	Elizabeth windbreaks detention basin
4	5.2.4	Elizabeth Park windbreaks detention basin
5	5.2.5	Dwight Reserve detention basin
6	5.2.6	Adams Creek outlet pipe upgrade
7	5.2.7	Gawler railway line cross culverts
8	5.2.8	Salisbury pipe upgrades
9	5.2.9	Hogarth Road detention basins
10	5.2.10	Diversion of Helps Road drain around RAAF base
11	5.2.11	Smith Creek overflow detention basin
12	5.2.12	Enlarging the Gap



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Drawn: MM

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Roads and railways from DataSA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT OVERVIEW OF STRUCTURAL MITIGATION MEASURES

Figure 5.1

5.2 Structural flood management strategies

5.2.1 Promotion Drive flood detention dam

This proposed detention dam adjacent to Promotion Drive, Hillbank, is located at the most upstream point of the Grenadier Road drain, which is known to overflow in large storm events causing flood inundation of the properties to the west. The purpose of the dam is to reduce the peak 1% AEP inflow to the drain such that overtopping of the drain is avoided or minimised. The minimum capacity of the Grenadier Road drain is estimated to be 1 m^3/s at the upstream end.

The detention dam has been sited at the downstream end of the contributing rural catchment, avoiding adjacent residential areas. The dam spans across the natural valley with the storage volume defined by the existing topography.

The height-storage relationship has been optimised within the constraints of the site. The dam spans the full width of the downstream Council reserve. The dam characteristics are shown in Table 5.1, with an illustration of the dam footprint shown in Figure 5.2.

Table 5.1 Promotion Drive flood detention dam characteristics (6 hour rainfall event)

Embankment height (m)	**Storage volume** (m^3)	**Basin footprint** (m^2)	**1% AEP peak inflow** (m^3/s)	**1% AEP peak outflow** (m^3/s)
11.5	24,000	6,000	4.2	0.42

The reduction in peak flows is observed to improve flooding within the downstream catchments. Figure 5.3 shows the impact of the proposed upgrade on the 1% AEP flood extents.

During large flood events, a significant volume of water will be detained behind the embankment. Embankment failure could result in catastrophic flood damages, that could include the loss of life. Periodic inspection of these embankments is required to ensure that there is no risk of their failure during a flood event and the dam will need to have a spillway incorporated into it.

Runoff from the Boral quarry located on Black Top Road is discharged to the location of the proposed dam. The water quality of runoff from the quarry is unknown, but if it is identified that removal of sediments or nutrients is required, the dam could be used as a treatment location.

The potential for dams at the downstream end of valleys to the north was also investigated (Tonkin 2016b) but were found to be not as effective as the Promotion Drive dam in reducing downstream flood risk.

5.2.2 Grenadier Road drain upgrade

Flood flows presently spill from the Grenadier Road drain at locations of restricted capacity. One such location is at the Kinkaid Road culvert; flows spilling out of the channel at this location flow along Midway Road and Fletcher Road before reaching Main North Road. This is due to the low channel embankment upstream of the headwall at Kinkaid Road; as water builds up against the headwall, flows spill from the channel to the low-lying area to the west.

It is recommended that the height of the western embankment be raised in order to prevent flows spilling from the channel in the 1% AEP event. This is a relatively simple and cost-effective solution that will decrease flood inundation for the properties to the west (as discussed in Section 4.1.2).

Hydraulic modelling of the channel undertaken using HEC-RAS indicates that raising the western embankment by 160 mm would prevent spill in the 1% AEP event for a design flow of 5.4 m^3/s. This would raise water levels at the upstream culvert (Phelps Road) by no more than 10 mm. As such, increased flood risk to properties upstream would be very minimal.

It is proposed that the western embankment be raised by 500 mm. This includes a freeboard allowance of at least 300 mm. There is a dirt path and some trees along the bank of the channel. It is likely that the path will be raised with the batters matching into the channel. The trees would need to be assessed to determine if they would be impacted by the filling. The freeboard could be sacrificed should the full 500 mm not be available.

The concept design is shown in Figure 5.4. The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.5.

5.2.3 Elizabeth windbreaks detention basin

The 'windbreaks' are open reserve areas along Main North Road from Elizabeth Grove to Elizabeth Downs. In some areas, floodwaters are ponding along the windbreak reserves prior to spilling across Main North Road. The proposed Elizabeth windbreaks detention basin is located within the alignment of a relatively large overland flood flow path, in the vicinity of Donhead Street and Short Road, with the intention of reducing flooding to the west.

The basin has been designed to make use of the available space between the proposed commercial and residential buildings as shown on the Draft Playford Gateway Concept Designs Sub-Precinct C3 (Jensen Plus, 2017). The approximate proposed development boundary is shown on the concept design in Figure 5.6.

The size of the basin was constrained by the area available and the natural fall of the land. The basin has been designed to intercept surface flood flows generated by catchment to the north-east that spill over Main North Road. The underground drainage system has not been redirected into the basin.

The basin characteristics are summarised in Table 5.2. The basin comprises two ponds within land located between the future Playford Gateway development. The ponds are joined by a channel and are therefore acting as a single basin. The outlet is located in the northern pond, connecting to the existing underground pipe network in Short Road via a 600 mm diameter pipe.

Table 5.2 Elizabeth windbreaks detention basin characteristics (6 hour rainfall event)

Basin depth (m)	**Storage volume** (m^3)	**Basin footprint** (m^2)	**1% AEP peak inflow** (m^3/s)	**1% AEP peak outflow** (m^3/s)
1.6	19,000	16,000	3.7	1.6

The basin is to be located in a public reserve area. The basin is designed to intercept surface flood flows only. As such, the basin will become inundated during large storm events only and hence could continue to be used as public open space. A gentle batter slope of 1V:5H would allow public access and maintenance.

Consideration was given to construction of a basin within the vacant land on the upstream (eastern) side of Main North Road to intercept flows before they pass over the road. However, there are currently no plans for development of this land, and hence removal of a significant amount of vegetation would be required, in addition to the vegetation removals associated with the proposed development on the western side of the road. Incorporating construction of the basin as part of the development to the west of Main North Road minimises the additional disturbance required. Review of the flood hazard maps has been undertaken to assess the hazard of flood flows passing across Main North Road. The maps show that the hazard within both carriageways is low.

The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.7.

5.2.4 Elizabeth Park windbreaks detention basin

Similarly to that described in Section 5.2.3, surface floodwaters are also ponding at the windbreaks near Tolmer Road, Elizabeth Park. It is proposed to construct a detention basin at this location to intercept surface flood flows. Two basins (either side of Tolmer Road) were originally considered, however, so as not to preclude the high-density development anticipated within the area, it was decided to proceed with a single basin to the north of Tolmer Road.

The size of the basin was constrained by the area available and the natural fall of the land. The basin has been designed to intercept surface flood flows arriving from the north-east. In addition, it is recommend that base flows passing along the open channel to the north are diverted into the basin where it can be collected and transferred, via a pump, to the Council's existing storage and pump facility at Yorktown Road.

The peak inflow to the basin varies depending whether the upstream Dwight Reserve detention basin (refer Section 5.2.5) is implemented. The flow rates and volumes for each scenario are provided in Table 5.3.

Table 5.3 Elizabeth Park windbreaks detention basin inflows and volumes (1 hour rainfall event)

Scenario	1% AEP peak inflow (m^3/s)	1% AEP volume (m^3)
Without Dwight basin	5.9	19,600
With Dwight basin	4.1	17,800

The volume of flow into the windbreaks detention basin is reduced by approximately 10% if the upstream Dwight Reserve detention basin is constructed. The floodplain mapping has been undertaken assuming that the Dwight Reserve basin will be constructed. For the purpose of ensuring that a sufficient storage volume is provided in the Elizabeth Park basin, the basin has been sized for the scenario without the Dwight Reserve basin.

The basin characteristics are summarised in Table 5.4 with the concept design shown in Figure 5.8. The outlet of the basin would connect to the underground drainage network in Main North Road via a 1200 mm diameter pipe.

Table 5.4 Elizabeth Park windbreaks basin characteristics (3 hour rainfall event)

Embankment height (m)	Storage volume (m^3)	Basin footprint (m^2)	1% AEP peak inflow (m^3/s)	1% AEP peak outflow (m^3/s)
1.8	19,500	13,000	4.6	3.0

The basin is to be located in a public reserve area. The basin is designed to intercept surface flood flows only. As such, the basin will become inundated during large storm events only and hence could continue to be used as public open space. A gentle batter slope of 1V:5H would allow public access and maintenance.

Tree removals would be required as part of basin excavation works. It is recommended that the trees be assessed for health and significance to determine which trees could remain if development allows.

The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.9. The basin also demonstrates improvements to flooding downstream in Elizabeth West, as described in Section 4.1.5.

5.2.5 Dwight Reserve detention basins

There is an opportunity to intercept both surface flood flows and underground drainage pipes within Dwight Reserve, adjacent to Yorktown Road, Elizabeth Downs. The land is narrow and steep which limits the excavation and hence storage volume potential. Given this constraint, three separate basins are proposed, as follows:

- Basin 1 In Dwight Reserve adjacent to Litton Street and Yorktown Road
- Basin 2 Adjacent to Marshalsea Road and Yorktown Road
- Basin 3 Intersection of Yorktown Road and Midway Road.

Basins 1 and 2 would require substantial cut and filling due to the steepness of the sites, as shown in the concept design (Figure 5.10). The basins have been sized to achieve the maximum volume possible within the constraints of the site. The basins have been modelled in DRAINS to estimate the outlet pipe size such that the basins do not overtop in the 1% AEP event (2050 scenario).

Basin 3 is an embankment around the intersection of Yorktown and Midway Roads that will intercept surface flows only. The height of the embankment is the maximum that can be achieved within the constraints of the site.

The characteristics of each basin are summarised in Table 5.5.

Table 5.5 Dwight Reserve basin characteristics

Name	**Embankment height** (m)	**Storage volume** (m^3)	**Basin footprint** (m^2)	**1% AEP peak inflow** (m^3/s)	**1% AEP peak outflow** (m^3/s)
Dwight basin 1	3.6	14,000	8,500	3.3	2.2
Dwight basin 2	1.7	3,500	4,500	0.67	0.26
Dwight basin 3	1.5	4,000	8,500	1.3	0.15

Each basin is located within public open space. Basins 1 and 2 are designed to intercept underground drainage flows, which means that the reserve may become inundated during minor rainfall events; this limits the availability of the space for public use. Basin 3 is designed to intercept surface flood flows only. As such, the basin will become inundated during large storm events only and hence could continue to be used as public open space.

Due to the basin footprints a number of established trees will require removal.

The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.11. If constructed, the basins would also reduce the required size for the Elizabeth Park windbreaks detention basin, as discussed in Section 5.2.4.

5.2.6 Adams Creek outlet pipe upgrade

Elizabeth City Centre is situated in a low-lying area and is subjected to flooding primarily from overflows of Adams Creek at Main North Road (as described in Section 4.1.3). Adams Creek ends at Main North Road (in Fremont Park) and is conveyed underground via twin 1200 mm diameter pipes. These pipes increase in size progressively downstream and eventually outfall into the Helps Road Drain via 5 x 1350 mm diameter pipes.

An assessment of the TUFLOW model shows that approximately 12.4 m^3/s is approaching Main North Road in Adams Creek in the 1% AEP event, of which 8.8 m^3/s is passing through the twin 1200 mm diameter pipes. An additional pipe from Main North Road to the Helps Road Drain to supplement the existing drainage network would likely prevent much of this spill from occurring and hence reduce flooding of the Elizabeth City Centre.

The total length of pipe required is in the order of 700 m, running parallel to the existing system, with pipe diameters ranging from 1200 mm to 1500 mm. In addition to being a costly exercise, several construction issues have been identified, including:

- Services within the road
- Passing the Magistrates Court, Police Station and other buildings
- Crossing Main North Road
- Potential for easement acquisition.

The concept design is shown in Figure 5.12 while the impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.13.

5.2.7 Gawler railway line cross culverts

The section of the Gawler railway line extending south from Winterslow Road, Edinburgh for an approximate distance of 1.5 km is impeding the flow of flood waters. This is largely due to there being inadequate provision of culvert crossings in addition to the flat gradient along the railway line, and is causing pooling at the railway line and flood inundation of surrounding properties in major storm events.

The most severe area of flood inundation occurs near Ridley Road (as described in Section 4.1.1). The provision of culvert crossings beneath the railway line at this location would allow surface flows to be conveyed to the western side of the railway line, ideally to the Edinburgh Parks North detention basin.

An estimate of the 1% AEP flood flows reaching the railway line was obtained from the existing TUFLOW model (Tonkin, 2016c). The culvert size was calculated assuming inlet control with the outcomes as follows:

- Design flow 7 m^3/s
- Headwater depth 1100 mm
- Culvert span 2100 mm
- Culvert height 750 mm
- Number of culverts 3

The concept design in Figure 5.14 shows three cross culverts distributed along the length of the railway line. The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.15.

5.2.8 Salisbury pipe upgrades

Surface flooding is observed for all modelled events within the City of Salisbury residential area. An extensive underground drainage network services the area, including two major outfall drains along Waterloo Corner Road and Burton Road. These drains discharge flows to the Kaurna Park and Burton Road wetlands, respectively.

In order to alleviate the flooding within the area, it is proposed that an additional pipe be added to each of these drainage runs. Details of the proposed upgrades are included in Table 5.6.

Table 5.6 Salisbury pipe upgrade details

Location	Parallel pipe size (mm)	Length (m)
Waterloo Corner Road (between Whites Road and Bolivar Road)	1200	1160
Waterloo Corner Road (between Bolivar Road and Helps Road)	1650	1150
Burton Road (between Lyndon Road and Neil Street)	1050	1250

Location	Parallel pipe size (mm)	Length (m)
Burton Road (between Neil Street and Deuter Road)	1200	505

The additional pipes will assist with the flooding described in Section 4.1.8. The concept design of the pipe upgrades is shown in Figure 5.16 while the impact of the works on the 1% AEP flood extents is shown in Figure 5.17.

5.2.9 Hogarth Road detention basins

There is an opportunity to intercept both surface flood flows and underground drainage flows within the vacant reserves on Hogarth Road. Two separate basins are proposed, as follows:

- Basin 1 An embankment around the intersection of Hogarth Road and Guerin Road
- Basin 2 An embankment around the intersection of Hogarth Road and Haydown Road

The characteristics of each basin are summarised in Table 5.7. The size of the basins is constrained by the area available and the natural fall of the land, as shown in the concept design (Figure 5.18).

Table 5.7 Hogarth Road basin characteristics

Name	Embankment height (m)	Storage volume (m^3)	Basin footprint (m^2)	1% AEP peak outflow (m^3/s)
Hogarth basin 1	1.0	11,200	15,700	0.94
Hogarth basin 2	2.0	4,750	14,000	0.29

Basin 1 will intercept surface flood flows spilling over Main North Road from the east. A new inlet at the north-western corner of Basin 1 is proposed, allowing the flows captured by the basin to be directed to the existing underground drainage network (600 mm diameter pipe).

A similar configuration is recommended for Basin 2, however in addition to capturing surface flows from the south and east, pipe flows will also be restricted. It is proposed to reduce the diameter of the existing pipes (525 mm and 900 mm, respectively) to 300 mm. A new pit at the junction of these pipes will allow flows to surcharge to the surface and be detained by the basin. A second pit at the north-western corner of the basin will allow the surface flows to be directed underground where they will be conveyed by the existing 525 mm drainage network to the north.

Each basin is located within public open space. Basin 1 is designed to intercept surface flood flows only. As such, the basin will become inundated during large storm events only and hence could continue to be used as public open space. Basin 2 is designed to intercept underground drainage flows, which means that the reserve may become inundated during minor rainfall events; this limits the availability of the space for public use.

Due to the basin footprints a number of established trees will require removal.

The impact of the proposed upgrade on the 1% AEP flood extents is shown in Figure 5.19. The reduction in flood depths due to construction of these basins is widespread throughout Elizabeth Grove and Elizabeth South, and contributes improvements to the flooding adjacent to the railway line described in Section 4.1.1.

5.2.10 Diversion of Helps Road Drain around RAAF base

A high-level investigation of options for diverting the Helps Road Drain to the east of the RAAF base has been undertaken. This has been driven by the PFAS contamination within the RAAF base. Rerouting the drain to avoid the extents of contamination will likely result in altered patterns of flood inundation for the site; improvements to the flooding described in Section 4.1.6 could be expected.

The Helps Road Drain grades towards the west. Based on an assessment of levels, the lowest downstream section of the Helps Road channel that could be diverted to the east of the RAAF base is where the channel invert is at a level of approximately 19.0 mAHD, approximately 300 m to the west of Stebonheath Road (refer Figure 5.20). However, there is still a relatively large area north of the RAAF base that cannot be diverted as the invert level of the Helps Road Drain is too low.

The downstream end of the diversion can connect into the large east-west channel that runs parallel with Edinburgh Road (the Kaufmann Canal) at an invert level of approximately 17 mAHD. Based on HEC-RAS modelling, this channel appears to be large enough to take the 1% AEP flow from its own catchment and the Helps Road Drain in the section to the west of West Avenue.

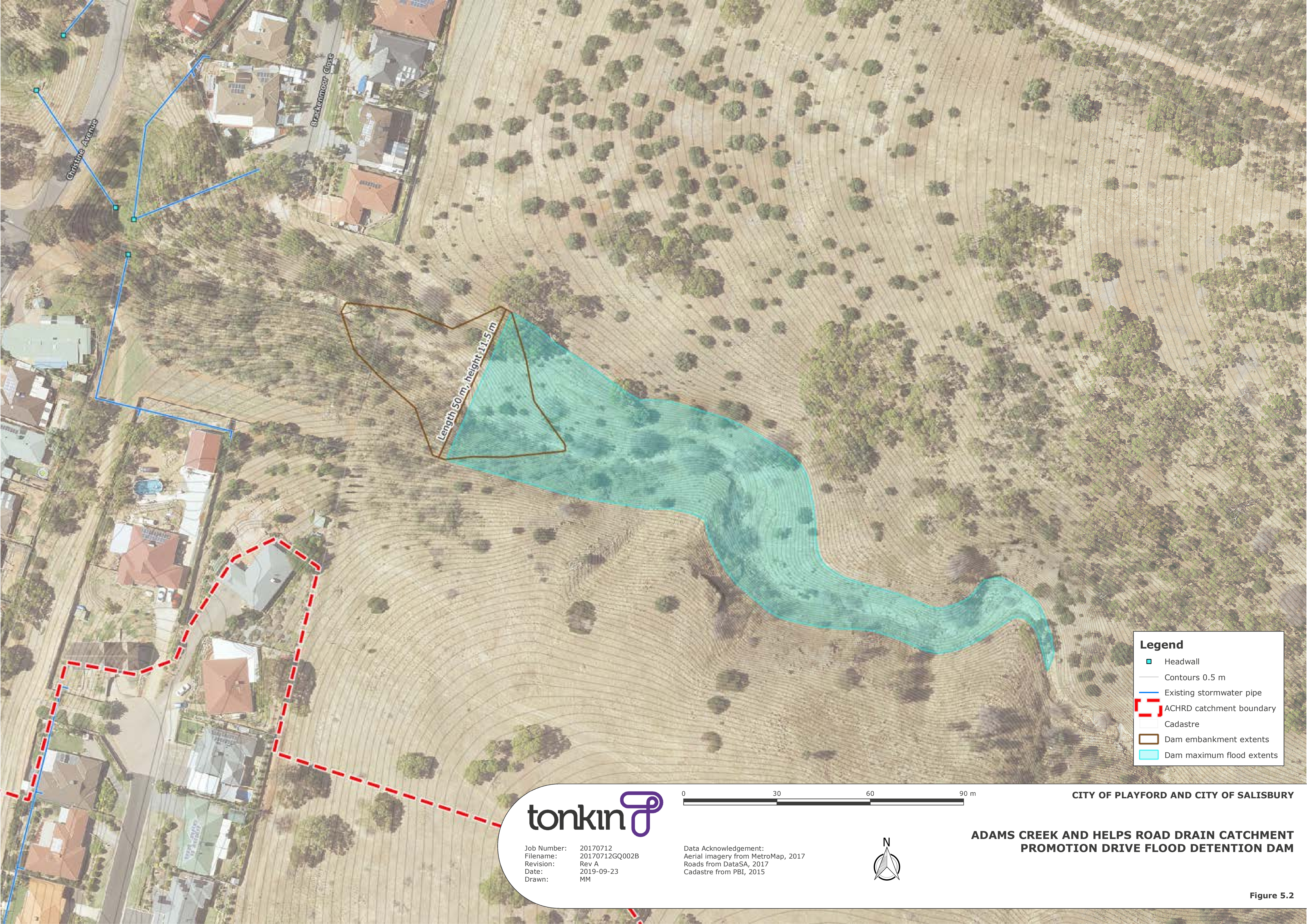
Two potential drain alignments have been investigated, as shown in Figure 5.20. The 'western alignment' runs along the boundary of the RAAF base. The 'eastern alignment' runs in relatively close proximity to the rail corridor. Both alignments pass through land owned by DST. Consideration should be given to the management of any contamination issues (other than PFAS) that may be present within these parcels of land.

A comparison of the two alignments is provided in Table 5.8. Results of the TUFLOW modelling indicate that the drain will need to have capacity to convey flows in the order of 25 m^3/s if it is to have a 1% AEP standard. It has been assumed that the channels are grass lined with 1 in 4 batter slopes and longitudinal grades in the order of 0.05% (1 m fall per 2,000 m). The western alignment requires significantly less excavation and would therefore be the more viable route.

The possibility of piping flows within the existing channel alignment has also been investigated. Such an option would allow upstream flows to be kept separate from flows generated within the RAAF base. The number of pipes required would be in the order of ten 1,650 mm diameter pipes or six 2.4 m wide by 1.5 m high box culverts. A bank of drains this large would essentially occupy the entire width of the existing open channel and therefore construction of a new open channel to serve the RAAF base would be required. The cost of the drains or culverts (over a length of approximately 2.9 km) is estimated to be in the vicinity of $35 million. Based on cost alone, enclosing the Helps Road Drain to isolate the RAAF water from the upstream flows is not considered to be a viable alternative.

Table 5.8 Comparison of channel alignments

	Western alignment	Eastern alignment
Average depth (m)	3.5	6.0
Maximum depth (m)	7	12
Excavation volume (m^3)	300,000	1,600,000
Average channel width (m)	40	70
Maximum channel width (m)	70	120
Number of culvert crossings	4	2



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Data Acknowledgement:
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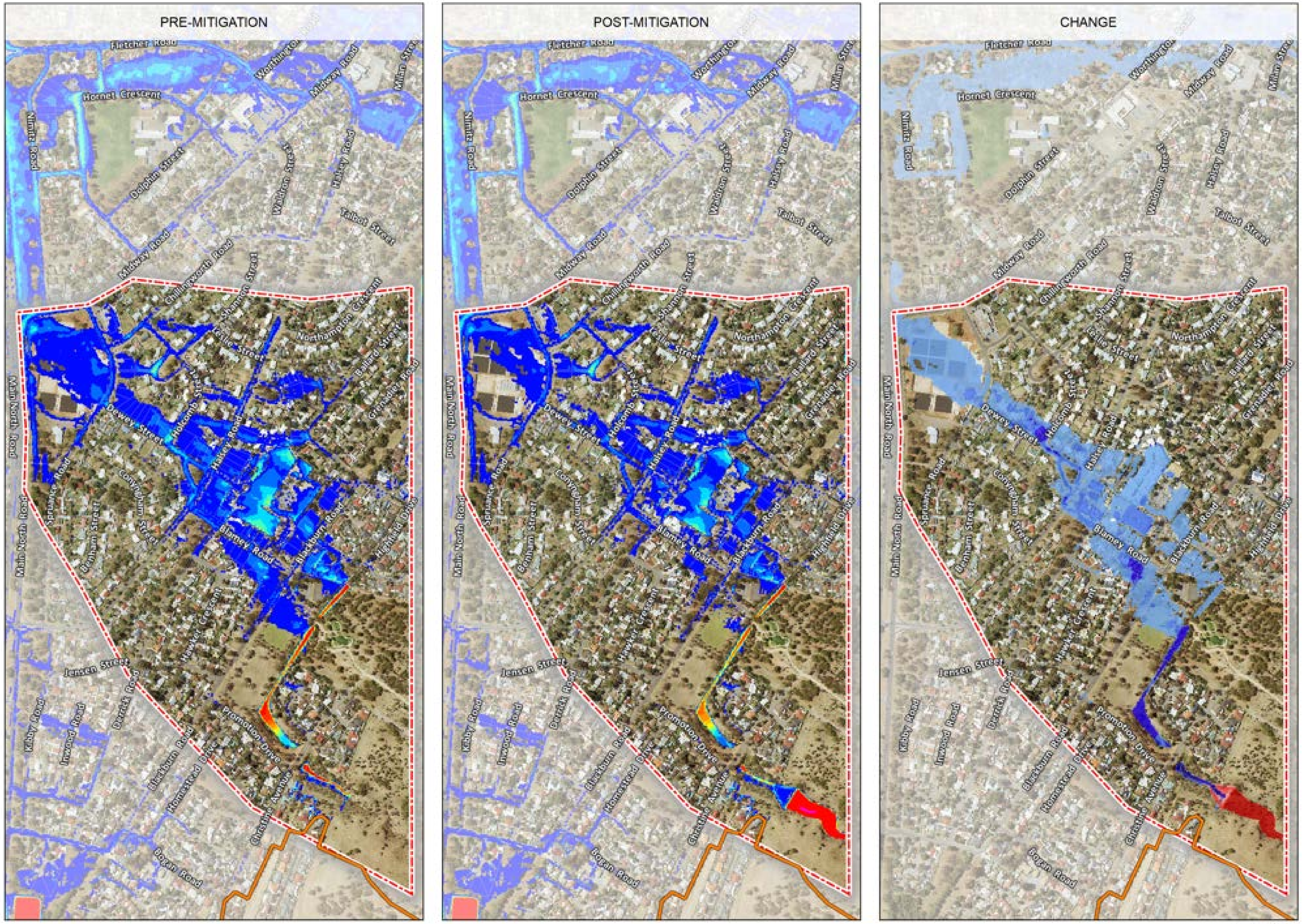
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
PROMOTION DRIVE FLOOD DETENTION DAM

Figure 5.2



Legend

ACHRD flood zones

- Flood zone
- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm (not shown)
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 250 500 750 m

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Cadastre from PBI, 2015

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
PROMOTION DRIVE FLOOD DETENTION DAM
1% AEP CHANGE MAP

Figure 5.3

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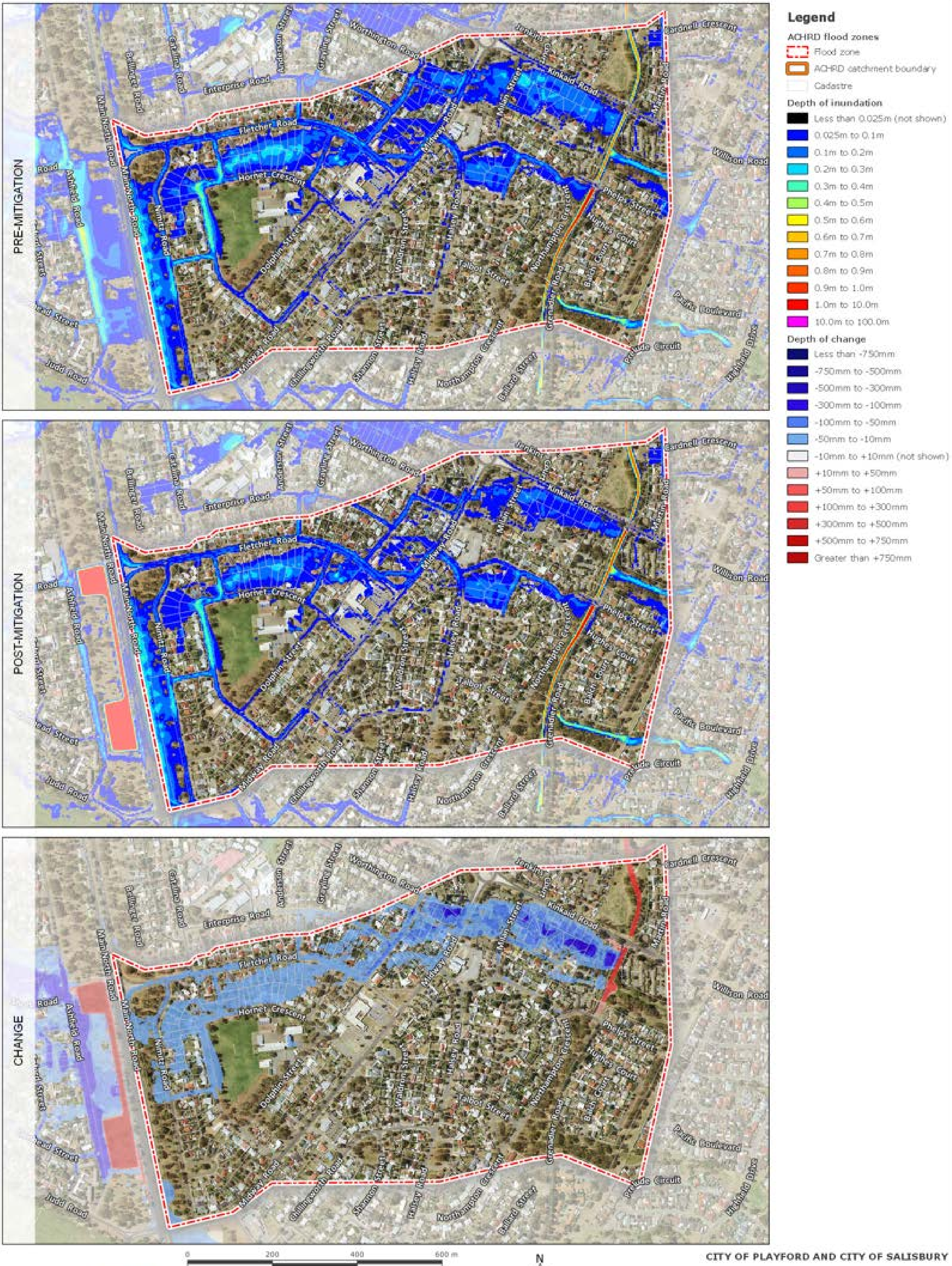
CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
GRENADIER ROAD DRAIN UPGRADE

Figure 5.4



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ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
GRENADIER ROAD DRAIN
1% AEP CHANGE MAP

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Figure 5.5

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ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ELIZABETH WINDBREAKS DETENTION BASIN

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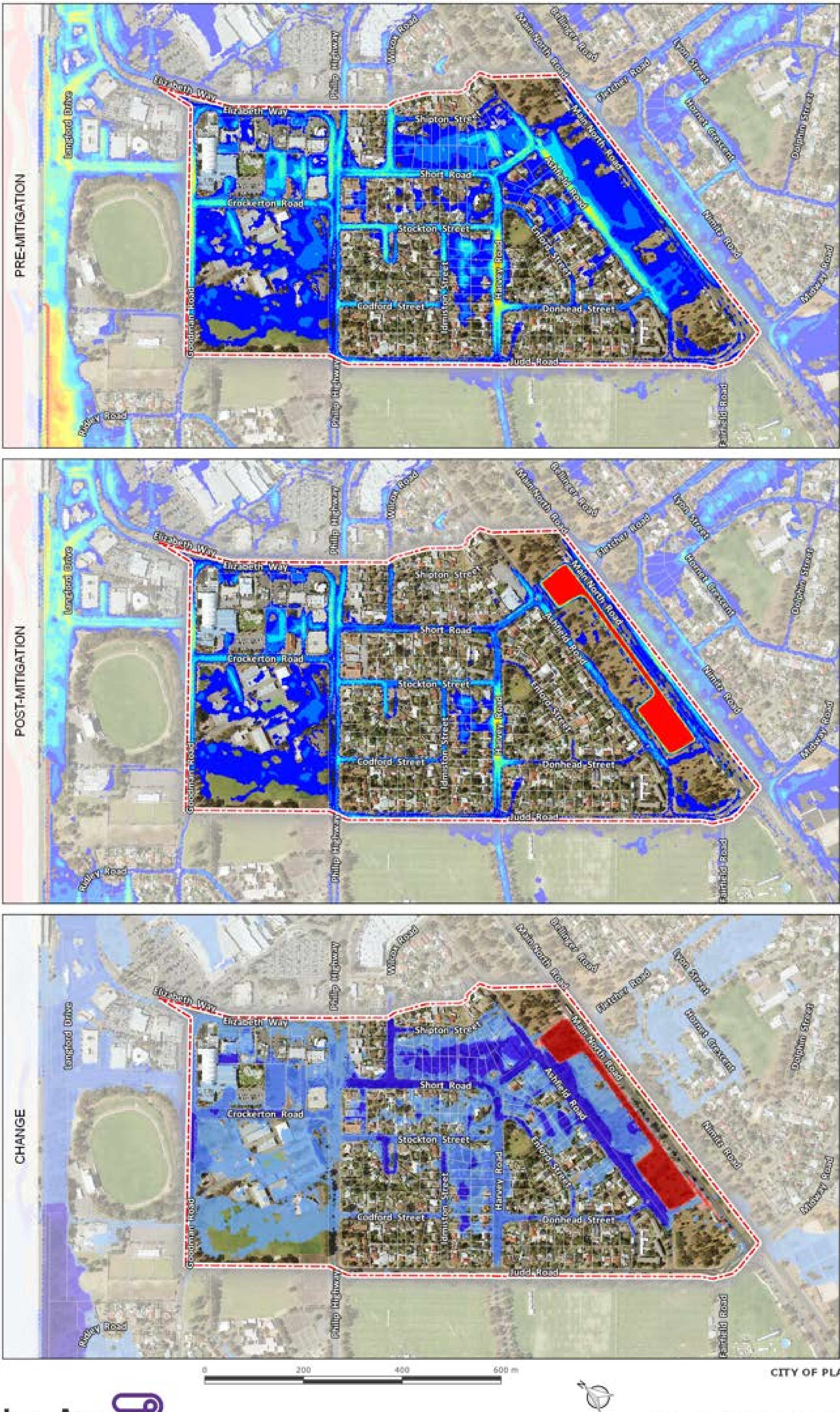
Figure 5.6



Legend

ACHRD flood zones

- Flood zone
- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm (not shown)
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

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Date:	2020-04-06
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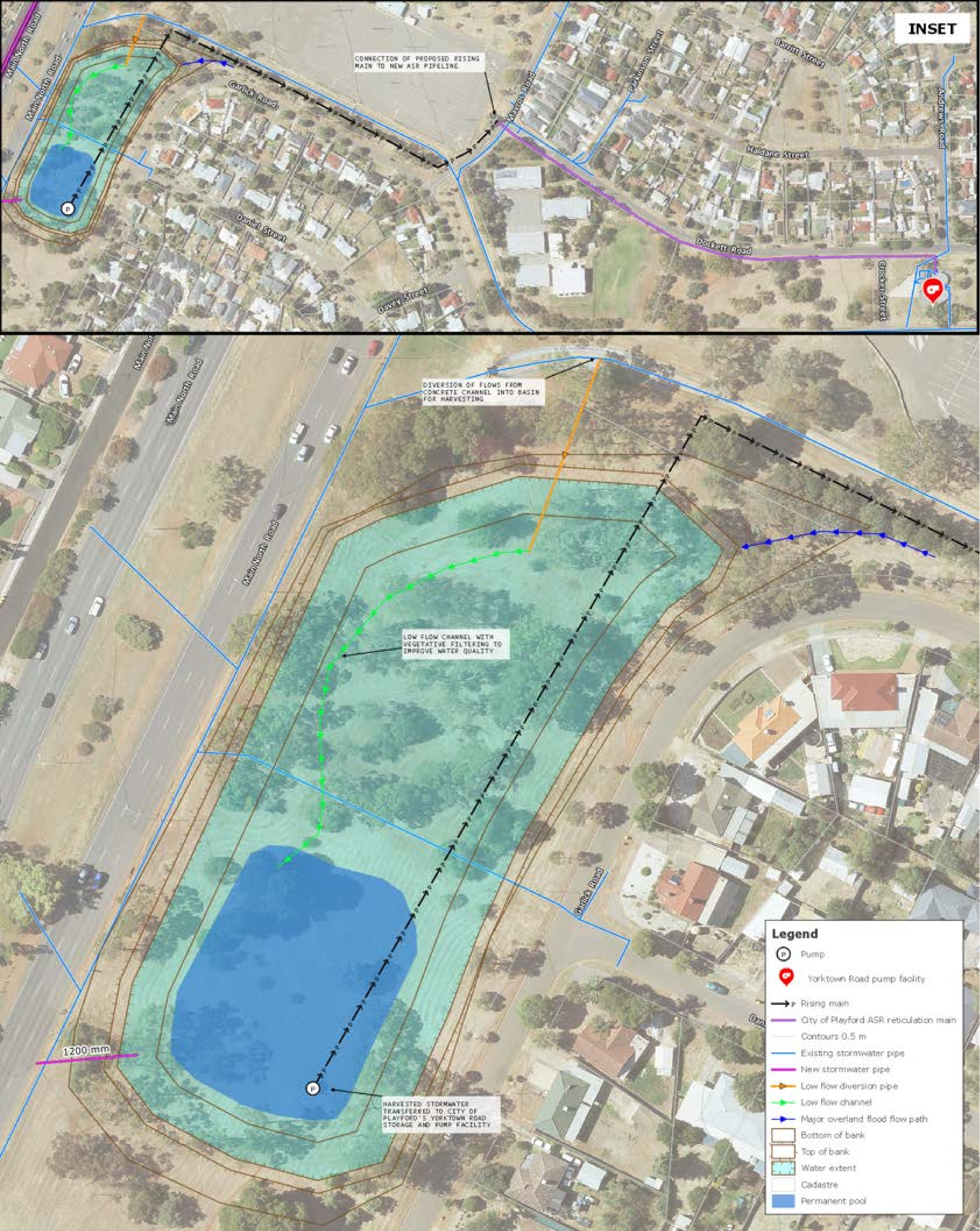
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ELIZABETH WINDBREAKS DETENTION BASIN
1% AEP CHANGE MAP

Figure 5.7



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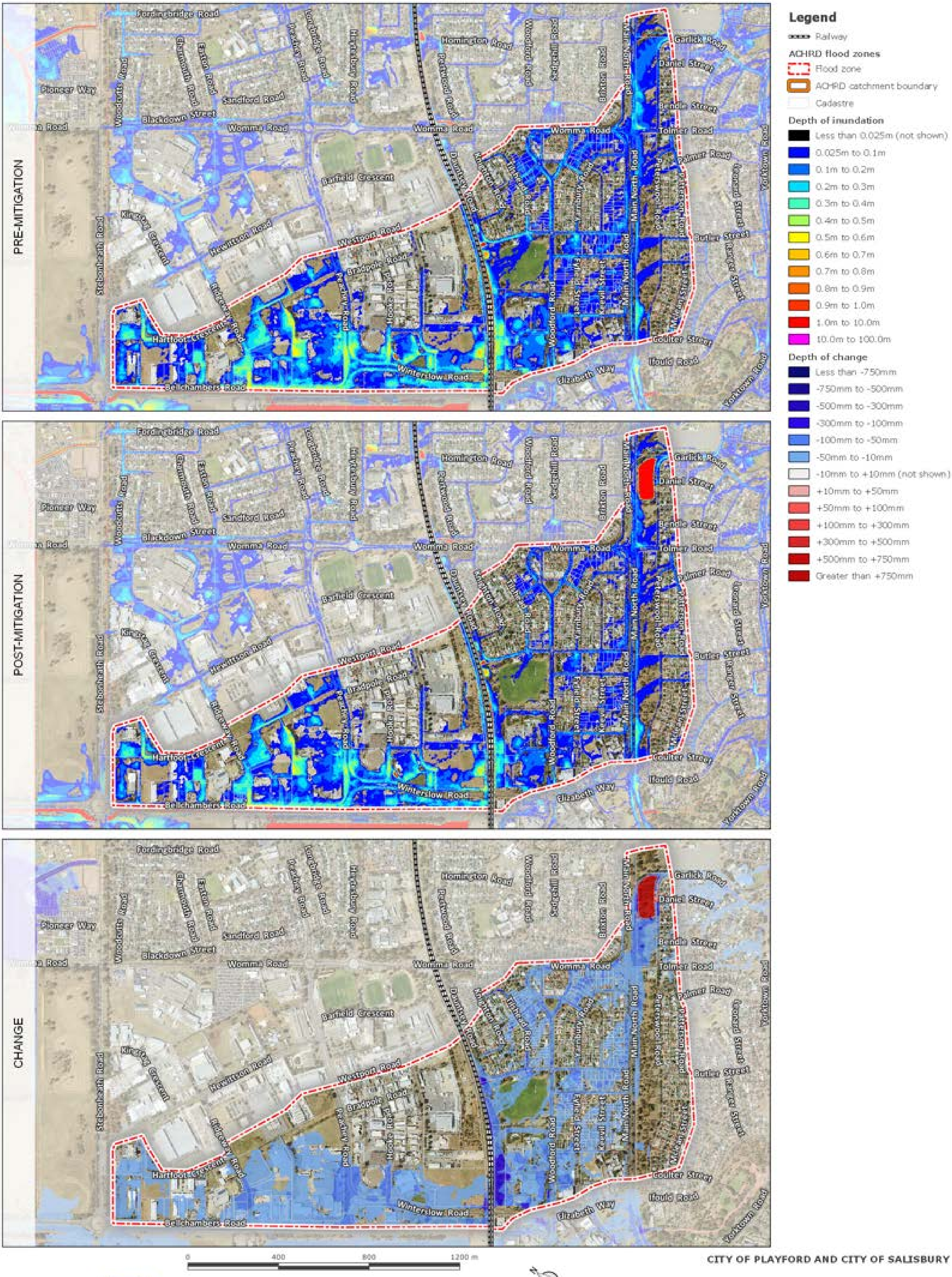
CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ELIZABETH PARK WINDBREAKS BASIN

Figure 5.8



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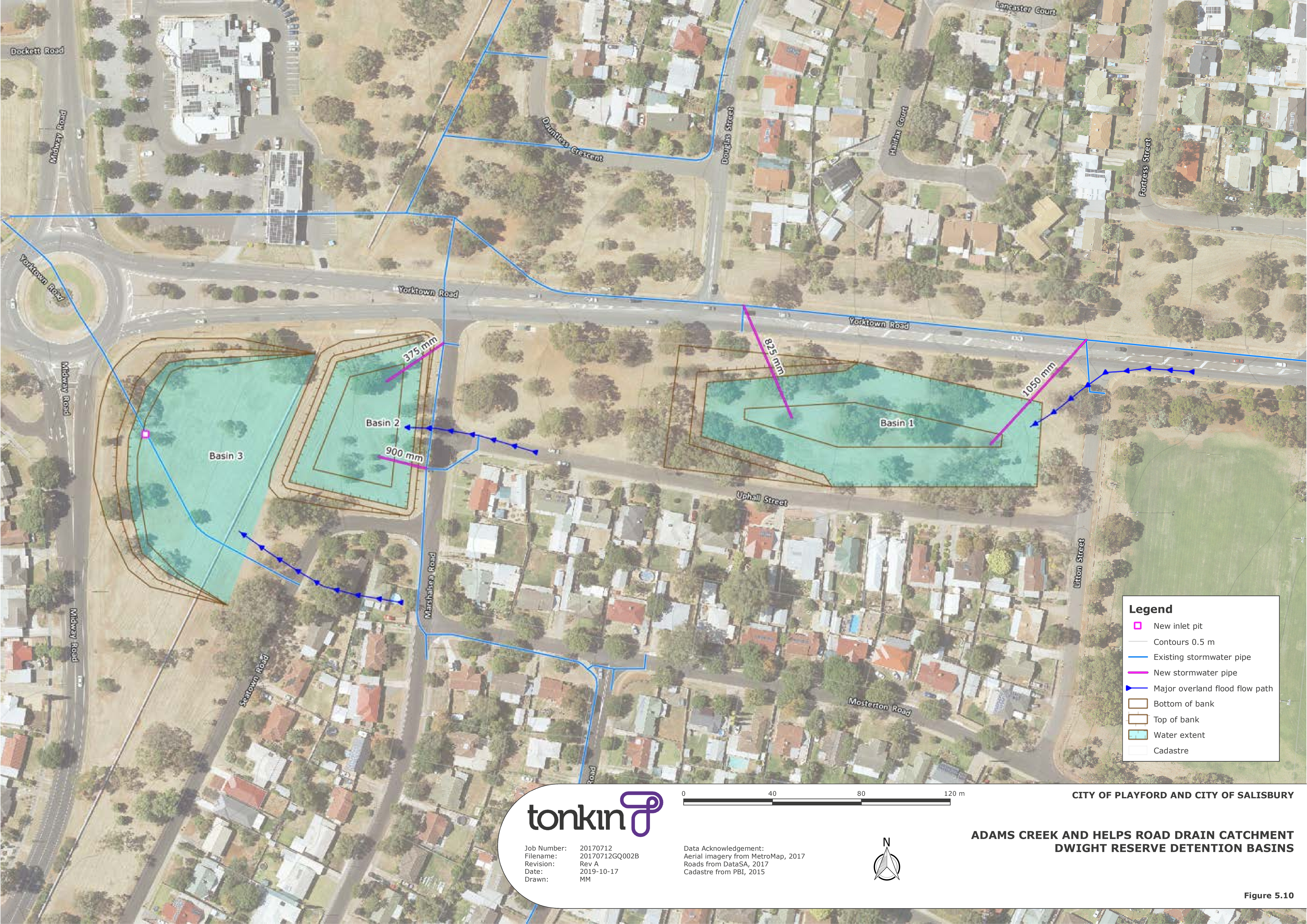
ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ELIZABETH PARK WINDBREAKS DETENTION BASIN
1% AEP CHANGE MAP

Figure 5.9



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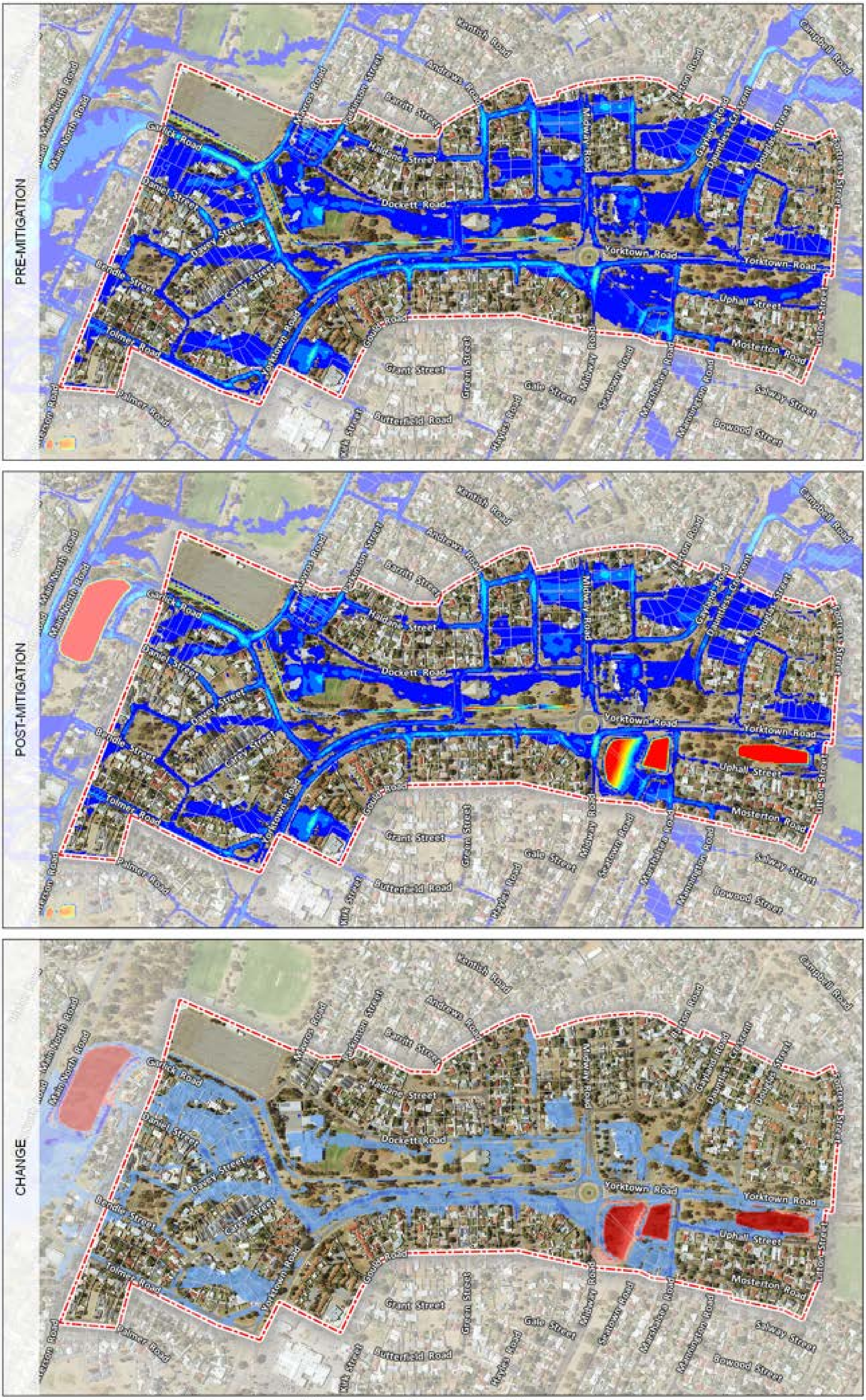
CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
DWIGHT RESERVE DETENTION BASINS

Figure 5.10



Legend

ACHRD flood zones

- Flood zone
- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm (not shown)
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 200 400 600 m

N

tonkin

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Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PB1, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
DWIGHT RESERVE DETENTION BASIN
1% AEP CHANGE MAP

Figure 5.11

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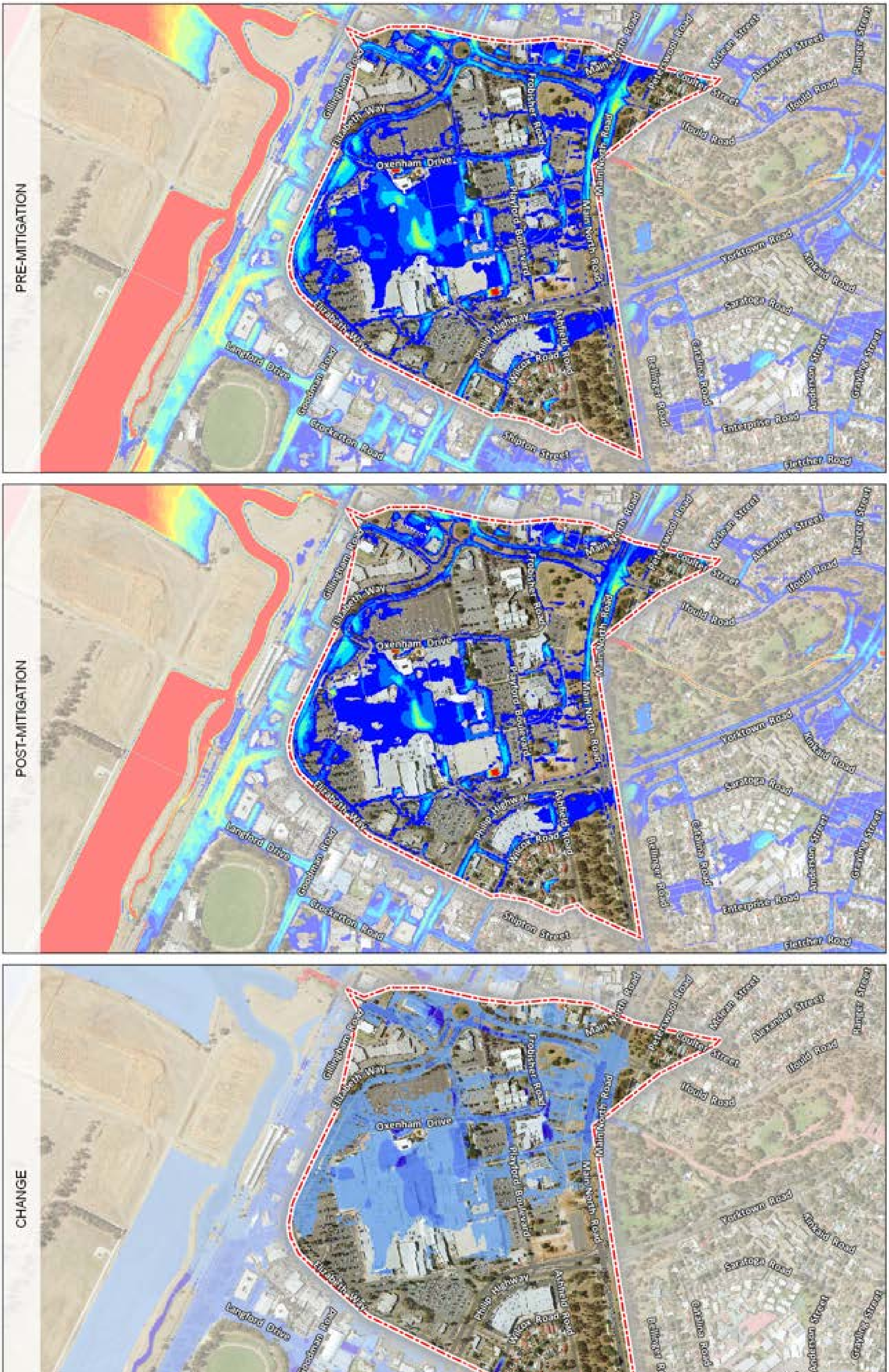
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ADAMS CREEK OUTLET PIPE UPGRADE

Figure 5.12



Legend

ACHRD flood zones

- Flood zone
- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm (not shown)
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 200 400 600 m

N

tonkin

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Cadastre from PB1, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
ADAMS CREEK OUTLET PIPE UPGRADE
1% AEP CHANGE MAP

Figure 5.13

tonkin

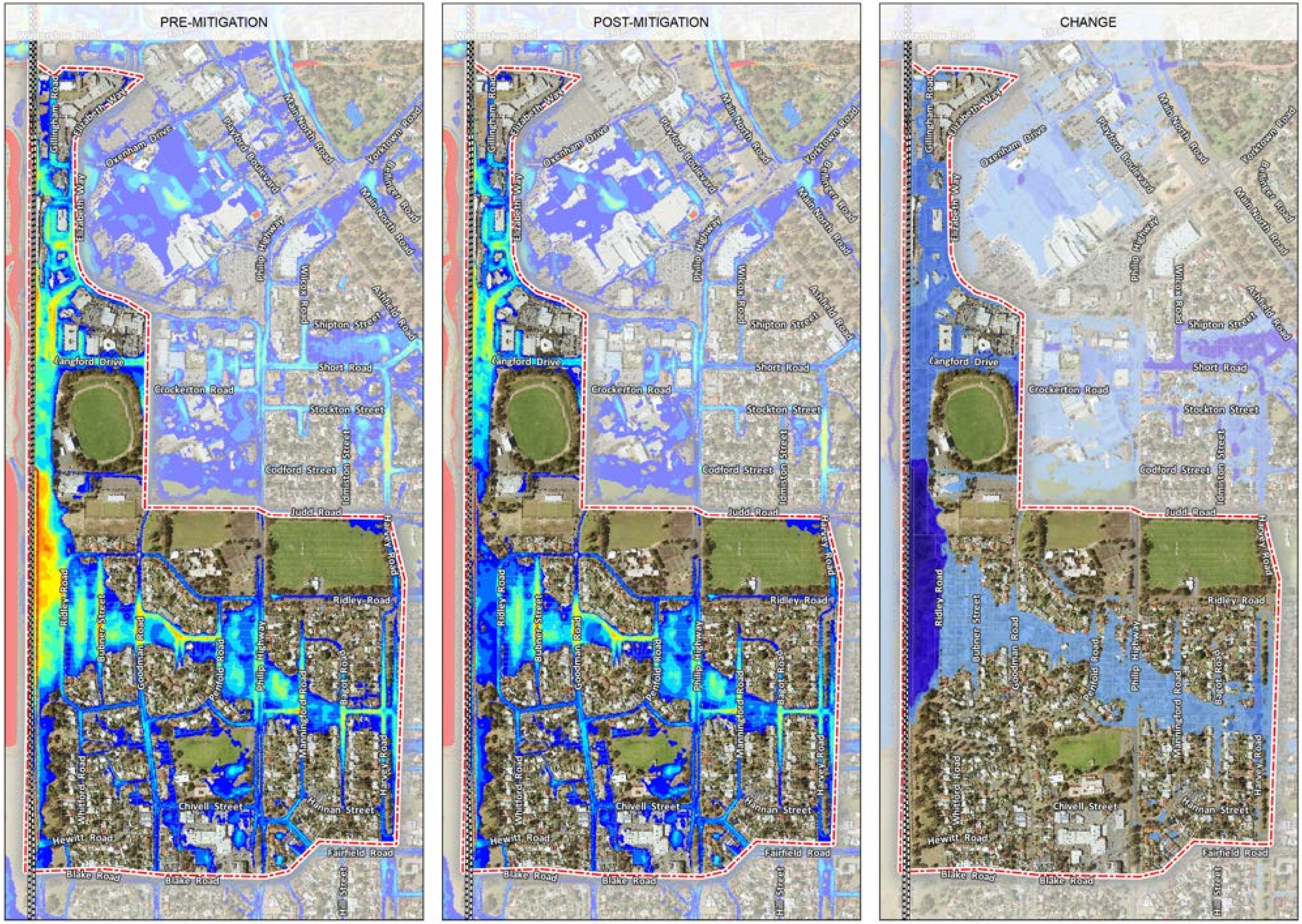
Job Number: 20170712
Filename: 20170712GQ002B
Revision: Rev A
Date: 2019-09-18
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
GAWLER RAILWAY LINE CROSS CULVERTS

Figure 5.14



Legend

- Railway

ACHRD flood zones

- Flood zone
- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm (not shown)
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

tonkin

Job Number:	20170712
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Revision:	Rev B
Date:	2020-04-06
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
GAWLER RAILWAY LINE CROSS CULVERTS
1% AEP CHANGE MAP

Figure 5.15

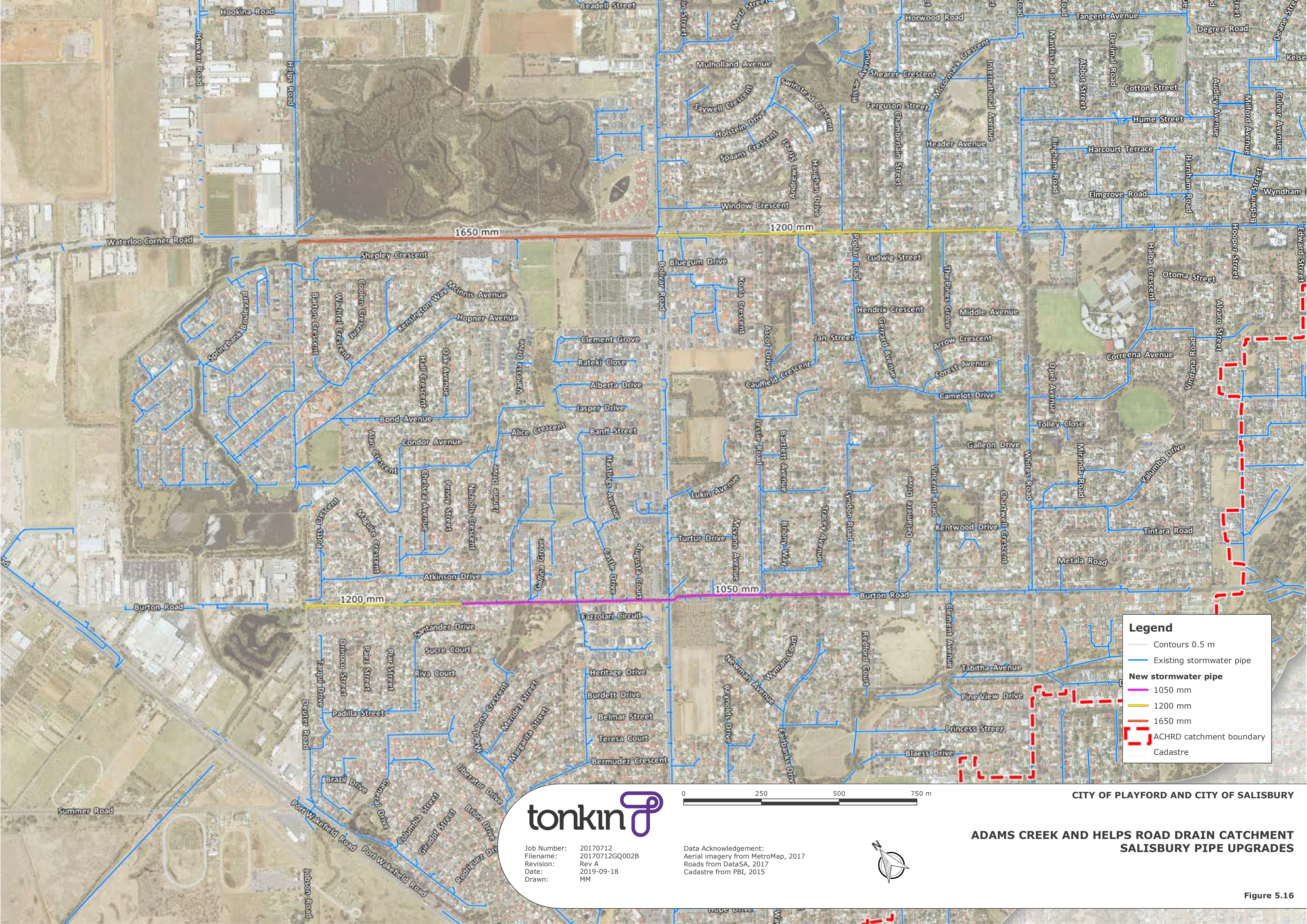
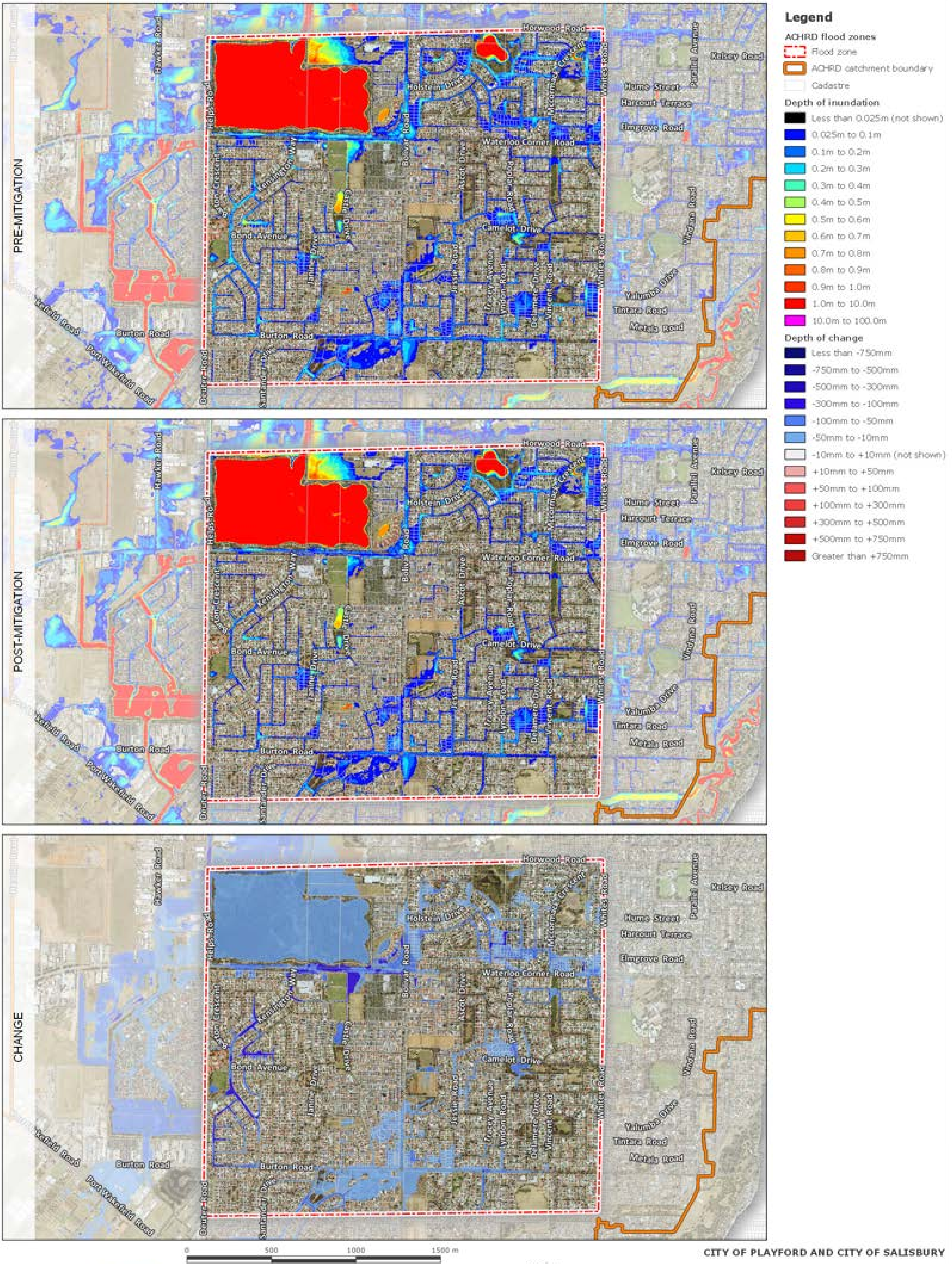

1650 mm
1200 mm
1050 mm
1200 mm
Legend
Contours 0.5 m
Existing stormwater pipe
New stormwater pipe
1050 mm
1200 mm
1650 mm
ACHRD catchment boundary
Cadastre
0 250 500 750 m
tonkin
Job Number: 20170712
Filename: 20170712GQ002B
Revision: Rev A
Date: 2019-09-18
Drawn: MM
Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015
CITY OF PLAYFORD AND CITY OF SALISBURY
ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
SALISBURY PIPE UPGRADES

Figure 5.16



CITY OF PLAYFORD AND CITY OF SALISBURY

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Job Number:	20170712
Filename:	20170712GQ003A
Revision:	Rev B
Date:	2020-04-06
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
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Cadastre from PBI, 2015

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
SALISBURY PIPE UPGRADES
1% AEP CHANGE MAP

Figure 5.17

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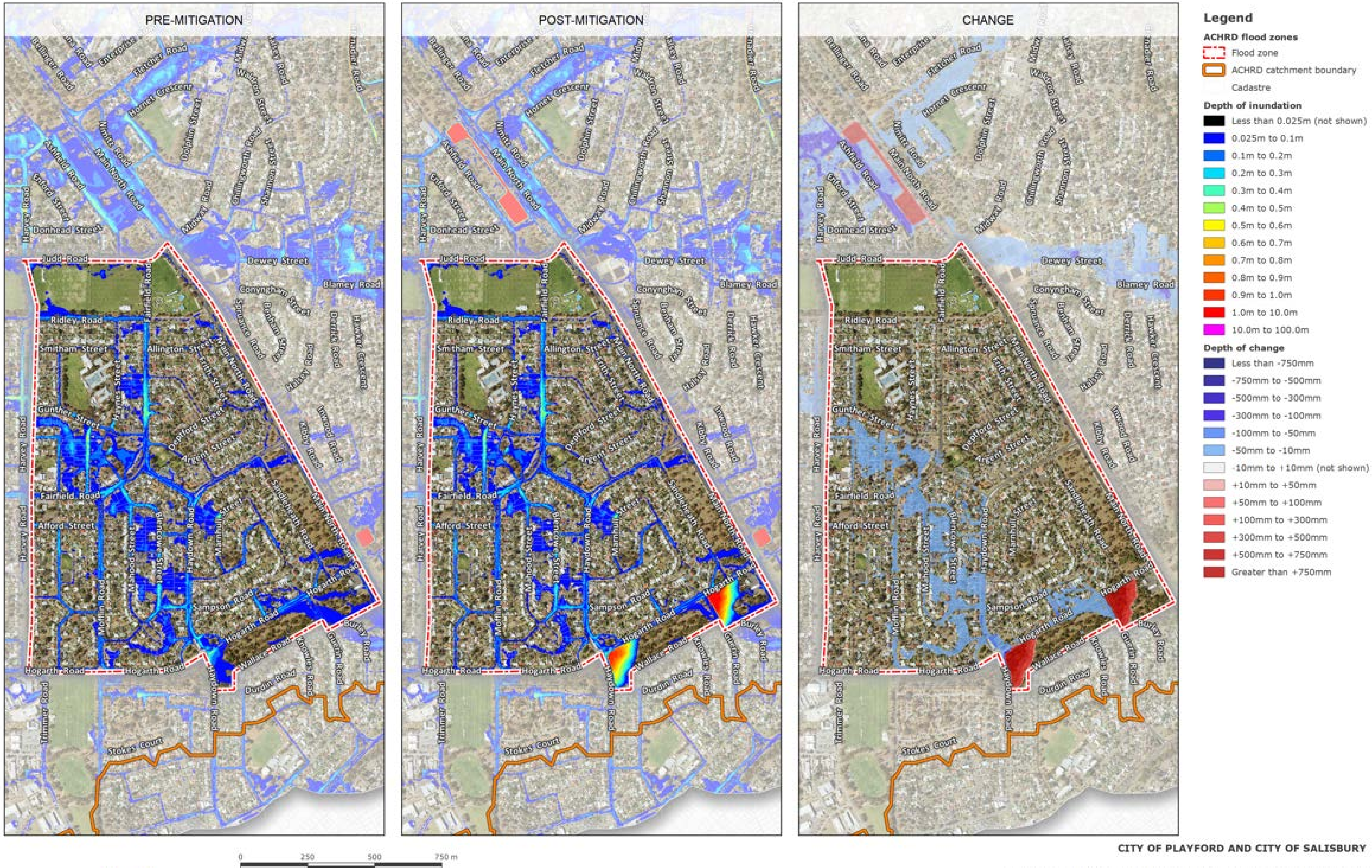
CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
HOGARTH ROAD DETENTION BASINS

Job Number: 20170712
Filename: 20170712GQ002B
Revision: Rev A
Date: 2019-09-18
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

Figure 5.18



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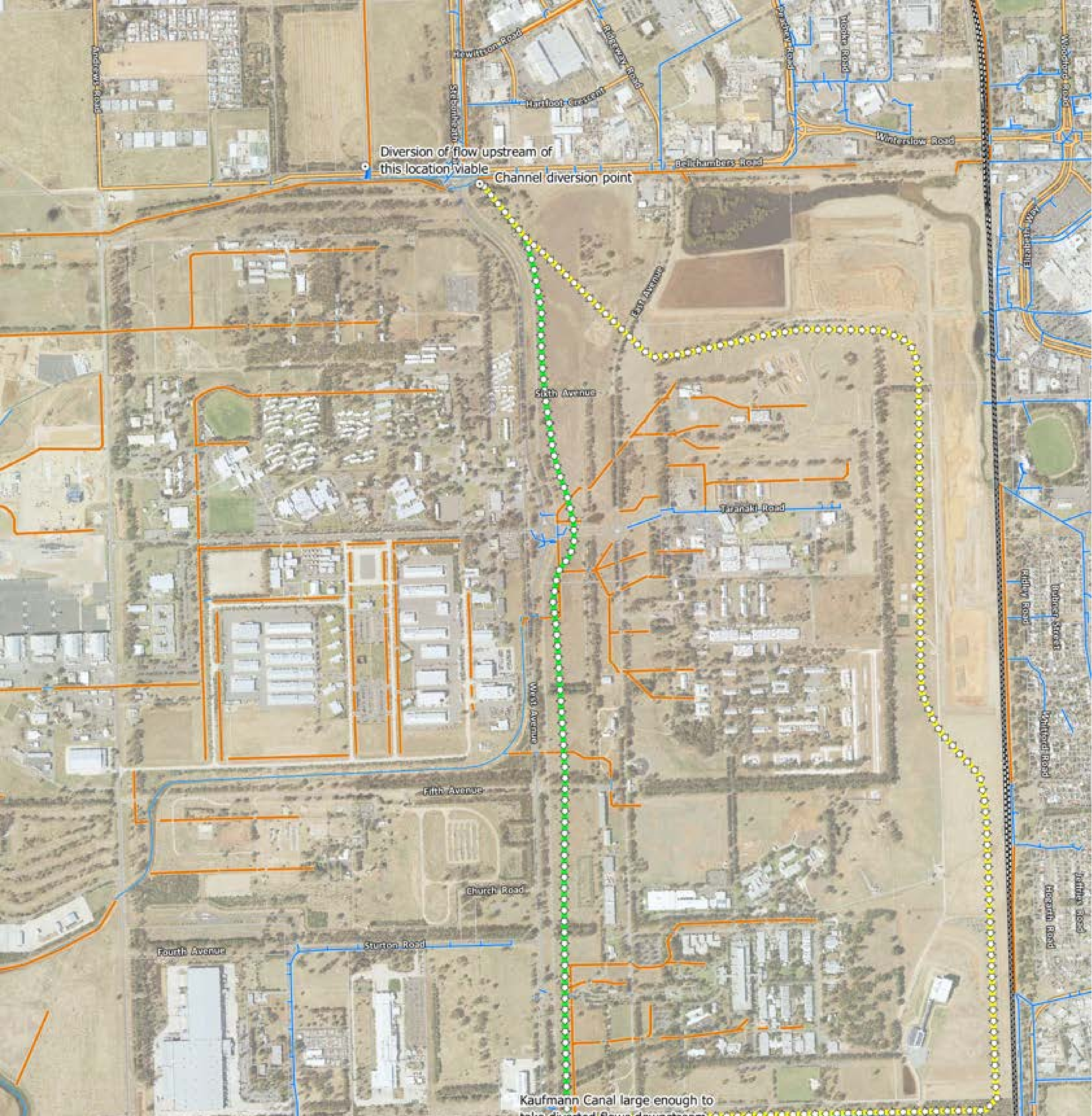
Job Number: 20170712
Filename: 20170712GQ003A
Revision: Rev B
Date: 2020-04-06
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
HOGARTH ROAD DETENTION BASINS
1% AEP CHANGE MAP

Figure 5.19



tonkin

Job Number: 20170712
Filename: 20170712GQ002B
Revision: Rev B
Date: 2020-04-14
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from DataSA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
RAAF BASE DRAIN DIVERSION OPTIONS

Figure 5.20

5.2.11 Smith Creek overflow detention basin

The floodplain mapping shows flooding of the Eyre Development due to overflows from Smith Creek. As part of the Smith Creek SMP (Water Technology, 2019), it is proposed to mitigate this flooding such that no overflows enter the ACHRD catchment.

In the event that these mitigation works do not proceed, it is proposed to relocate the current spill point to a location further downstream. The flows could then be captured and detained in a new detention basin, as shown in Figure 5.21. The location shown is indicative only, but represents the area of acquisition likely required.

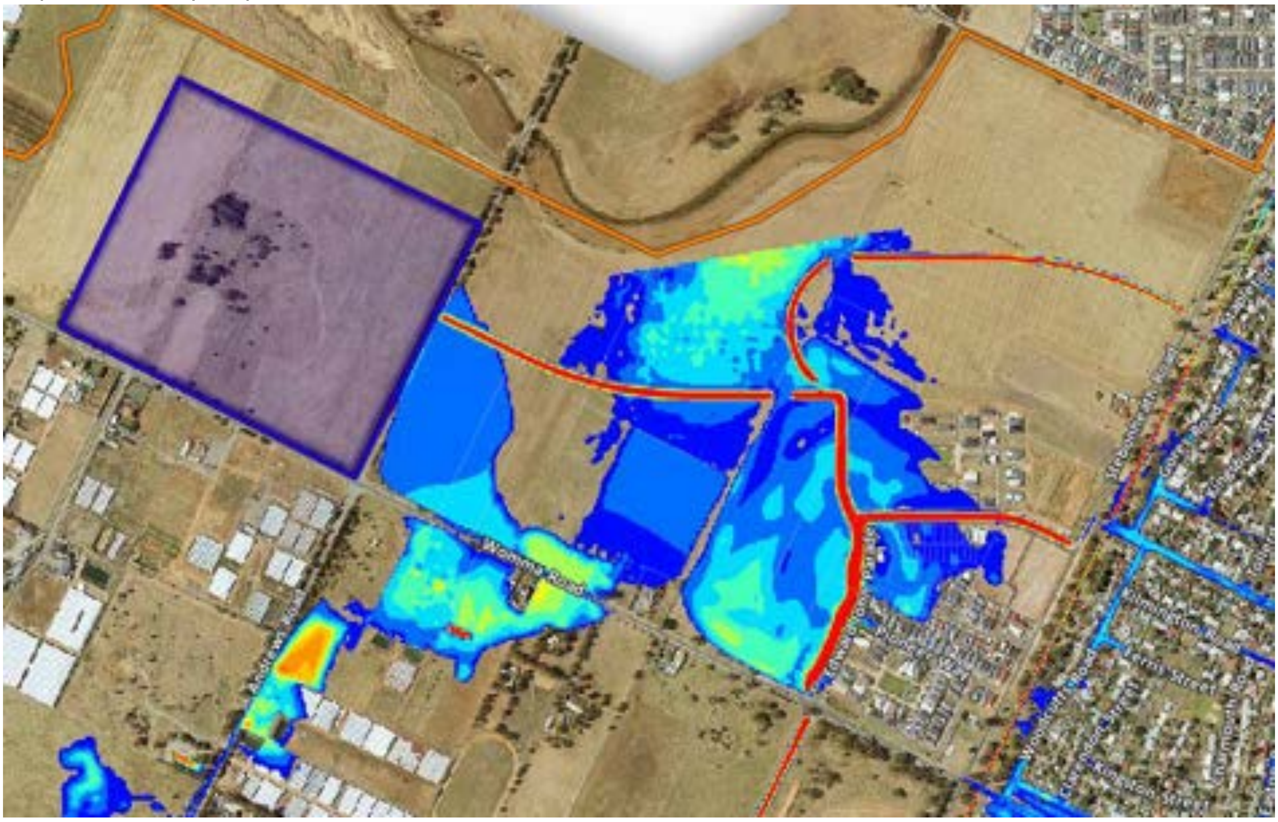


Figure 5.21 Indicative location of Smith Creek overflow detention basin

Indicative detention basin sizes have been derived by routing the hydrographs provided by Water Technology (2050 climate change scenario) through a DRAINS model. The outlet to the basin has been restricted to a range of maximum outflow rates, as summarised in Table 5.9. The area of land required to construct the basin has been based on an assumed average basin depth of 1.5 m. It is assumed that 100% of the required basin volume is excavation.

Table 5.9 Indicative basin sizes to detain overflows from Smith Creek

Target discharge rate (L/s)	**Volume** (ML)	**Outlet pipe diameter** (mm)	**Basin area** (ha)
200	390	300	32
500	380	450	31
1000	360	675	30

Target discharge rate (L/s)	Volume (ML)	Outlet pipe diameter (mm)	Basin area (ha)
2000	338	900	28
6000	225	2 x 1200	18

For the purpose of producing flood maps to accompany this SMP, it has been assumed that no overflows from Smith Creek will enter the ACHRD catchment for events up to and including the 1% AEP event (i.e. mitigation measures within the Smith Creek catchment will be implemented). For the 0.2% AEP event, based on the hydrographs supplied by Water Technology the overflow from Smith Creek into the ACHRD catchment is expected to be in the order of 31 m^3/s. The maximum overflow for the probably maximum flood (PMF) event is unknown.

5.2.12 Enlarging the Gap

An assessment of the capacity of the Gap outfall channel has been undertaken. The Gap currently receives inflows from three separate sources: the Helps Road Drain, the Little Para overflow channel and the Burton Road drain. For the long-term 2050 development conditions, the peak flow arriving at the Gap outfall in the 1% AEP event is approximately 52 m^3/s (during the 9 hour event). The flow is comprised of the following:

- 31 m^3/s from Helps Road Drain
- 17 m^3/s from Little Para overflow channel
- 4 m^3/s from Burton Road drain.

HEC-RAS modelling of the existing Gap outfall channel has indicated that its current capacity is 35 m^3/s. This is consistent with the TUFLOW modelling, which also showed that 35 m^3/s could pass along the channel with an upstream water level of 5.1 mAHD. To prevent flooding upstream of the inlet to the Gap outlet, the upstream hydraulic grade line (HGL) needs to be below the lowest natural ground level in the area (4.8 mAHD). A HGL of this level would allow the area to be free draining and would not result in ponding, provided the upstream channel system has the capacity to convey the flows into the Gap's inlet.

By deepening the invert of the channel such that it occupies the full width of the channel through the Bolivar lagoons (typical example shown in Figure 5.22), the capacity of the channel can be increased from 35 m^3/s to 80 m^3/s (i.e. providing higher than a 1% AEP standard).

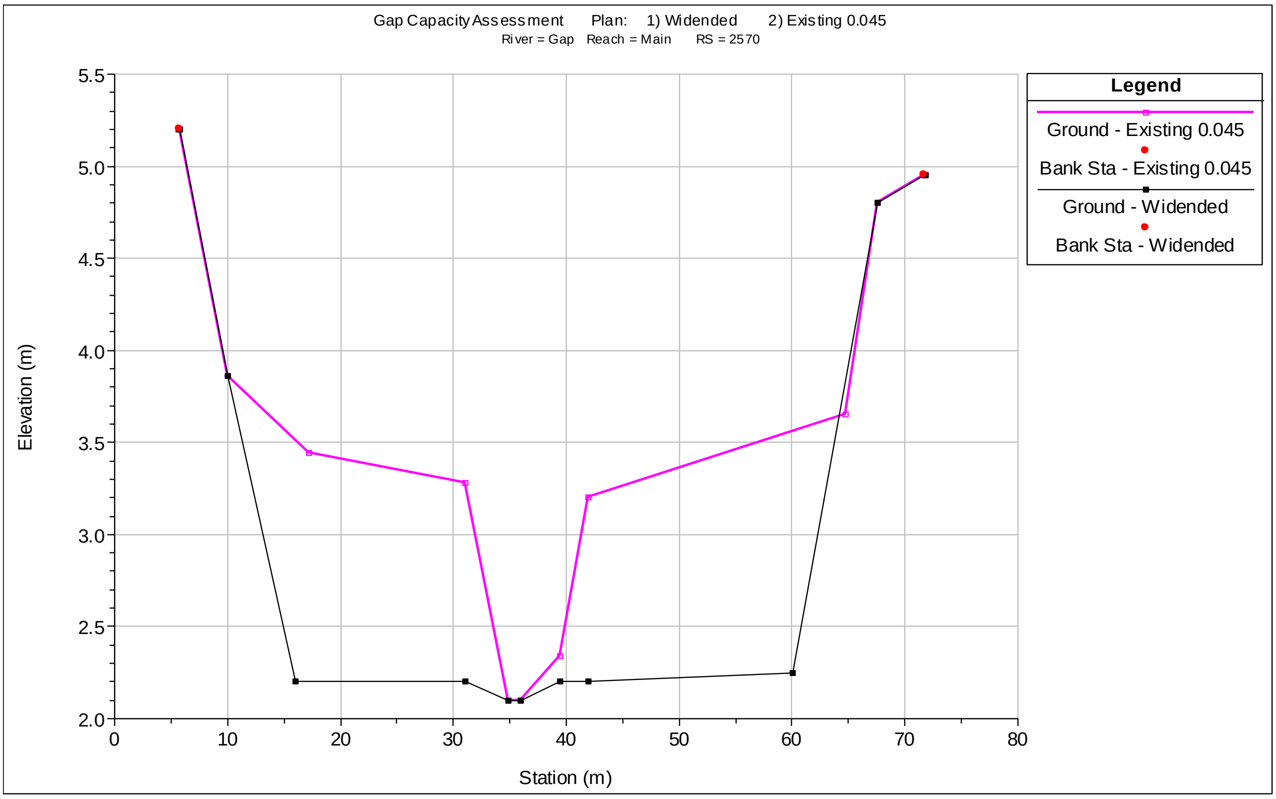


Figure 5.22 Gap channel cross-section modification

Once the channel reaches the salt ponds it bends sharply to the south. The right (western most) bank downstream of the bend reduces to a level of approximately 2.5 mAHD, and the downstream channel invert grades flatten to 1 in 6,000 (0.017%). This section of drain has a capacity of approximately 15 m^3/s, irrespective of the flow rate arriving at the bend, with any flows in excess of this spilling across the right (western) bank into the adjacent salt ponds within the first 400 m section downstream of the bend.

The bank between the channel and the salt ponds would need to be raised to a level of 4.0 mAHD to prevent this spill from occurring, along with upgrades at the outlet to the ocean. If this was not undertaken, upgrading the upstream section of channel would increase both the volume and frequency of flows (in excess of 15 m^3/s) spilling into the salt pond.

EBS Ecology was engaged by Tonkin to undertake a field assessment of the watercourses within the ACHRD catchment in order to identify areas of high quality vegetation that should be protected or enhanced. The assessment (EBS Ecology, 2019) determined that the vegetation within the downstream area of the Gap outlet is described as Samphire shrubland. The vegetation is intact (excellent condition), comprising 100% native cover (Figure 5.23), and is therefore of high conservation significance.

Between the Bolivar water treatment ponds the vegetation is described as exotic grassland +/- scattered shrubs with patches of reedbed in the watercourse (moderate condition) (Figure 5.24).

Given the high value placed on remnant vegetation, it is recommended that the works described herein (deepening the Gap channel and raising the western embankment) are not undertaken.

Figure 5.23 Intact high value samphire shrubland (EBS Ecology, 2019)

Figure 5.24 Reedbed surrounded by exotic grassland +/- scattered shrubs (EBS Ecology, 2019)

5.2.13 Upgrading Adams Creek culverts

Modelling of Adams Creek shows that floodwaters spill out of the creek, overtopping the road at the following locations:

- Midway Road
- Yorktown Road

Culvert upgrades at these locations can be considered. However, as the valley is fairly well defined, the upgrades would result in relatively minor improvements to flooding (and hence annual average damages). As such, these works have been excluded from the TUFLOW modelling.

5.2.14 Burton Road detention basin

As described in Section 4.1.8, a strip of relatively shallow flooding (typically 0.2 m deep) is located in the vicinity of Burton Road to the east and west of Bolivar Road. A large parcel of agricultural land (approximately 2 ha) is located on the corner of Burton Road and Bolivar Road. If this land was purchased by the City of Salisbury, it would be possible to construct a basin to detain surface flows.

The improvements to flooding provided by this option would potentially allow the pipe sizes required for the Salisbury pipe upgrades detailed in Section 5.2.8 to be reduced. However, the cost of purchasing this parcel of land is estimated to be in the order of $3 million. When also considering basin excavation costs, in addition to the loss of 2 ha of developable land, the potential benefit provided by the basin is not considered great enough to warrant pursuit. Consideration has been given to the potential of harvesting stormwater at this location in order to improve the benefit-cost ratio, however the upstream catchment is not considered large enough to make harvesting viable. As such, the Burton Road detention basin has not been further investigated.

5.2.15 Channel maintenance

The Adams and Helps Road watercourse vegetation assessment study (EBS Ecology, 2019) identified areas of illegal dumping in parts of the central and eastern portion of the catchment. many cases of self-seeded trees within the profile of the main channel were also observed, in addition to pockets of dense reed growth. Each of these items has the potential to restrict the capacity of the trunk drainage system, possibly resulting in flooding. Periodic inspections should be undertaken along the major channels to monitor illegal dumping and to remove any vegetation that has the potential to cause a flood risk by reducing the hydraulic capacity of the watercourses.

5.2.16 Detention basin design

A number of the proposed detention basins described in the previous sections are connected to the existing underground drainage network, and hence will receive inflows during a range of rainfall events (both frequent and infrequent). As part of the design of the basins it is recommended that consideration be given to heavily detaining the outflows from the basins during frequent, small flow events. This will provide a number of benefits, including:

- Increased infiltration, thereby reducing the volume of runoff discharged from the catchment
- Increased water reuse, where possible.

5.3 Non-structural flood management strategies

5.3.1 Education and awareness

Detailed floodplain mapping of the catchment is available. This information should be made widely available to the community so that they understand where flooding is likely to occur. Awareness of flood risk can allow them to better manage the risk and reduce flood damages. This awareness could be in the form of mail outs to flood affected property owners, making the maps publicly available (such as accessible via the internet) or having information available at public places such as libraries and Council offices. Businesses and residents can be encouraged to develop flood action plans to reduce damages in the event of a flood and change the way in which valuable items are stored.

5.3.2 Flood warning and flood forecasting

Whilst the response time for the local drainage catchments is relatively short, if the community is given some warning of the potential for a flood the magnitude of the social and economic damages can be reduced significantly. People and emergency services would have more time to sand bag flood prone areas and valuable portable property could be moved away from areas that may have otherwise suffered flood damages. The potential reduction in flood damages when more than 12 hours of warning is provided, as opposed to less than two hours, can range from 20% up to 50%, depending on the relative experience of the community in dealing with flooding (DNRE, 2000). Similarly to education and awareness, these potential reductions are significant compared to the structural measures.

Given the relatively short response time for the local catchments (typically 1-2 hours) the only opportunity to provide a significant warning time would be to issue a flood warning before the rainfall event reaches the catchment. The reliability of this information may result in complacency if the warnings are issued too frequently without actual flood events occurring.

5.3.3 Use of flood mapping outputs

The SMP has generated GIS-based flood modelling data for the study area (for future development conditions with an allowance for climate change). This information should be utilised in the planning of new developments to ensure that they are provided with adequate flood protection. It is recommended that this should include ensuring existing overland flood flow paths are retained and floor levels are set above the predicted level of the 1% AEP flood (including appropriate freeboard).

Councils should utilise E-Planning and the Planning Portal to more regularly and quickly update the extent of floodplain areas shown in the Planning and Design Code (as an overlay) when revised modelling is undertaken or when mitigation measures are implemented.

5.3.4 Consistent strategic plans

Each Council should continue to work collaboratively to ensure that stormwater management goals, objectives, strategies and actions within strategic documents recognise the need for cross boundary management of stormwater and flood risk.

5.3.5 Development controls

Development controls will be required to ensure development is protected from flooding during the 1% AEP. This would include requiring development to be set above adjacent road levels such that the roads are able to convey flood flows when the capacity of the underground drainage network is exceeded.

The new State Government Planning and Design Code governs controls for new development. There may be limitations to the code that are not in the best interests for Council in relation to stormwater management, particularly in a non-residential setting (such as hot houses). A recommended action is to undertake a detailed interrogation of the new code to check that it can still lead to satisfactory outcomes to Council in relation to stormwater management and protection from flooding. A further action may involve liaising with the State Government to amend the code.

5.4 Water reuse

5.4.1 Managed aquifer recharge

Wallbridge Gilbert Aztec were engaged to undertake a hydrological assessment for the Study Area. They investigated (WGA, 2018) locations for new or enlarged managed aquifer recharge (MAR) schemes, as summarised in Section 4.2.

The existing MAR schemes at the Edinburgh Parks South and Kaurna Park wetlands have a combined water harvesting design yield of up to 2,000 ML/a, however are currently not operational due to PFAS contamination within the RAAF base upstream. Given that this large yield is not currently being utilised, it is recommended that the diversion of the Helps Road Drain around the RAAF base (described in Section 5.2.10) be further investigated in order to allow these existing MAR schemes to be reactivated.

Additionally, the Edinburgh Parks North detention basins and Springbank Park wetlands (which have not previously been used for water harvesting purposes) each have potential yields of 600 ML/a. The Springbank Park wetland is downstream of the Kaurna Park wetland, and hence may also be subject to receiving PFAS contaminants, however it is recommended that the viability of each of these options be assessed.

It is also recommended that a harvesting facility be incorporated within the proposed Elizabeth Park detention basin. The facility should include a pump and rising main to transfer water to the existing rising main leading to the City of Playford's Yorktown Road storage and pump facility.

Given the ongoing issues with the Olive Grove wetlands, this site is not deemed to be suitable for water reuse.

5.4.2 Large rainwater tanks

Rainwater tanks can be used to encourage the on-site reuse of stormwater runoff. In areas of new development, each Council should encourage (potentially via financial subsidisation) the installation of rainwater tanks which, at a minimum, are plumbed into the hot water service and toilet. The volumes of reuse achieved will be dependent on the following factors:

- the area of roof plumbed into the rainwater tank
- the size of the tank
- the daily water demands for rain water.

Yield curves showing indicative annual yields for rainwater tanks of various sizes (assuming a connected roof area of 150 m^2) are shown in Figure 5.25. Assuming an average daily demand of 200 L, the curves show that yields may range from 35 kL/year for a 1 kL tank to 65 kL/year for a 20 kL/year. Based on review of the yield curves it is recommended that new dwellings should incorporate a tank with a minimum capacity of 5 kL (corresponding to a yield of approximately 50 kL/year). A smaller size may be more appropriate if the connected roof area is smaller.

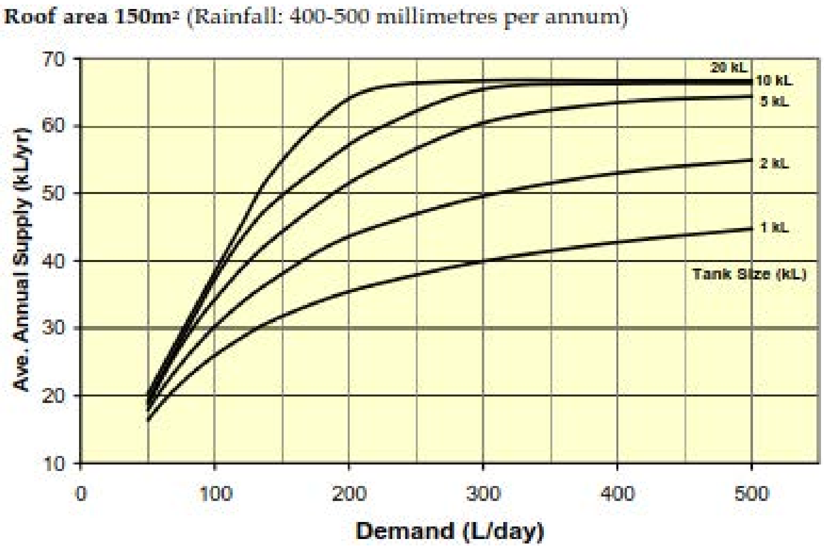


Figure 5.25 Rainwater yield curve (150 m² roof area) (DPLG, 2010)

5.4.3 Infiltration systems

A range of passive infiltration systems will facilitate water to recharge into the shallow groundwater system close to the location where the runoff was first generated. The following systems can be used to promote infiltration:

- Raingardens (refer Section 5.5.9) can allow for soakage of runoff that is diverted into the raingarden.
- Permeable paving (refer Section 5.5.11) can be incorporated into road reconstruction projects to encourage infiltration. Permeable pavements can be particularly effective if they are connected into small basins that can act to increase the volume of the storage area available for passive infiltration.
- Tree pits (refer Section 5.5.11) can help to increase the amount of moisture reaching the root zone of trees. This can enhance tree health and therefore has the added benefit of improving amenity.

5.5 Water quality improvement

5.5.1 Introduction

The following sections detail the proposed strategies for improving the water quality of the runoff from the developed areas of the catchment. Consistent with the stormwater management planning guidelines, the status of existing stormwater quality and opportunities for water quality improvement have been considered in the development of the ACHRD SMP.

The stated water quality objectives for the study area reflect South Australia's state wide performance targets for stormwater runoff quality (Department of Environment, Water and Natural Resources, 2013), as follows:

- 80% reduction in average annual total suspended solids
- 60% reduction in average annual total phosphorous
- 45% reduction in average annual total nitrogen, and
- 90% reduction in litter/gross pollutants.

The primary pollutants carried by stormwater within the study area are likely to be sediments (TSS), nutrients (TP and TN), pathogens, oxygen demanding substances and gross pollutants (GP).

The quality of runoff from the study area was modelled using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Details of the development of the MUSIC model are provided in Appendix F (Tonkin, 2019).

There are currently no official guidelines for the use of MUSIC in South Australia. The adopted approach to modelling is therefore based on the recommendations made by the Goyder Institute in their report (Myers et al. 2015) which reviewed the use of MUSIC for the development of stormwater management plans. The report includes a comprehensive review of guidelines for the use of MUSIC in other regions and makes recommendations for MUSIC simulations in South Australia.

5.5.2 Existing water quality improvement features

The MUSIC model of the current state of the catchment incorporates the existing features that contribute to water quality improvement. These include the following:

- Whitford Road detention basin
- Olive Grove wetland
- Edinburgh Parks detention basin
- Edinburgh Parks wetland
- Kaurna Park wetland
- Springbank wetland
- Burton Road wetland
- Lake Windemere detention basin
- Existing vegetated open channels

5.5.3 Existing water quality modelling results

A 'base case' MUSIC model was run to understand the patterns of flow and pollutant generation based on the long-term level of development within the catchment. The results of the base case model at the downstream receiving node are summarised in Table 5.10. The source loads represent total flows and pollutants generated within the study area. The residual load reflects the flows and pollutants arriving at the downstream end of the model, considering the existing water quality improvement measures included in the model. Due to the known PFAS contamination, water harvesting has not been included in the base case model.

Table 5.10 MUSIC base case model – annual loads at downstream end

	Sources	Residual load	% Reduction	Daily mean (95th percentile)
Flow (ML/yr)	10,800	8,220	24.1	1.32 m^3/s
Total Suspended Solids (kg/yr)	2,730,000	254,000	90.7	96.0 mg/L
Total Phosphorus (kg/yr)	3,970	974	75.4	0.19 mg/L
Total Nitrogen (kg/yr)	23,900	12,100	49.6	1.71 mg/L
Gross Pollutants (kg/yr)	448,000	17,500	96.1	437.5 kg/day

The MUSIC modelling of the existing water quality improvement features within the study area demonstrates a significant reduction in pollutant loads prior to discharge to Gulf St Vincent. The target load reductions are met for each of the four pollutant types, however the 95th percentile concentration targets for phosphorus and nitrogen (0.1 mg/L and 1 mg/L, respectively) have not been met.

For comparison, interrogation of pollutant concentrations mid-catchment has been undertaken. The results of the 'base case' model upstream of the Kaurna Park wetland are summarised in Table 5.11.

Table 5.11 MUSIC base case model – annual loads upstream of Kaurna Park

	Sources	Residual load	% Reduction	Daily mean (95th percentile)
Flow (ML/yr)	8,080	6,180	23.5	0.84 m^3/s
Total Suspended Solids (kg/yr)	2,050,000	158,000	92.3	95.8 mg/L
Total Phosphorus (kg/yr)	2,970	876	70.5	0.24 mg/L
Total Nitrogen (kg/yr)	17,800	10,300	41.7	1.86 mg/L
Gross Pollutants (kg/yr)	333,000	4,420	98.7	115.0 kg/day

There is an existing flow gauge and water quality monitoring site within the Helps Road Drain, located 100 m downstream of Summer Road (site A5051013), towards the downstream end of the catchment. Records of the daily flow data between 2015-2020 show an average annual discharge from the catchment of 2,600 ML. As such, the estimates of total flows, and hence pollutant loads, are overestimated within the MUSIC model, compared to the recorded data. A sensitivity analysis of the MUSIC model was undertaken, with the impervious proportion of all catchments reduced to 20%. This resulted in an estimated total annual flow of 6,000 ML (i.e. still exceeding the recorded volume). Calibration of the model could be undertaken, however further reducing the catchment's impervious area is not considered realistic. Given that MUSIC is a conceptual model, the catchment data adopted within the base case scenario is considered reasonable for comparing the relative improvements associated with various options.

5.5.4 Post-development water quality modelling

The detention basins described as part of the structural flood mitigation strategies (Section 5.2) will also provide water quality benefits due to the slow flow velocities through them, which will facilitate vegetative filtering and settling of sediments. This is especially true for the Elizabeth Parks detention basin, which will incorporate a low flow channel. The MUSIC model was updated to incorporate these proposed water quality improvement features. Additionally, the water harvesting opportunities described in Section 5.4.1 have also been included (on the assumption that solutions to remediate the PFAS contamination issues will be implemented). The results of the modelling for the post-development scenario are summarised in Table 5.12.

Table 5.12 Modelled annual pollutant loads at the downstream receiving node (post-development scenario)

	Sources	Residual load	% Reduction	Daily mean (95th percentile)
Flow (ML/yr)	10,800	5,100	52.9	0.75 m^3/s
Total Suspended Solids (kg/yr)	2,730,000	194,000	92.9	131.0 mg/L

	Sources	Residual load	% Reduction	Daily mean (95th percentile)
Total Phosphorus (kg/yr)	3,970	647	83.7	0.26 mg/L
Total Nitrogen (kg/yr)	23,900	7,870	67.1	1.94 mg/L
Gross Pollutants (kg/yr)	448,000	17,500	96.1	438.5 kg/day

The inclusion of detention basins and water harvesting opportunities results in improvements to the residual pollutant loads discharging from the catchment. Additional effort will be required to ensure that the 95th percentile concentration targets for phosphorus and nitrogen (0.1 mg/L and 1 mg/L, respectively) are met.

Large areas of open space are not readily available within the catchment area, and hence there are limited opportunities for major WSUD measures such as new wetlands along the main drainage alignment. In order to achieve the stated targets, it is likely that a wide-scale rollout of decentralised WSUD measures targeting smaller areas (e.g. lot-scale) would be required.

5.5.5 Modelled annual flows for future climate projections

The MUSIC model also provides an understanding of the reduction in annual average flows discharged from the site for different climate projections. Climate change is likely to impact the volumes, and quality, of water available for harvest and reuse. Reduced rainfall will result in lower runoff volumes, while higher evaporation rates will increase storage losses.

The 2050 and 2090 seasonal scaling factors were applied to the model to compare the impacts of climate change on the water balance outcomes. This is summarised in Table 5.13 for all climate scenarios, with and without the water harvesting schemes discussed in Section 5.3.5.

Table 5.13 Modelled annual flows (ML/yr) at the downstream receiving node

Scenario	Sources	Residual Load	% Reduction
Current climate scenario with no water harvesting	10,800	8,220	24.1
Current climate scenario with water harvesting	10,800	5,100	52.9
Projected 2050 climate scenario with no water harvesting	8,430	4,570	45.8
Projected 2050 climate scenario with water harvesting	8,430	3,150	62.6
Projected 2090 climate scenario with no water harvesting	7,550	4,430	41.3
Projected 2090 climate scenario with water harvesting	7,550	2,500	66.9

As expected, the annual runoff from the catchment decreases both in a drier climate, and when water harvesting schemes within existing wetlands are adopted. The 63% reduction in flows discharged from the catchment for the 2050 scenario with water harvesting is approaching the specified target of 75%.

When also considering the potential future uptake of rainwater tanks and infiltration systems across the catchment, it is likely that the target will be achieved.

No analysis of pollutant loading for the future climate projections has been undertaken. Reducing the rainfall within MUSIC to represent a drier climate also results in a reduction in pollutant loading. Realistically, reduced rainfall will not impact on total loads, rather it will result in greater loads and concentrations being discharged into receiving waters during the first flush events.

5.5.6 PFAS contamination

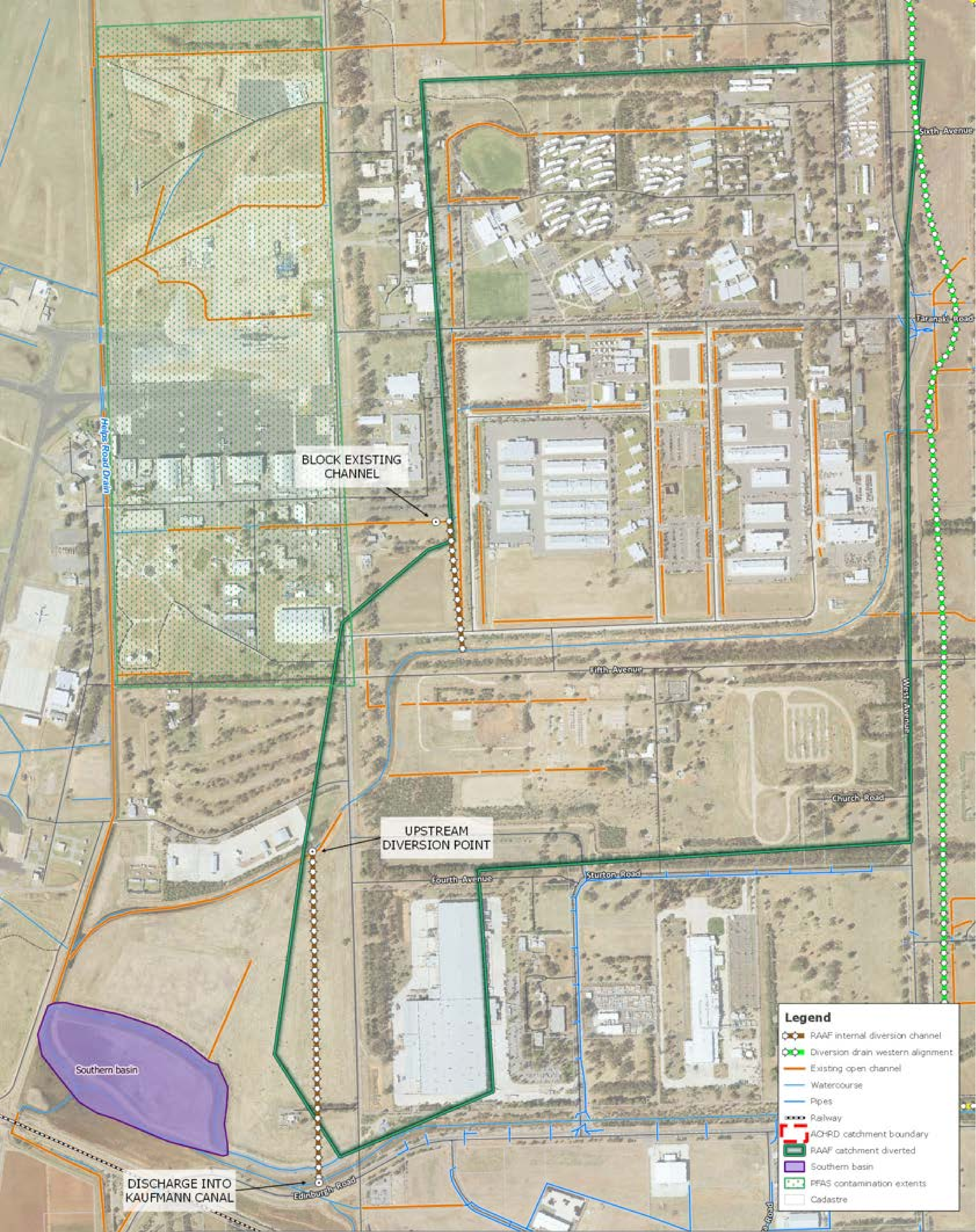
Section 5.2.10 describes opportunities to divert the Helps Road Drain around the RAAF base to avoid passing runoff through known areas of PFAS contamination (and hence mobilising the contaminants).

If the diversion drain along the western alignment is constructed, the size of the RAAF base catchment requiring treatment for PFAS contamination would reduce from approximately 3,500 ha to 770 ha (containing approximately 170 ha of imperious area). Of this 770 ha, about 130 ha is external to the RAAF base.

It is understood that the main PFAS contamination extents extend for a width of approximately 600 m to the east of the main Helps Road Drain and that the areas to the east of this have little or no contamination. On this basis, an additional 270 ha of catchment within the RAAF base could potentially be redirected, via the construction of additional open channels, such that this area would not need treatment, reducing the catchment area to 500 ha. The realignment option is shown in Figure 5.26. This effectively halves the amount of impervious area that would need treatment to about 85 ha.

The most viable treatment option would be to temporarily detain flows on site and then treat the flow at a controlled rate. The southern detention basin on the DST site is the most likely location to temporarily store flows. This basin is approximately 10 hectares in size and could potentially pond to a depth of up to 1.5 m. Therefore it has a potential storage volume in the vicinity of 140,000 m^3.

It is understood that a treatment flow rate in the order of 100 L/s is potentially viable. Based on the two contributing catchment options outlined above (500 ha and 770 ha) and three treatment flow rates (20, 50 and 100 L/s) the total proportion of inflow into the southern detention basin that could be treated has been calculated using a daily water balance model, the results of which are shown in Table 5.14.



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
INTERNAL RAAF BASE FLOW DIVERSIONS

Figure 5.26

Table 5.14 RAAF southern detention basin spill proportion and frequencies

Catchment area	% of inflow that spills (% of years with any spill)		
	Treatment flow rate		
	20 L/s	50 L/s	100 L/s
500 ha (85 ha impervious)	6.5% (26%)	1.0% (3.7%)	0.1% (1.2%)
770 ha (170 ha impervious)	21.4% (78%)	3.1% (27%)	0.8% (8.5%)

The results indicate that a significant proportion of flows into the southern basin could be treated. Virtually all water (99.9%) is treated when the highest treatment flow rate is combined with the smallest catchment. Even for the worst scenario (largest catchment and lowest treatment rate) the proportion of flow treated is close to 80%.

On this basis, the diversion of the Helps Road Drain to the east of the RAAF base could result in a scheme where it is viable to use the southern basin to capture and treat a significant proportion of the contaminated flows, reducing the concentration of PFAS contaminants leaving the site via stormwater discharges.

5.5.7 On-site measures

Much of the study area is already developed. However, it is anticipated that any new industrial or commercial developments will incorporate site specific water quality control measures, such as installing oil and grit separators prior to discharge of water from their site, particularly from high pollutant sources such as car parking areas. Runoff from hardstand areas should also be directed to adjacent landscaped areas to be used as a source of passive irrigation.

It is recommended that the relevant development plans be updated such that developers are required to incorporate sufficient measures within new developed areas to reduce the water quality mitigation requirements downstream and assist in achieving the water quality objectives of the SMP.

5.5.8 Gross pollutant traps

The installation of gross pollutant traps (GPTs) at locations upstream of outfall locations into a channel should be considered in order to alleviate the total mass of pollutants discharging into waterways. This will reduce the residual load of gross pollutants that are discharged to the receiving waters. The maximum removal of gross pollutants will be dependent on the selected GPT and maximum treatable flow rate.

While the primary purpose of GPTs is to remove gross pollutants and coarse sediments, an in-ground GPT (as opposed to a trash rack) may also provide a reduction in TSS, TP and TN. Specifications provided by manufacturers suggest that in-ground GPTs may remove up to 80% of TSS and 30% of TP and TN. Independent field trials of GPTs suggest that the actual treatment efficiencies is heavily influenced by operations and maintenance practices. If organic matter is allowed to accumulate in the wet sump of a GPT, anaerobic decomposition can occur resulting in the release of highly bio-available forms of nutrients into downstream waterways (DPLG, 2010).

Locations of GPTs would be subject to further design development, with a need to consider issues such as access for maintenance and hydraulic losses that the GPT would introduce into the underground drainage network. Potential GPT locations within the catchment include the following:

- Downstream of the intersection of Hogarth Road and Kettering Road, Elizabeth South
- Upstream of Lake Windemere wetland, Salisbury North
- Western end of Burton Road, Burton

- Upstream of Springbank wetland, Burton
- Intersection of Yorktown Road and Midway Road, Elizabeth Downs
- Eastern side of the railway line near Elizabeth Oval

Council should also consider the installation of GPTs on any outlets that drain catchments that are predominantly commercial or industrial, such as in Edinburgh North and the Elizabeth City Centre.

5.5.9 Raingardens

Raingardens are typically shallow, planted depressions that can provide water quality improvement benefits via biofiltration mechanisms. Raingardens can be implemented at a range of scales from individual residential blocks up to the treatment of whole of catchment flows. Raingardens can reduce the quantity of sediment and nutrients exported to receiving waters.

As a part of new development streetscape raingardens should be considered within the ACHRD catchment area in order to provide improved stormwater quality. Typically constructed within verges or roads, streetscape raingardens receive gutter flows via gaps in the kerbing. Flows are then allowed to pond and infiltrate. A high level overflow/outlet may be provided to discharge flows exceeding the storage capacity of the raingarden into the underground drainage network.

Design Flow (2016) determined that the required area of a raingarden to achieve the State Government’s stormwater treatment targets can be approximated as 0.7% of the impervious area of the contributing catchment. Raingardens of a smaller size will still provide some water quality treatment. A typical layout for a streetscape raingarden is illustrated in Figure 5.27.

Raingardens are likely more suited to implementation within the City of Salisbury, given the flatter terrain. Runoff from some areas at the downstream end of the catchment, such as the southern portion of Paralowie, is not subject to water quality treatment from existing wetlands. Areas such as this would benefit from the installation of raingardens and should be targeted for treatment.

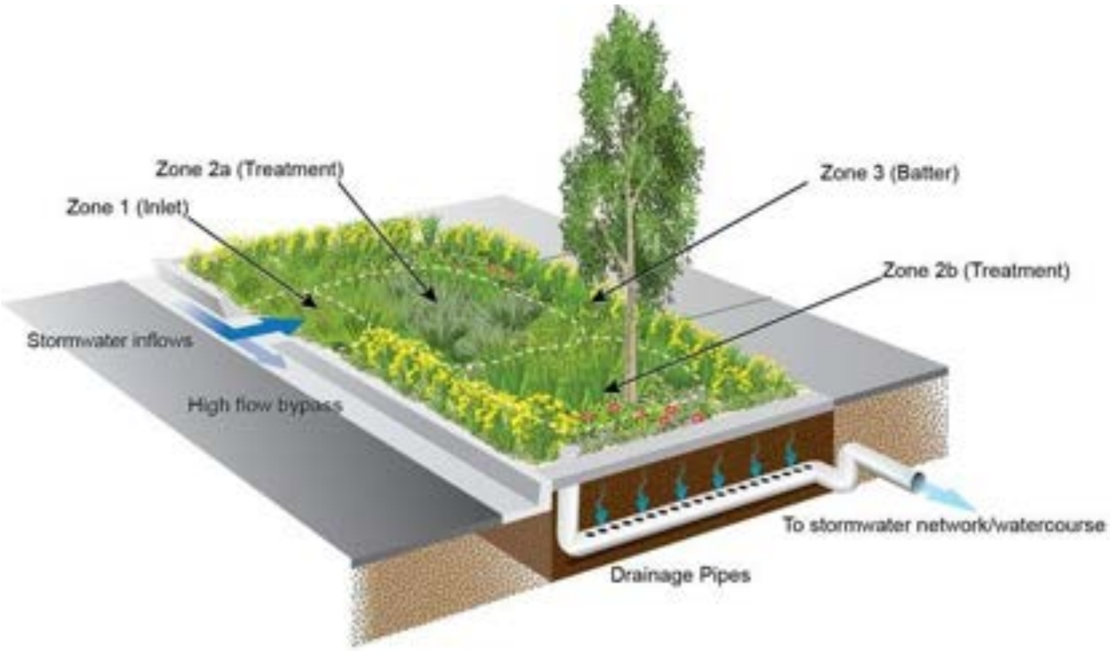


Figure 5.27 Typical layout of a raingarden (Water Sensitive SA, 2016)

To test the potential effectiveness of streetscape gardens within the ACHRD SMP area, a suitable test catchment was identified, located between Potts Crescent and Bolivar Road, Burton. This catchment was selected on the basis of its relatively flat topography. The locations of thirty-eight potential raingarden sites are shown in Figure 5.28. These locations have been primarily selected due to the presence of existing stormwater pits; construction of a raingarden upstream of an inlet will allow runoff to be treated prior to entering the underground drainage network. During detailed design it will be necessary to consider additional site constraints, including:

- Traffic considerations (such as sight distances and turning circles)
- Impacts arising from the loss of parking spaces
- Property access
- Impacts to existing trees.

The test catchment has an impervious area of 30 ha. Based on the work of Design Flow (2016), a total raingarden area of approximately 2,115 m^2 would be required to provide the State Government water quality improvement performance targets.

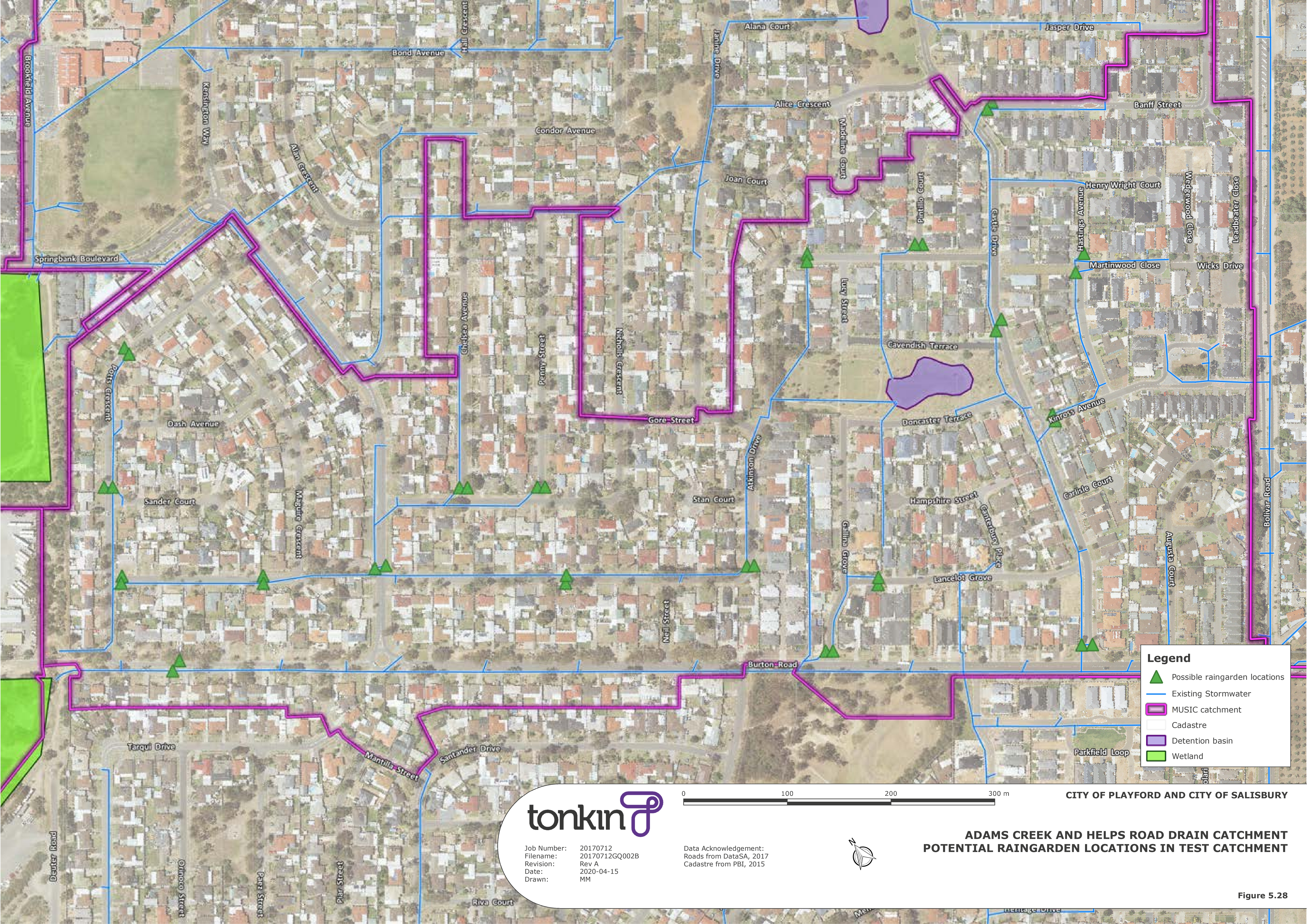
The associated water quality improvement effectiveness of the raingardens was assessed using a lumped approach with a single bioretention node at the downstream extent of the catchment in the MUSIC model. The modelling assumed a total raingarden area of 2,115 m^2, with 0.15 m ponding depth. The filter media was assumed to have a total area of 1,800 m^2 with a depth of 0.5 m. The base of the raingarden was assumed to be unlined and vegetated with effective nutrient removal plants. The modelled treatment effectiveness of the raingardens is summarised in Table 5.15. It can be seen that the construction of 2,115 m^2 of raingardens within the catchment results in a significant reduction in pollutants from the catchment, however further treatment would be required to reduce the nitrogen and phosphorus concentrations to the targeted levels.

The level of water quality improvement achieved will be dependent of the size of the raingarden relative to the upstream catchment. It is recommended that in the future, Council considers opportunities for incorporating raingardens and other WSUD elements into planned capital works.

Table 5.15 Modelled treatment effectiveness of raingardens for test catchment

	Sources	Residual load	% Reduction	Daily mean (95^{th} percentile)
Flow (ML/yr)	84.4	26	69.2	N/A
Total Suspended Solids (kg/yr)	18,300	2,250	87.7	42.9 mg/L
Total Phosphorus (kg/yr)	37.8	6.6	82.6	0.18 mg/L
Total Nitrogen (kg/yr)	176	49.6	71.8	1.78 mg/L
Gross Pollutants (kg/yr)	4,280	207	95.2	N/A

For investigative purposes, an additional raingarden area of 20,000 m^2 was incorporated across the study area. This resulted in a 95^{th} percentile total nitrogen concentration of 0.6 mg/L (i.e. complying with the target concentration of 1 mg/L). However, the total phosphorus concentration (0.12 mg/L) still slightly exceeded the target of 0.1 mg/L.



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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
POTENTIAL RAINGARDEN LOCATIONS IN TEST CATCHMENT

Figure 5.28

5.5.10 Watercourse erosion management

The Adams and Helps Road watercourse vegetation assessment report (EBS Ecology, 2019) assessed erosion along the watercourses within the catchment. The main erosion issues were identified in the eastern section of the catchment (typically east of Main North Road) with some areas of significant erosion within private property where the channels have been cleared and the banks are steep. Ongoing erosion would result in transportation of silt and sediments into the downstream sections of the catchment. Revegetation or structural works to flatten the bank batters would be required to prevent this.

The outcomes of the erosion assessment (EBS Ecology, 2019) showing the areas of erosion within the eastern and central portions of the catchment are shown in Figure 5.29 and Figure 5.30, respectively. It is recommended that works be undertaken to address the areas of erosion identified as severe. No instances of severe erosion within the western portion of the catchment were observed.

5.5.11 Other small-scale potential water quality improvement measures

A number of other small-scale water sensitive urban design measures should be implemented within the catchment, either as stand-alone projects or incorporated into other capital works projects. These are described below.

Modifications to existing basins

There are a number of new detention basins proposed within the study area. There is an opportunity to provide stormwater quality improvement within these basins by constructing vegetated low flow channels and/or lowering the invert of the basins to provide a wetland within the detention basins, particularly for the basins that receive piped flows, which include:

- Promotion Drive flood detention dam
- Dwight Reserve detention basins 1 and 2
- Hogarth Road detention basin 2

Other small-scale opportunities that should be considered where space exists include the construction of bioretention swales and basins.

Permeable paving

Permeable paving, also known as porous paving, is a load bearing pavement structure which can be used on trafficable surfaces including roads and driveways with low traffic volumes, carparks and pedestrian areas. It is best suited to areas that are relatively flat (DPLG, 2010).

Permeable paving typically comprises a permeable surface layer overlying an aggregate storage layer and provides many runoff management benefits including:

- Reduction in peak discharges and volumes.
- Increased groundwater recharge.
- Water quality improvement as a result of infiltration.

It is recommended that permeable paving is included within the relevant development plans as a requirement for new developments. For new industrial developments, permeable paving should be included where possible, such as in areas of the site where heavy vehicle loadings do not occur. Additionally, Council should consider permeable paving in lieu of other footpath pavement options across the catchment, and as part of road reconstruction projects in flatter areas of the catchment, typically to the west of Main North Road.

Figure 5.29 Erosion locations (eastern portion of catchment)

Figure 5.30 Erosion locations (central portion of catchment)

Tree pits

Tree pits typically involve the construction of an opening in the kerb to divert low gutter flows into infiltration pits behind the kerb. The primary objective of the pits is to provide passive irrigation for street trees, with associated amenity and cooling benefits. However, the pits also provide a reduction in stormwater volumes and pollutant loads discharged to receiving environments.

Within the catchment, tree pits will be best suited to the flatter areas west of Main North Road, and with soils that have high infiltration rates.

WSUD in the backyard

'WSUD in the backyard' should be encouraged by each Council for both existing residences and new developments. Examples of measures could include rainwater tanks (with effective reuse), permeable paving and small-scale raingardens. Potential benefits that could be achieved by a WSUD in the backyard approach include reduced peak flows and runoff volumes and improved water quality.

Implementation of WSUD in the backyard will require community buy-in, in addition to a community awareness and education campaign.

5.6 Amenity, recreation and environmental enhancement

The recommended strategies for achieving the SMP objectives relating to amenity, recreation and environmental enhancement are summarised in the following sections.

5.6.1 Utilisation of open space

The establishment of wetlands, open channels or detention systems provides an opportunity to increase biodiversity, improve amenity, create education and recreation facilities, offers habitat for fauna and improves water quality treatment. These opportunities for providing enhancements to areas of open space must be considered when implementing the detention systems identified within this SMP (Dwight Reserve, Elizabeth windbreaks, Elizabeth Park windbreaks and Hogarth Road detention basins).

Green corridors

Additionally, given the long, linear lengths of the Helps Road Drain, there is potential to establish green corridors/linear parks along the drainage route. Green corridors contribute to the conservation of urban wildlife and can provide positive effects for human health and climate change adaptation. They can be used for the purposes of transport (walking, cycling) and be landscaped and vegetated with local plant species.

5.6.2 Soil erosion and drainage management plans

Given the construction works associated with the new residential developments proposed within the study area, as well as potential commercial and industrial (Edinburgh Parks) developments, there is an increased risk of sediment loads being transported off-site and deposited into Gulf St Vincent. Soil erosion and drainage management plans (SEDMP) will be required for each site, and these will need to be strictly enforced.

5.6.3 Watercourse enhancement

Weed management

The Adams and Helps Road watercourse vegetation assessment (EBS Ecology, 2019) identified 30 declared weeds or weeds of concern that should be targeted. Some weeds were observed as isolated occurrences only and should therefore be the target of initial weed management to prevent them from spreading further. Areas of higher conservation value (such as the western samphire shrubland upstream of the Gap outlet) should be targeted first. The report also suggests a large-scale weed control project in conjunction with restoration works in the remnant *Eucalyptus porosa* woodland areas in the eastern portion of the catchment.

Revegetation

Other than at the very downstream end of the catchment the EBS Ecology (2019) report determined that the vegetation condition along the major channels is in poor condition. There is therefore significant potential for improving the quality of the watercourse through revegetation. The eastern portion of the catchment is under private ownership so would require cooperation from land owners. From a biodiversity perspective, the highest priority is to remove the *Olea europaea ssp.* (olive, declared weed) within areas of remnant woodland and restore the mid and understorey with locally sourced seed from existing remnant native species.

The RAAF airfield and surrounds are not suitable for revegetation due to the potential increased risk of bird strike. Approvals should be sought before undertaking any revegetation works in other areas of the RAAF base in case there are issues regarding line of sight or restricted access.

5.7 Asset management

A number of recommendations of this SMP include infrastructure that will require regular maintenance to ensure that it will continue to function as intended. It is recommended that the City of Playford and City of Salisbury develop maintenance plans to cover the long-term management of their drainage assets, particularly the assets that have a high maintenance frequency. These plans would be expected to align with each Council's existing asset management plans, and would need to include the following key areas:

- The location and description of the asset.
- The likely frequency (or event trigger such as a heavy rainfall event) that maintenance will be required.
- The type of maintenance that will be required (such as removal of silt, weeding).

Each Council will also need to allow for adequate resourcing and budgets to maintain the additional infrastructure that may be constructed as part of the implementation of the recommendations of this SMP.

Detailed inspections of existing infrastructure, including CCTV and physical inspection by qualified people, will enable an informed estimation of the residual design life for key components of the drainage system to be made. For underground drainage infrastructure priority should be given to inspecting drains that have at least two or three of the characteristics described in Table 5.16 (drain characteristics not listed in any specific order).

Table 5.16 Criteria defining CCTV inspection priority

Drain characteristic	Discussion
Large drain size (larger than 750 mm diameter)	Large drains comprise the highest value component of Council's drainage assets and the unplanned replacement of a section of large drain would have a large impact on Council's financial resources.
Old drain	The older the drain the more likely that it will be nearing the end of its service life.
Prominent location	Some drains are located in prominent locations such as the centre of a commercial area or within an arterial road. Should these drains fail it would result in major traffic disruptions (if the area was no longer trafficable) and the potential for flood damages is highest.

Drain characteristic	Discussion
Box culverts	Experience shows that box culverts can fail well before the end of their design life which increases the need to understand their current condition.

Based on the outcomes of these investigations, future works can be prioritised to ensure that the drainage system is replaced prior to the end of its design life.

Money should be set aside to initially prioritise which drains should be inspected and then recurring funding should be made available to undertake CCTV inspections of the drainage assets.

It is recommended that an audit of drains located outside of road reserves be undertaken to confirm the location of existing easements and to identify where easements should be put in place.

The inspection/maintenance requirements recommended by the Department of Planning and Local Government (2010) for a number of other assets are outlined in the following sections.

5.7.1 Gross pollutant traps

The main environmental issues with GPTs are associated with:

- Long-term storage of pollutants that may be remobilised or cause odour.
- Limitations on the disposal of the trapped material.

Maintenance involves removing collected pollutants manually or with a vacuum system. For GPTs treating large catchment areas, eWater (2011) price guidelines indicate that maintenance costs in the order of $6,000/year per GPT would be expected.

5.7.2 Watercourses and vegetated open channels

Regular inspections and maintenance are required during the establishment period of channels. Typical maintenance for watercourses and vegetated open channels will involve:

- Routine inspection of the watercourse/channel profile to identify any areas of obvious increased sediment deposition, or scouring of the swale invert from a storm.
- Routine inspection of the watercourse/channel profile to identify any damage from vehicles.
- Routine inspection of batters to identify any rill erosion caused by lateral inflows.
- Routine inspection to identify any areas of scour, litter build up or blockages.
- Removal of self-seeded vegetation within the main flow paths that has the potential to significantly reduce the watercourse/channel capacity if they are allowed to mature.
- Removal of woody weeds within the watercourse/channel that can potentially choke their hydraulic capacity.
- Removal of sediment where it is impeding the conveyance of the watercourse/channel and/or smothering vegetation and, if necessary, reprofiling of the channel and revegetating to original design specification.

5.7.3 Basins

Typical maintenance of basins will involve:

- Routine inspection of the basin to identify depth of sediment accumulation, damage to vegetation, scouring, or litter and debris build up (after the first three significant storm events and then at least every three months).
- Routine inspection of inlet and outlet points to identify any areas of scour, litter build up and blockages.

- Removal of litter and debris.
- Removal and management of invasive weeds (both terrestrial and aquatic).
- Periodic (usually every five years) draining and desilting, which will require excavation and dewatering of removed sediment (and disposal to an approved location).
- Regular watering of littoral vegetation during plant establishment.
- Replacement of plants that have died (from any cause) with plants of equivalent size and species.
- Inspections are also recommended following large storm events to check for scour and damage.

5.7.4 Landscaped areas

For landscaped areas, the following items should be inspected:

- Signs of plant moisture stress.
- Dead or damaged vegetation.
- Weed infestation.
- Signs of surface erosion and scouring.

The following maintenance activities should be undertaken:

- Repair/replace any damaged vegetation.
- Reapply or apply mulch litter.
- Watering.
- Repair surface erosion and scouring.

5.7.5 Urban water harvesting and reuse

Appropriate maintenance of urban water harvesting and reuse schemes is important to ensure that the scheme continues to meet its design objectives in the long term and does not present public health or environmental risks.

Protection from contamination is a necessary part of designing an urban water harvesting and reuse system. This includes constructing treatment systems away from flood prone land, taking care with or avoiding the use of herbicides and pesticides within the surrounding catchment, planting non-deciduous vegetation (evergreens), and preventing mosquitoes and other pests breeding in storage ponds (noting that well-functioning and healthy wetlands do not exacerbate or create mosquito issues (Uni SA, 2014)).

Contingency plans should be developed to cater for the possibility of contaminated water being inadvertently utilised. These plans should focus on:

- Determining the duration of recovery pumping required (to extract contaminated water).
- Sampling intervals required.
- Managing recovered water.

Regular inspections of a scheme are needed to identify any defects or additional maintenance required. The inspections may need to include:

- Storages for the presence of cyanobacteria (i.e. algae), particularly during warmer months.
- Spillways and creeks downstream of any on-line storage after a major storm for any erosion.
- Water treatment systems.
- Distributions systems for faults (e.g. broken pipes).
- Irrigation areas for signs of erosion, under watering, waterlogging or surface runoff.

5.8 Safety in design

Safety in design best practice involves identifying any hazards that could be eliminated or reduced through changes in design.

A safety in design register associated with the design and construction of the stormwater management strategies detailed in this report is included in Appendix G.

6 Flood damages and economic assessment

The damages resulting from flooding were estimated using the Rapid Appraisal Method (RAM), developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000). The RAM provides a rapid approach for economic evaluation of the floodplain management measures in a benefit-cost framework.

6.1 Methodology

The calculation process uses the modelled flood maps to estimate the damages at individual allotments. The damages are calculated as a function of the amount of flooding at an allotment, the damage potential of that allotment and the associated damage rate or equation.

It relies on information within the digital cadastral database, including allotment boundaries, the type of land use and property valuations. The cadastral database was processed prior to performing the calculations in order to get all of the required information in the correct format.

A flow chart outlining the process, in addition to a list of the land use codes, is shown in Appendix H.

6.1.1 Data preparation

The flood damages process requires some pre-processing of the data before the damages assessment can be undertaken, as discussed below. This process should only need to occur once for an area.

Step 1: Assign damage potential

Obtain the latest land use information (cadastral information) for the area of interest and categorize the land uses into low, medium and high flood damage potential. Land use coding currently allocates a 4 digit code to each land use type. The following table summarises how the breakup should broadly be undertaken.

Table 6.1 Land use flood potential

Land use code (first digit)	Broad land use description	Valuation
1	Residential	High
2	Retail	High
3	Industrial	High
4	Reserves	Low
5	Education	Medium
6	Public utilities	Medium
7	Recreation	Low
8	Not used	N/A
9	Agricultural	Low

Step 2: Remove top levels of multi-storey dwellings

Exclude all first story and above units from the land use database (land use codes 1321 through to 1327).

Step 3: Isolate standard residential and other small blocks

Select all property boundaries that have land use codes from 1100 through to 1335 (essentially residential allotments) and all other properties that have a size of 1,000 m^2 or below. Exclude any parcels that are less than 50 m^2 in size to remove any very small cadastral blocks that would have little flood damage potential.

Create centroids for the selected blocks.

Obtain valuation data for the standard residential blocks and annotate the information to each property in the GIS database.

6.1.2 Determine flood damages

The following six steps need to be undertaken for each AEP event or scenario being assessed. If for example there are three AEPs being investigated for three different scenarios the steps would need to be run nine times (3 times 3).

Step 4: Determine flood depths

Utilising the flood depth data from a particular event and scenario determine the depth of flooding for each of the centroids that have been selected from Step 3.

Step 5: Residential damages

Calculate the average property value for residential properties based on the area being investigated.

To assist with calibration of the flood damages estimation, the finished floor level of 80 residential dwellings, deemed to be flood prone in the 1% AEP event, were surveyed to develop a more accurate representation between floor levels and the centroid of each allotment. The centroid of allotments are used as the assumed location of each building. Based on an assessment of the surveyed levels we have assumed floor levels are 0.2 m above the level of the centroid.

For standard residential allotments multiply the depth of flooding by the following damages multiplier. This is only where the depth of flooding exceeded 0.2 m at the centroid of the block.

$$Damage = \$31{,}902 + \$31{,}902 \times depth\ of\ flooding\ at\ centroid\ \times \frac{value\ of\ property}{average\ property\ value}$$

The $31,902 amount is based on 2018 damages estimates and would potentially need to be adjusted over time with inflation. The *value of property* is to be taken from Step 3. The average property value (residential) was found to be $209,000.

Step 6: Small non-residential block damages

For all other small blocks less than 1,000 m^2 the depth of flooding at the centroid should be calculated. The number of blocks inundated to a depth of 0.2 m at the centroid should then be collated based on the valuation type of each block (as determined from Step 1). The number of inundated blocks should then be multiplied by the multipliers in Table 6.2 (factored up by the consumer price index (CPI)) to determine the total amount of flood damages for the small blocks.

Table 6.2 Damage multipliers for small blocks (less than 1,000 m^2)

Land use damage type	Damage multiplier
Low	($4,000 plus CPI) = $4,254
Medium	($32,000 plus CPI) = $34,029
High	($80,000 plus CPI) = $85,702

Step 7: Damages for large non-residential blocks

The flood depth information for the particular AEP and scenario should be trimmed such that all depths below 0.2 m are removed from the flood extends. The area of remaining flooding should then be summated based on the low, medium and high value land uses to create a total inundated area for each type. The total inundated area should then be multiplied by the damage rates shown in Table 6.3.

Table 6.3 Damage multipliers for large blocks (larger than 1,000 m^2)

Land use damage type	Damage multiplier per m^2
Low	($5 plus CPI) = $5*
Medium	($40 plus CPI) = $43
High	($100 plus CPI) = $107

* Different values (typically lower) to be used for agricultural areas.

Step 8: Damages to roads

Damages to roads should be multiplied by the unit rates shown in Table 6.4 where the depth of flooding at the road centreline exceeds 300 mm. The damage multipliers have been factored by 1.56 (CPI increase between 2000 and 2017) from figures shown in Table 3.9 of the RAM.

Table 6.4 Road damage multipliers

Road Type	Damage multiplier ($ per km)
Major sealed road	$92,100
Minor sealed road	$28,900
Unsealed road	$13,100

Step 9: Indirect damages

Steps 1 through to 7 have determined the theoretical direct damage amount. Indirect damages need to be added to these values using the multipliers in Table 6.5.

Table 6.5 Indirect damage multipliers

Land use damage type	Indirect damage multiplier (%)
Residential	25
Low	25
Medium	60
High	60

Step 10: Potential to actual damages reduction

The direct and indirect damages should be then be reduced by a factor to allow for the ability for people to respond to a flood and reduce the actual amount of flood damages. Given the relatively short warning times available and low frequency of significant flooding a reduction by 10% is recommended.

6.1.3 Exclusions

The following damages are not collated as part of the above assessment:

- Damages to vehicles
- Damages due to injury or loss of life

These damages cannot be easily assessed as part of a cadastral-based flood assessment.

6.1.4 Economic analysis

The final damages amount can be utilised to determine an annual average damage. Comparing the reduction in annual average damage between scenarios can then be utilised to determine the economic effectiveness of undertaking works to reduce flood risk by calculating and comparing benefit to cost ratios.

6.2 Damages results

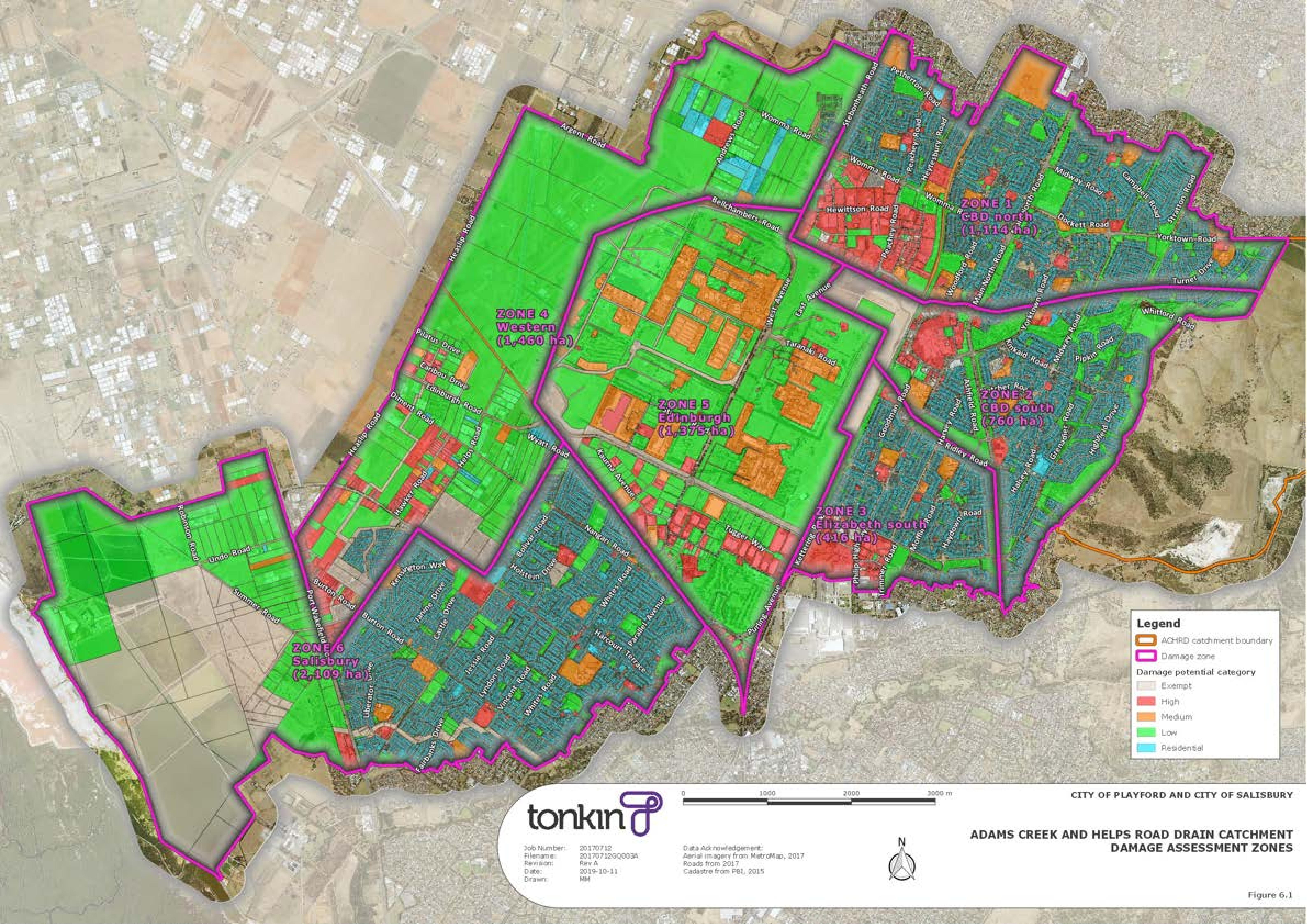
Damages for the study area have been calculated for the full range of modelled flood AEPs for the following scenarios:

- Long-term development with 2050 climate change
- Long-term development with 2050 climate change and structural flood mitigation measures.

The damages were assessed using the zones shown in Figure 6.1 which are broadly described as follows:

- Zone 1 – CBD north (City of Playford)
- Zone 2 – CBD south (City of Playford)
- Zone 3 – Elizabeth south (City of Playford)
- Zone 4 – Western (primarily City of Salisbury)
- Zone 5 – Edinburgh (City of Salisbury)
- Zone 6 – Salisbury (City of Salisbury)

It should be noted that while the flood depth data incorporates changes to the catchment to represent long-term development, the damage value was assigned using the available cadastral data, which relates to the current development status of the catchment.



ZONE 1
CBD north
(1,114 ha)
ZONE 2
CBD south
(760 ha)
ZONE 3
Elizabeth south
(416 ha)
ZONE 4
Western
(1,460 ha)
ZONE 5
Edinburgh
(1,375 ha)
ZONE 6
Salisbury
(2,109 ha)
Legend
ACHRD catchment boundary
Damage zone
Damage potential category
Exempt
High
Medium
Low
Residential
0
1000
2000
3000 m
N
tonkin
Job Number: 20170712
Filename: 20170712GQ003A
Revision: Rev A
Date: 2019-10-11
Drawn: MM
Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads from 2017
Cadastre from PBI, 2015
CITY OF PLAYFORD AND CITY OF SALISBURY
ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
DAMAGE ASSESSMENT ZONES

Figure 6.1

6.2.1 Damages results (2050 scenario)

The flood damages and annual average damages (AAD) for the 2050 scenario are summarised in Table 6.6. The total damages have been reduced by 10% to account for the preparedness of the community.

Table 6.6 2050 flood damages and annual average damages ($ million)

Zone	Annual exceedance probability					AAD
	20%	5%	2%	1%	0.2%	
1	4.8	11.9	22.0	35.0	85.9	2.5
2	1.4	4.9	8.8	13.5	56.9	1.1
3	2.3	4.1	7.4	10.9	52.5	1.0
4	4.7	10.1	16.2	30.2	60.8	2.1
5	3.4	7.8	13.2	24.2	74.8	1.7
6	2.6	5.4	9.2	13.6	30.5	1.1
Total	**19.1**	**44.1**	**76.8**	**127.5**	**361.5**	**9.5**

The damage-probability curve for each zone within the study area is shown in Figure 6.2.

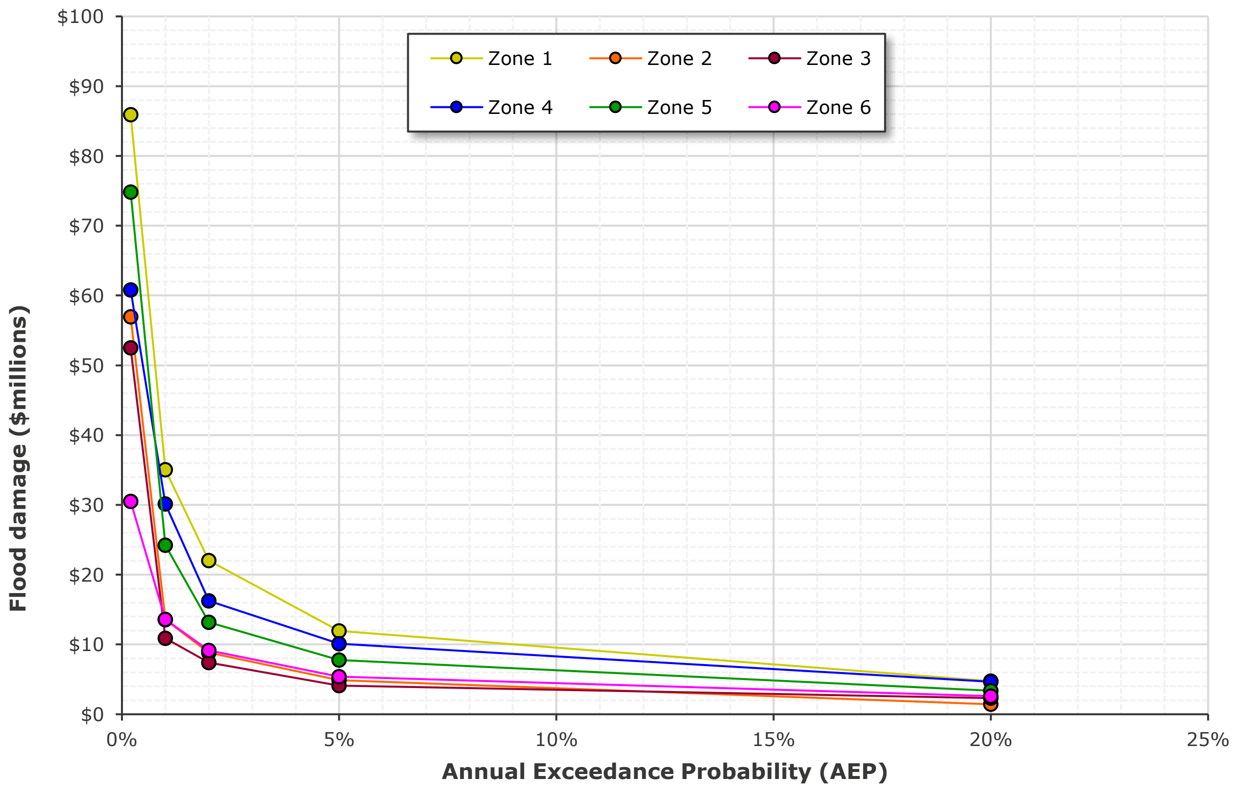


Figure 6.2 Damage-probability curve (2050)

The assessment of damages shows that the greatest damage costs occur within the CBD north zone (Zone 1). This is due to the large number of high value commercial properties affected by flooding. A summary of the number of properties impacted by flooding is provided in Table 6.7.

Table 6.7 Number of properties impacted by flooding, 2050 scenario (residential properties shown in brackets)

Zone	Annual exceedance probability				
	20%	5%	2%	1%	0.2%
1	120 (0)	147 (0)	172 (1)	199 (3)	348 (76)
2	77 (1)	105 (2)	116 (4)	137 (12)	532 (363)
3	22 (0)	38 (5)	64 (23)	87 (41)	311 (243)
4	93 (0)	119 (0)	155 (0)	229 (3)	464 (30)
5	51 (0)	76 (0)	92 (0)	116 (0)	153 (0)
6	74 (0)	96 (0)	134 (3)	173 (15)	408 (161)
Total	**437 (1)**	**581 (7)**	**733 (31)**	**941 (74)**	**2216 (873)**

6.2.2 Damages results (2050 mitigation scenario)

The structural mitigation measures incorporated in the 2050 mitigation scenario (providing improvements to flood damages) are included in Table 6.8. The resulting flood damages and AAD for this scenario are summarised in Table 6.9. It has been assumed that no overflows from Smith Creek will enter the ACHRD catchment for events up to and including the 1% AEP event. The total damages have been reduced by 10% to account for the preparedness of the community.

Table 6.8 Structural mitigation measures included in 2050 mitigation scenario

Mitigation measure	Report section	Damages zone
Promotion Drive flood detention dam	Section 5.2.1	Zone 2
Grenadier Road drain upgrade	Section 5.2.2	Zone 2
Elizabeth windbreaks detention basin	Section 5.2.3	Zone 2
Elizabeth Park windbreaks detention basin	Section 5.2.4	Zone 1
Dwight Reserve detention basin	Section 5.2.5	Zone 1
Adams Creek outlet pipe upgrade	Section 5.2.6	Zone 2
Gawler railway line cross culverts	Section 5.2.7	Zone 3
Salisbury pipe upgrades	Section 5.2.8	Zone 6
Hogarth Road detention basins	Section 5.2.9	Zone 3
Smith Creek works	Section 5.2.11	Zone 4

Table 6.9 2050 mitigation flood damages and annual average damages ($ millions)

Zone	Annual exceedance probability					AAD	AAD reduction	AAD reduction (%)
	20%	5%	2%	1%	0.2%			
1	4.3	8.0	16.4	29.0	84.0	2.0	0.6	22
2	1.3	3.2	5.2	8.2	54.8	0.8	0.3	27
3	2.3	3.9	6.2	10.0	50.6	0.9	0.06	6
4	4.6	9.7	15.5	24.0	58.0	2.0	0.1	6
5	3.4	7.7	13.0	20.7	73.4	1.7	0.04	2
6	2.5	4.2	7.2	12.0	27.9	0.9	0.02	16
Total	**18.3**	**36.7**	**63.6**	**104.0**	**348.7**	**8.3**	**1.3**	**13**

The damage-probability curve for each zone within the study area is shown in Figure 6.3.

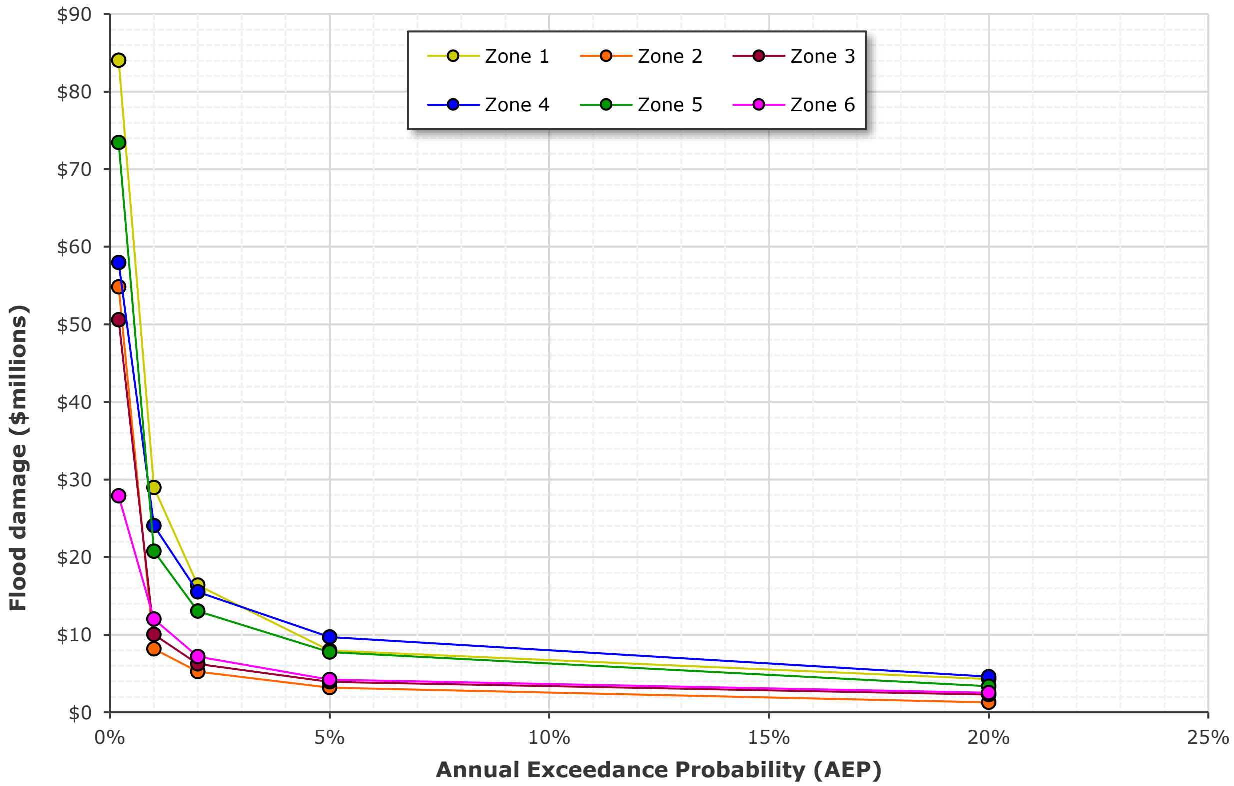


Figure 6.3 Damage-probability curve (2050 mitigation)

The number of properties affected by flooding is summarised in Table 6.10.

Table 6.10 Number of properties impacted by flooding, 2050 mitigation scenario (residential properties shown in brackets)

Zone	Annual exceedance probability				
	20%	5%	2%	1%	0.2%
1	118 (0)	137 (0)	163 (0)	191 (0)	319 (58)
2	73 (0)	99 (0)	105 (1)	118 (2)	512 (342)
3	23 (0)	34 (3)	50 (14)	79 (33)	272 (205)
4	93 (0)	117 (0)	154 (0)	169 (0)	455 (27)
5	51 (0)	76 (0)	92 (0)	116 (0)	152 (0)
6	65 (0)	86 (0)	117 (1)	157 (7)	370 (132)
Total	**423 (0)**	**549 (0)**	**683 (16)**	**830 (42)**	**2080 (764)**

Based on review of the available cadastral data, the total number of residential dwellings currently within the catchment area is 23,637. The 42 residential properties impacted by flooding in the 1% AEP event following implementation of the proposed mitigation strategies represent 0.2% of the catchment.

The total flood damages for these 42 properties has been calculated as $1.75 million. This is in comparison to the estimated total residential property valuation of $4.9 billion across the catchment (i.e. 0.04% of property capital value). As such, the targets relating to inundation of habitable buildings (Table 3.1) have been achieved.

While the flood depths used in the damages assessment incorporated allowances for long-term development, the available cadastral data relates to the current development status. As such, future development in the catchment may modify the total flood damages estimate.

6.3 Economic assessment

To assist in understanding the relative economic benefits of offsetting flood damages via structural mitigation strategies, a benefit-cost ratio (BCR) has been determined for each of the damage assessment zones. Some of the strategies (for example the Elizabeth Park detention basin and the Dwight Reserve detention basins) are interlinked; the performance of one strategy influences the performance of the other.

The BCRs were calculated using a discount rate of 4% across a 50 year period (Commonwealth of Australia, 2018). The BCRs within each zone are summarised in Table 6.11.

Table 6.11 Benefit-cost ratios

Zone	Benefit-cost ratio	Flood mitigation strategies
1	6.85	Dwight Reserve detention basins; Elizabeth Park windbreaks basin
2	1.92	Promotion Drive flood detention dam; Grenadier Road drain upgrade; Elizabeth windbreaks basin; Adams Creek outlet pipe upgrade
3	1.14	Hogarth Road detention basins; Gawler railway line cross culverts
4	N/A	*Reduction in Smith Creek overflows*
5	N/A	*No structural works proposed in this zone, but flooding is influenced by strategies within zones 1, 2 and 3*
6	0.35	Salisbury pipe upgrades

The flood mitigation strategies located within zones 1, 2 and 3 result in positive net benefits (i.e. benefit-cost ratio greater than 1). The high ratio associated with the Dwight Reserve and Elizabeth Park basins is likely a result of the reduction in flooding through the industrial precinct to the north of Bellchambers Road, which has been assigned a 'high' flood damage potential.

7 Optimised decision making methodology

7.1 Background

The New Zealand National Asset Management Steering Group (2004) has developed optimised decision making guidelines (ODMG) to "allow the application of the very best management techniques and practices to ensure that the decisions made on maintaining, renewing and investing in new assets are both optimal and sustainable".

The ODMG are particularly suited to the solving of a single problem or opportunity with a number of worked examples given within the guidelines such as:

- Footpath renewal
- Wastewater treatment plant upgrade
- Road realignment
- Stormwater flooding at a particular location

The development of this SMP has required the selection of solution(s) to identified problem(s) from a range of available solutions.

7.2 Process overview

The guidelines have been used as a tool to support the decision making process, taking into account a range of objectives, in the preparation of this SMP. The four step process is described below.

Step 1: Define the problem or opportunity

The definitions are generally concise, well defined and typically relate to a particular problem (such as a flooding hotspot) or desire to achieve a particular objective (such as a catchment water harvesting target).

Step 2: Identify potential options to manage the problem or opportunity

This step requires the broad identification of all possible solutions. Alongside these, a list of non-negotiable criteria ('deal breakers' such as performance standards and use of valuable open space) would apply, some of which may emerge in response to the nature of the solutions put forward. The options list is then subsequently cut down to a shortlist of potential options according to these criteria.

Step 3: Multi-criteria analysis of the potential options

The options are evaluated against a range of criteria that may include economic, environmental and social considerations. Each option is scored against each of the criteria which are given a weighting based on their relative importance.

Step 4: Identify the optimal solution

This step generally involves selecting a solution that obtains the highest score in the evaluation process.

7.3 Evaluation criteria

A workshop, attended by stakeholders within the catchment area, was facilitated by URPS with the intention of establishing desired outcomes for stormwater management within the catchment. A list of desired outcomes was collated into common themes; the attendees were asked to vote on what they considered to be the most important. It was found that the themes were too interlinked to make a clear distinction of importance. The full outcomes of the workshop can be found in Appendix I.

It was found that planning, policy and governance facilitates and supports:

- Development

- Horticulture
- Use of open space and corridors as a dual stormwater function
- Drainage and flood management
- Implementation of WSUD
- Funding
- Water Policy and pricing

These outcomes contribute to water quality, integrated stormwater management, economic development and harvesting and reuse to deliver a healthy receiving environment, connected healthy communities and economic prosperity.

The outcomes of the workshop were used to help assign weightings to six main evaluation criteria. A number of sub-criteria within each area have also been established. Each of these is described in more detail below.

7.3.1 Flood protection of development

Improved flood protection and public health

This criterion is related to a likely improvement in flood hazard at known flood prone areas and improving public health due to minimising heat island effects.

7.3.2 Runoff quality and impact on receiving environment

The runoff from the catchment should at least be of a quality that does not further contribute to the degradation of Adelaide's coastal marine environment through inputs of nutrient rich, turbid and coloured water. Pollutant reductions can be modelled using MUSIC. The latest water quality targets for new development are provided in Table 7.1.

Table 7.1 Stormwater performance targets (DEWNR, 2013)

Pollutant	Current best practice performance targets
Total suspended solids (TSS)	80% reduction of the untreated urban annual load
Total phosphorus (TP)	60% reduction of the untreated urban annual load
Total nitrogen (TN)	45% reduction of the untreated urban annual load
Litter	90% reduction of the untreated urban annual load

7.3.3 Beneficial use of stormwater

Direct infiltration

Reducing the volume of stormwater runoff through passive infiltration of surface water into the underlying shallow aquifer and the irrigation of vegetated areas. Some examples are raingardens, swales and directing impervious areas to landscaped areas.

Stormwater reuse

Stormwater harvesting for purposes such as irrigation or horticulture through water reuse. A target for reuse would be to provide a noticeable reduction in mains water usage. Examples could be rainwater tanks through to MAR schemes or integration with existing reuse schemes in the catchment.

7.3.4 Social values

Improved visual amenity

Beautify developed areas by landscaping drainage elements such as wetlands and other WSUD features. Rehabilitate degraded assets such as open channels and watercourses. Encourage passive irrigation to improve vegetative health.

Improved safety

Reduce high flood hazard (i.e. deep and fast flowing water) for the public.

Safety considerations at the Edinburgh RAAF base (e.g. bird strike).

Reduce heat island effects through the use of stormwater to improve vegetative health.

Additional useful open space

Improve the functionality and the services available within an area of open space that is currently unavailable for public use, such as wetlands or green space/green trails within drainage corridors.

Disruption during construction

The implementation of some items of new infrastructure may result in disruption to the public. This could include physical displacement and traffic disruptions during construction.

7.3.5 Ecological benefit

Habitat creation

Some stormwater related works have the potential to create new areas of habitat. This would predominantly be within regional scale facilities such as wetlands and basins.

Increased biodiversity

Regional scale stormwater facilities may also provide increased biodiversity in the area by providing new areas of habitat. Biodiversity may be increased by providing green corridors. Environmental flows will help to mimic the natural hydrological cycle.

7.3.6 Economics

Capital cost

This relates to the upfront capital cost of the proposed works. This would be compared against what could reasonably be afforded by Council and the sources of financial support that may be available.

Recurring / maintenance cost

Once established, most new infrastructure will require some form of maintenance.

Economic viability

The economic viability compares the capital cost of the works to the benefits derived from less flood damages to enable the derivation of a benefit to cost ratio.

7.4 Criteria weightings

Weightings have been applied to the evaluation criteria with consideration to the current catchment characteristics, anticipated future catchment development and outcomes from the Stormwater Management Plan Workshop (URPS, 2017). The criteria and sub-criteria weightings have been provided in Table 7.2 and Table 7.3 with the justifications below.

Table 7.2 Weighting of main criteria

Criteria	Weighting
Flood protection of development	30
Runoff quality and impact on receiving environment	25
Beneficial use of stormwater	10
Social values	5
Environmental benefit	5
Economics	25
TOTAL	**100**

Table 7.3 Weighting of sub-criteria

Criteria	Sub-Weighting
Flood protection of development	
Improved flood protection	100
Runoff quality and impact on receiving environment	
Reduction in GP	10
Reduction in TSS	40
Reduction in TN	25
Reduction in TP	25
Increase in beneficial use of stormwater	
Direct infiltration	25
Stormwater reuse	75
Social values	
Improved visual amenity	20
Improved public safety	30
Additional useful open space	30
Disruption during construction	20
Ecological benefit	
Habitat creation	50
Increased biodiversity	50

Criteria	Sub-Weighting
Economics	
Capital cost	50
Maintenance cost	10
Economic viability	40

7.4.1 Flood protection of development

The ACHRD catchment largely consists of residential development with areas of commercial and industry. There are known flooding 'hot-spots' throughout the catchment and flood protection has been given a high weighting.

7.4.2 Runoff quality and impact on receiving environment

The Adelaide Coastal Waters Study (SA EPA, 2007) has found that Adelaide's coastal marine environment has undergone significant modification and degradation as a result of many years of near continuous inputs of nutrient rich, turbid and coloured water. Therefore, it is vital to the health of Adelaide's coastal marine environment that the quality of stormwater discharged to the Gulf is of a standard acceptable to the SA EPA, and hence this criterion has been given a high weighting.

7.4.3 Beneficial use of stormwater

Whilst direct infiltration would better mimic natural groundwater recharge processes, it is more practical to employ aquifer storage and recovery (ASR) or managed aquifer recharge (MAR) in built environments. The water quality and injection and reuse volumes can be controlled such that environmental impacts to the aquifer can be minimised.

There is potential to further harvest stormwater within the catchments. Given that the Cities of Salisbury and Playford have a recycled water network in place, this was given a lower weighting.

7.4.4 Social values

The character of the catchment is already established, however some improvements to social values could be achieved around proposed stormwater infrastructure. There were few social outcomes raised during the stormwater management workshop (URPS, 2017) and therefore social values have been given a lower weighting.

It is likely that the community will value improved safety and additional useful open space more than visual amenity and disruption during construction.

7.4.5 Environmental benefits

The environmental benefits relate to improved habitats and increased biodiversity. The catchment is largely established with existing wetland areas. Whilst some biodiversity improvement will be likely with integrated stormwater management and WSUD, the outcomes of the Stormwater Management Workshop (URPS, 2017) showed a greater emphasis on water quality rather than increased biodiversity. Therefore, this criterion has been given a lower weighting.

7.4.6 Economics

The qualitative and quantitative value of a proposed strategy will be compared with the capital and ongoing outlay when selecting preferred solutions. The viability of a solution is dependent on the availability of funds and based on the outcomes of the Stormwater Management Workshop (URPS, 2017) the economics criteria has been given a higher weighting.

Consideration will also be given to the economic benefits with regards to job creation and decreased flood damages. As this catchment is largely developed, a reduction in flood damages has been given more weighting than economic development.

7.5 Ratings

Each option was given a rating against each criterion. The ratings ranged from 0 through to 4 as described in Table 7.4. This was a qualitative assessment only, with ratings prescribed relative to the other options.

Table 7.4 Criterion rating guide

Rating	Flood protection of development
0	No improvement to existing flood risk.
1	Minor improvement to flood risk.
2	Moderate improvement to flood risk.
3	Major improvement to flood risk. 10%-2% AEP flood protection.
4	Significant improvement to flood risk. 1% AEP flood protection, the maximum level that can reasonably be expected.

Rating	Runoff quality and impact on receiving environment
0	No improvement in water quality.
1	Minor improvement in downstream water quality .
2	Moderate improvement in downstream water quality.
3	Major improvement in downstream water quality.
4	Significant improvement in downstream water quality. Maximum level of improvement that could reasonably be achieved.

Rating	Increase in beneficial use of stormwater
0	No increase in beneficial use of stormwater.
1	Minor increase in beneficial use of stormwater.
2	Moderate increase in beneficial use of stormwater.
3	Major increase in beneficial use of stormwater.
4	Significant increase in beneficial use of stormwater. Maximum level of improvement that could reasonably be achieved.

Rating	Social values
0	No improvement in social values.
1	Minor improvement in social values.
2	Moderate improvement in social values.
3	Major improvement in social values.
4	Significant improvement in social values. Maximum level of improvement that could reasonably be achieved.

Rating	Ecological benefit
0	No ecological benefit.
1	Minor ecological benefit.
2	Moderate ecological benefit.
3	Major ecological benefit.
4	Significant environmental benefit. Maximum level of improvement that could reasonably be achieved.

Rating	Capital, economic viability and maintenance cost
0	Significant costs incurred. Major Council expenditure. Would require significant forward financial planning. Benefit / cost ratio significantly lower than other options and below 1.0.
1	Large costs incurred. Large Council expenditure. Likely to require changes to Council financial planning. Benefit / cost ratio moderately lower than other options.
2	Moderate cost option. Likely to be accommodated based on existing Council budgets. Benefit / cost ratio similar to other options.
3	Low cost option. Benefit / cost ratio moderately higher than other options.
4	Insignificant cost option. Benefit / cost ratio significantly higher than other options and above 1.0.

7.6 Assessment of benefits through implementation of the multi-criteria assessment

Each of the main stormwater management strategies has been assessed using the multi-criteria analysis framework described above. A summary of the resultant ratings is provided in Table 7.5. A full breakdown of the analysis is contained within Appendix J.

Table 7.5 Summary of multi-criteria assessment

Works description	Flood protection	Runoff quality	Beneficial use	Social values	Ecological benefit	Economics	Total score
Elizabeth Parks windbreaks detention basin	22.5	12.5	6.25	1.75	2.5	18.1	63.6
Dwight Reserve detention basins	22.5	3.1	0.6	1.5	1.3	17.5	46.5
Elizabeth windbreaks detention basin	22.5	3.1	0.6	2.1	1.3	15.6	45.3
Raingardens	7.5	11.3	4.4	1.9	2.5	16.3	43.8
WSUD in the backyard	7.5	11.3	5.6	1.6	0	16.3	42.3
Edinburgh Parks North MAR scheme	7.5	11.9	7.5	0.5	0	14.4	41.8
Asset inspection program	22.5	0	0	1.9	0	16.3	40.6
Promotion Drive flood detention dam	15	6.3	0.6	1.4	1.3	15.6	40.1
Education and awareness	7.5	6.3	1.9	1.6	1.3	21.3	39.8
Kaurna Park upgrade	7.5	11.9	7.5	0.5	0	11.3	38.6
Infiltration systems	7.5	5.6	4.4	1.1	0	19.4	38.0
Revegetation of watercourses	7.5	5.6	0.6	2.1	3.8	16.3	35.9
Hogarth Road detention basins	15	3.1	0.6	2.4	1.3	13.1	35.5
Grenadier Road drain upgrade	7.5	0	0	1.1	0	25	33.6
Channel maintenance	7.5	2.5	0	2.4	0	19.4	31.8

Works description	Flood protection	Runoff quality	Beneficial use	Social values	Ecological benefit	Economics	Total score
Adams Creek outlet pipe upgrade	15	0	0	1	0	13.1	29.1
Gawler railway line cross culverts	15	0	0	1	0	10.6	26.6
RAAF flow diversion drain	7.5	0	8.1	1.1	1.3	8.1	26.1
Flood warning system	7.5	0	0	1.8	0	12.5	21.8
Salisbury pipe upgrades	15	0	0	0.8	0	5	20.8
Outfall channel upgrades	15	0	0	1.5	0	0.6	17.1

8 Priorities, costings, responsibilities and consultation

The multi-criteria analysis detailed in Section 7 was used to assess the proposed stormwater management strategies. These strategies have been prioritised, as shown within the following sections and summarised in Table 8.13.

A summary of the costs required to implement a number of the strategies that have been outlined within Section 5 of the report is also provided. The cost estimates for structural mitigation strategies include a 10% allowance for preliminaries and a 20% contingency. A more detailed breakdown of the costs is provided in Appendix K which also lists the assumptions that have been made. One of the key assumptions is that no allowances have been made for service relocation costs, which would need to be refined as part of further design development.

The strategies outlined in this SMP will require implementation to be scheduled across many years in order to be accommodated sustainably within the budget of each council and other potential funding partners.

8.1 Priorities for flood mitigation works

8.1.1 Priority F1 (high priority): Elizabeth Park windbreaks detention basin

Construction of a basin within the Elizabeth Park windbreaks site provides a fairly significant reduction in flood depths through the residential properties to the south of Womma Road and east of Main North Road. Additionally, flooding through the commercial precinct to the north of Bellchambers Road is improved. Property valuations for the commercial precinct are high, and hence the reduced flood depths within this area result in a large improvement to annual average damages. This resulted in a high benefit-cost ratio (6.9, when implemented with the Dwight Reserve detention basins).

While the basin has been sized to predominantly intercept surface flood flows, it will also intercept the base flows passing along the channel to the north. This water can then be temporarily retained on site for water quality improvement purposes, through settling of sediments and capture of gross pollutants. It can then be transferred, via a pump station, to the Council's water harvesting scheme.

The Elizabeth Park detention basin requires excavation of close to 20,000 m^3 of material, in addition to connecting to the existing drainage network and tree removal costs. The cost estimate is provided in Table 8.1.

Table 8.1 Construction cost estimate for Elizabeth Park windbreaks detention basin

Item	Cost ($)
Preliminaries	65,000
Construction cost	542,000
Harvesting facility	$108,000
Land acquisition	N/A
Contingency	143,000
Total	**857,000**

8.1.2 Priority F2 (high priority): Dwight Reserve detention basins

The Dwight Reserve detention basins are located upstream of the Elizabeth Park windbreaks detention basin and contribute to the flood improvements observed within this precinct. As such, it is recommended that these two projects are undertaken in conjunction.

This series of three basins requires excavation works, building up of an embankment, connection to the existing drainage network and tree removals. The estimated costs are shown in Table 8.2.

Table 8.2 Construction cost estimate for Dwight Reserve detention basins

Item	Cost ($)
Preliminaries	57,000
Construction cost	577,000
Land acquisition	N/A
Contingency	127,000
Total	**761,000**

8.1.3 Priority F3 (high priority): Elizabeth windbreaks detention basin

Modelling results indicate that the Elizabeth windbreaks detention basin reduces flood depths through residential properties to the west of Main North Road by up to 300 mm in the 1% AEP event. While the full benefits of the basin are not realised without the implementation of the Grenadier Road drain upgrade and Promotion Drive flood detention dam, it is recommended that the basin be constructed first.

As with the other basins, this strategy will provide water quality improvements through the settling of sediments and capture of gross pollutants. The basin is designed to intercept surface flood flows only. As such, the basin will become inundated during large storm events only and hence could continue to be used as public open space.

This strategy requires excavation works, connection to the existing drainage network, as well as tree removals. The costs associated with this measure are summarised in Table 8.3.

Table 8.3 Construction cost estimate for Elizabeth windbreaks detention basin

Item	Cost ($)
Preliminaries	38,000
Construction cost	379,000
Land acquisition	N/A
Contingency	83,000
Total	**500,000**

8.1.4 Priority F4 (medium priority): Grenadier Road drain upgrade

The embankment upgrade to the Grenadier Road drain is an inexpensive strategy with reasonable improvements to flooding through residential properties to the west. The upgrade would not provide any water quality or environmental benefits, however given the low cost of implementation, it is suggested that it be undertaken following construction of the Elizabeth windbreaks detention basin downstream.

In terms of capital costs, the Grenadier Road drain upgrade is the cheapest flood mitigation strategy, the implementation of which is likely to be a relatively straightforward exercise. The cost estimate is shown in Table 8.4.

Table 8.4 Construction cost estimate for Grenadier Road drain upgrade

Item	Cost ($)
Preliminaries	1,000
Construction cost	15,000
Land acquisition	N/A
Contingency	3,000
Total	**19,000**

8.1.5 Priority F5 (medium priority): Promotion Drive flood detention dam

For a moderate capital cost (estimated to be $550,000), construction of the Promotion Drive flood detention dam will control flows through the Grenadier Road drain, improving flooding of residential properties within Elizabeth East, particularly along Dewey Street.

A significant proportion of the costs associated with this option are due to the requirement for a large quantity of fill material (10,600 m^3). Land acquisition and tree removals are also required. The costs are summarised in Table 8.5.

Table 8.5 Construction cost estimate for Promotion Drive flood detention dam

Item	Cost ($)
Preliminaries	42,000
Construction cost	419,000
Land acquisition	N/A
Contingency	92,000
Total	**553,000**

8.1.6 Priority F6 (medium priority): Education and awareness

For a relatively modest investment, a public education programme that raises awareness of flood risk and provides information to individuals and businesses that guides their response to floods can reduce flood damages. Increased public awareness of flooding allows a more effective response to flooding and has been demonstrated to result in lower damages.

The development of this SMP has led to a vastly improved understanding of the flooding characteristics within the study area and detailed floodplain maps for a range of events have been prepared.

This improved understanding, and the outputs from the SMP should be made available to, and communicated widely with, the community to improve the understanding of where flooding is likely to occur. Awareness of flood risk can assist the community to better manage the risk and reduce flood damages.

An initial cost of $70,000 is estimated for this regime, with ongoing annual costs of $10,000.

8.1.7 Priority F7 (medium priority): Hogarth Road detention basins

Detaining water within the Hogarth Road basins is observed to improve flooding through residential properties within Elizabeth Grove and Elizabeth South. The basins will be formed by creating embankments to capture surface flows, and hence the estimated construction costs are quite low.

Costs associated with the Hogarth Road detention basins include costs for fill material, connection to the existing drainage network and tree removals. The cost estimate is shown in Table 8.6.

Table 8.6 Construction cost estimate for Hogarth Road detention basins

Item	Cost ($)
Preliminaries	19,000
Construction cost	195,000
Land acquisition	N/A
Contingency	43,000
Total	**257,000**

8.1.8 Priority F8 (medium priority): Channel maintenance

Efforts to maintain the hydraulic capacity of the channels within the catchment by removing obstructions (such as illegal dumping and self-seeded vegetation) should be undertaken. Significantly less resources are required to remove small self-seeded trees than mature trees. Heavy infestations of woody weeds would require periodic removal and may require revegetation works to stabilise the banks. Initial maintenance is estimated to cost $30,000 followed by annual channel maintenance of $10,000 per year thereafter.

8.1.9 Priority F9 (medium priority): RAAF flow diversion drain

Despite not scoring highly in the multi-criteria analysis, the potential for harvesting non-contaminated water following construction of the RAAF flow diversion drain improves the appeal of this strategy.

The construction costs are based on a concept design and are indicative only. Significant variance could occur due to a range of unknown factors including encountering rock, having to excavate below groundwater levels, the potential for soil contamination and service relocation costs. Both the eastern and western alignments will require land acquisition but this has not been included in the cost estimate.

The proposed diversion drain would significantly reduce flood risk within the RAAF base. Further hydraulic modelling would be required to quantify the flood reduction benefits. Indicative construction costs (excluding land acquisition) are provided in Table 5.8.

Table 8.7 Indicative construction costs for the RAAF flow diversion drain

Western alignment	Eastern alignment
$10-$15 million	$40-$50 million

8.1.10 Priority F10 (low/medium priority): Adams Creek outlet pipe upgrade

The Adams Creek outlet pipe upgrade improves flooding through the Elizabeth City Centre. Given that there are no improvements to water quality or stormwater harvesting opportunities associated with this strategy, and the construction costs are high (exceeding $2 million), a lower priority ranking has been assigned.

This pipe upgrade option involves duplication of approximately 700 m of pipe across Main North Road and through Elizabeth City Centre. The cost estimate shown in Table 8.8 includes the supply and installation of new pipe, as well as the associated junction boxes and headwall. No allowance has been made for the creation of easements.

Table 8.8 Construction cost estimate for Adams Creek outlet pipe upgrade

Item	Cost ($)
Preliminaries	161,000
Construction cost	1,612,000
Land acquisition	N/A
Contingency	354,000
Total	**2,128,000**

8.1.11 Priority F11 (low/medium priority): Gawler railway line cross culverts

Significant reductions in flood depths are observed to the east of the railway line following construction of the proposed cross culverts. However, as with the Adams Creek outlet pipe upgrade, there are no improvements to water quality or stormwater harvesting opportunities, and hence this strategy has been given a lower priority ranking.

The cost estimate (Table 8.9) associated with construction of three culverts passing below the railway line includes an allowance for reinstatement of the railway as well as night works. No allowance has been made to the potential disruption to rail services.

Table 8.9 Construction cost estimate for Gawler railway line cross culverts

Item	Cost ($)
Preliminaries	57,000
Construction cost	574,000
Land acquisition	N/A
Contingency	126,000
Total	**758,000**

8.1.12 Priority F12 (not recommended): Outlet channel upgrades

While these works have the potential to significantly reduce flood risk to the east of the Bolivar lagoons, it would potentially require significant disturbance of samphire shrubland that has high conservation significance. The areas that are flood prone are also not developed, and therefore the reduction in damages would not be significant, given the amount of works that would be required.

8.1.13 Priority F13 (low priority): Flood warning system

Given the relatively short catchment response times a flood warning system would have little value in the catchment.

8.1.14 Priority F14 (low priority): Salisbury pipe upgrades

The Salisbury pipe upgrade is an expensive strategy to implement (cost estimate exceeds $10 million due to the long length of pipe required), resulting in a benefit-cost ratio of 0.35. While the upgrades result in improvements to flooding throughout the City of Salisbury, the high cost is considered to be a limiting factor, and hence this option has been given a low priority.

The cost estimate is shown in Table 8.10. This option also has potentially the highest risk of expensive service relocation costs.

Table 8.10 Construction cost estimate for Salisbury pipe upgrades

Item	Cost ($)
Preliminaries	825,000
Construction cost	8,252,000
Land acquisition	N/A
Contingency	1,816,000
Total	**10,893,000**

8.1.15 Priority F15 (medium priority): Review of Planning and Design Code

Review of the Planning and Design Code should be undertaken to assess its limitations in relation to flood controls.

8.1.16 Smith Creek overflow detention basin

It is assumed that for events up to and including the 1% AEP event, there will be no flows entering the ACHRD catchment from Smith Creek. However, if it is determined that the Smith Creek overflow detention basin should be constructed, the associated costs will be dependent on the target discharge rate selected. These costs are summarised in Table 8.11.

Table 8.11 Indicative basin sizes to detain overflows from Smith Creek

Target discharge rate (L/s)	Volume (ML)	Indicative cost ($ million)
200	390	17.2
500	380	16.8
1000	360	16.2
2000	338	15.2

Target discharge rate (L/s)	Volume (ML)	Indicative cost ($ million)
6000	225	9.9

8.2 Priorities for water reuse

8.2.1 Priority R1 (high priority): Edinburgh Parks North detention basin

The Edinburgh Parks North detention basin has not previously been used for water harvesting purposes, however has an estimated potential yield of 600 ML/a. As this wetland is not subject to PFAS contamination, it is recommended that the viability of utilising it for harvesting purposes be investigated. Discharging water into a well at this location is subject to the conditions specified in the Northern Adelaide Plains water allocation plan. The requirements of the plan are not expected to impact on the ability to implement this priority.

Given the presence of infrastructure that has been installed previously and is available for use, capital costs associated with the Edinburgh Parks North wetland water harvesting scheme are expected to be in the order of $400,000. It is anticipated that ongoing maintenance costs (such as cleaning of the wells) would be more than offset by the revenue generated from the sale of harvested water.

For the scheme to be worthwhile, the City of Salisbury will need to identify areas of demand. If no local demands are identified, there is potential for the harvested water to be sold to other nearby councils.

8.2.2 Priority R2 (high priority): Infiltration systems

Installation of infrastructure such as permeable paving and tree pits will allow stormwater to infiltrate into the soil. It can help to passively irrigate street trees and other landscaped areas. These systems should become a required component of all new road reconstruction projects and form part of the requirements for new developments.

Melbourne Water (2012) estimates that porous engineering paving is likely to cost between $100-$120 per m^2, while the City of Melbourne (2015) estimates that tree pits cost between $4,000 and $8,000 per tree.

8.2.3 Priority R3 (low priority): Kaurna Park water harvesting upgrade

Expansion of the Kaurna Park wetland would result in annual harvested volumes of up to 690 ML/a. However, as the wetland is located downstream of the RAAF base, and is currently receiving runoff carrying PFAS contaminants, the wetland could not be used for water harvesting purpose until the RAAF diversion drain is constructed.

If the PFAS contamination could be removed and the harvesting program authorised to recommence, the priority of this measure would be elevated. Discharging water into a well at this location is subject to the conditions specified in the Northern Adelaide Plains water allocation plan. The requirements of the plan are not expected to impact on the ability to implement this priority.

8.3 Priorities for water quality

8.3.1 Priority Q1 (high priority): Raingardens

In selected areas where there are wide road reserves and relatively flat topography (such as within the City of Salisbury), raingardens should be retrofitted into the existing street network. These works should become a required component as a part of any planned road works (such as the installation of traffic calming devices and road reconstruction projects). Due to the limited open space within the study area the opportunities for the implementation of large scale WSUD infrastructure, such as wetlands, are limited. Therefore, the importance of smaller scale WSUD infrastructure, such as raingardens, is increased.

Raingardens provide improved water quality and facilitate infiltration of small flow events and reductions in nuisance flooding. They provide improved aesthetics and will help to counteract urban heat island effects.

The estimated construction costs for a single streetscape raingarden are provided in Table 8.12. Works undertaken previously by the City of Adelaide to install 8 raingardens and 14 street trees within Waymouth Street cost a total of $385,000 (DEWNR, 2017). On this basis, a unit rate of $3,200/m^2 for the construction of a raingarden has been adopted, assuming an average surface area of 15 m^2.

Table 8.12 Construction cost estimate for a raingarden

Item	Cost ($)
Preliminaries	5,000
Construction cost	48,000
Contingency	11,000
Total	**63,000**

8.3.2 Priority Q2 (medium priority): WSUD in the backyard

Council should work with Water Sensitive SA to promote the concept of WSUD in the backyard. Activities may include the preparation of information materials and periodic publicity to encourage residents to take action at a domestic scale which will improve water quality.

A program to raise community awareness about WSUD in the backyard will require time and effort to promote. The expenses incurred may include preparation of materials, articles in the News Review Messenger, community presentations and liaison with developers. It is estimated that the cost of this will be $20,000 in the first year, with ongoing annual costs of $10,000.

8.4 Priorities for environmental protection and enhancement

8.4.1 Priority E1 (high priority): Weed management of watercourses

Initial investment should be spent in removing isolated cases of weeds before they become more widespread. Removal of weeds should also be prioritised in high conservation areas, including olives within the remnant woodland areas.

A large effort would be required up front to remove the declared weeds and weeds of concern identified by EBS Ecology (2019). Costs within the first two years are estimated to be $80,000 per year. Following this, annual maintenance of $30,000 is expected. Removal of weeds would be subject to agreement from the relevant landholder.

8.4.2 Priority E2 (high priority): Revegetation and erosion management of watercourses

In conjunction with weed management, areas should be revegetated, where appropriate, with carefully selected locally sourced native species, particularly in the eastern portion of the catchment. An initial focus should also be to manage the identified areas of channel erosion.

Following removal of weeds from the channels, revegetation with native species will provide additional watercourse enhancement and erosion protection. It is estimated that $50,000 per year for the first two years would be required for initial vegetation establishment and erosion management, followed by $20,000 per year thereafter.

8.5 Priorities for asset management

8.5.1 Priority A1 (medium priority): Asset inspection program

The CCTV inspection component of the program should be prioritised based on asset age and significance. Once a good asset condition database has been established the inspection program can focus on infrastructure nearing the end of its service life, such that the assets can be replaced before they fail.

Physical inspections of other assets, such as basins, should also be undertaken. Priority should be given to assets where failure could result in significant damages or reductions in water quality.

An allowance of $20,000 per year would cover periodic CCTV inspection of key drainage assets within the catchment that would provide a good ongoing understanding of the condition of existing stormwater assets. A further $10,000 is required for physical inspection of assets, such as watercourses and basins.

8.6 Funding opportunities

The strategies and projects identified in the SMP are regional solutions that will need to be considered on a project-by-project basis and considered against other priorities within each Council's annual budgeting cycle and against Council's Long Term Financial Plans.

The SMP will inform Council's decision to pursue funding opportunities to co-fund the works identified. In order to fund the works, there are several funding streams available, as described in the following sections.

8.6.1 Stormwater Management Authority

Stormwater management projects within catchments that have an area greater than 40 ha and are part of an endorsed SMP are eligible for SMA funding. The SMA typically prioritises funding towards schemes that provide a wide range of benefits including water quality and reuse. Given the large-scale strategies detailed within this SMP, almost all of the proposed structural flood mitigation strategies would be eligible. As such, it is recommended that SMA funding be sought.

8.6.2 Green Adelaide

The Green Adelaide Board may provide funding that can be used to help support measures that will benefit natural resources management, including actions which improve the quality of water within the study area or that will facilitate an increase in stormwater reuse. The Board could potentially help to co-fund some of the works recommended as part of the SMP or provide in-kind support.

8.6.3 Royal Australian Air Force (RAAF)

The RAAF could potentially be a key contributor for construction of the RAAF diversion drain. This project is only likely to proceed if the RAAF contribute a significant proportion of the construction costs. The benefits of this measure would primarily accrue to the Department of Defence, as both the beneficiary of the flood protection and as the PFAS contamination exacerbator.

8.6.4 Metropolitan Open Space System (MOSS)

There may be opportunities for funding through the MOSS from the State Government for some of the stormwater management works outlined in this study.

8.7 Timeframes

Council undertakes operational and renewal stormwater works on an annual basis which forms part of Council's Four Year Delivery Plan and Annual Business Plan. These works have a cost of $5.94 million. The projects identified in the SMP are regional solutions that would need to be considered on a project-by-project basis and considered against other priorities within the annual budgeting cycle.

The projects require a considerable expenditure and will need to be staged over several years and budget cycles. The timeframes outlined in this report are approximate, and subject to Council's budget cycle and may be influenced by the timing of external funding opportunities.

An indicative capital works plan is provided in Table 8.14.

8.8 Responsibilities

The ACHRD SMP provides a framework for the management of stormwater within the catchment. The Steering Committee which has overseen the development of the SMP comprises representatives from key stakeholder organisations that have responsibility for implementing the plan. These include the City of Playford, City of Salisbury and representatives of the SMA.

Many of the structural flood mitigation works are located within the City of Playford; it is only the Salisbury pipe upgrades and RAAF diversion drain that are located within the City of Salisbury.

Both Councils will be required to play an important role in implementing water quality management within the catchment.

Cost sharing principles outlined in the SMA SMP Guidelines have been adopted and the likely financial contributions required by each Council are summarised in Table 8.14. For capital works the costs are assumed to be wholly borne by the Council that the works are located in. For catchment wide education the costs are split evenly across the Councils, given the fairly even catchment split at the Council boundary. For distributed on ground works (such as raingardens) costs have been weighted based on where most of the works would be likely to occur. Recurrent costs are also expected to follow the same cost sharing distribution.

8.9 Consultation

The objectives of stakeholder consultation for the SMP are to:

- Communicate the SMP and its aims to stakeholders.
- Obtain stakeholder input to the SMP, specifically the identification of key stormwater management issues and opportunities.
- Obtain stakeholder feedback on structural and non-structural stormwater management measures developed for the SMP.

Key stakeholders include the City of Playford and the City of Salisbury. Additionally, the following State Government agencies have been identified:

- SA Water
- Department of Planning, Transport and Infrastructure
- Department for Environment and Water
- Coast Protection Board
- Environment Protection Authority South Australia
- Department of Primary Industries and Regions South Australia
- Department of State Development.

Consultation with Green Adelaide, as well as with the broader community, will also be required.

The following tasks are proposed to inform the identified stakeholders about issues that may affect them:

- Development of a media release to be published on each Council's website.
- Advertisement in the local Messenger.
- Display of the draft SMP at Council libraries and offices.
- Letter or leaflet to landholders that may be affected by proposed management actions, informing them of the recommendations of the SMP and opportunities for feedback.
- Development of feedback forms.

8.9.1 Consultation undertaken to date

An initial stakeholder workshop was undertaken at the Tonkin office in October 2017. It covered both this catchment and the adjacent GEP catchment with almost 70 issues and opportunities identified. Details of this workshop are included in Appendix I. The key SMP outcomes were voted on with the three most important being:

- Planning and development.
- Funding and costs.
- Receiving environments.

A meeting between the City of Playford and Kaurna representatives was held on 3 May 2019. It was recommended that a formal principles-based agreement (e.g. a memorandum of understanding) regarding Kaurna involvement in the SMP implementation and future reviews should be established. This is to ensure that, as the traditional owners of the Adelaide Plains, Kaurna values are respectfully recognised in the strategies included in the SMP.

8.9.2 Public consultation

A 28-day public consultation on the draft SMPs took place from 7 April 2022 to 9 May 2022 in accordance with the City of Playford Community Engagement Policy and Procedure.

The objective of the community engagement for the SMPs was to:

- **Inform** the wider community about the draft SMPs and build awareness of their role in guiding future decisions related to stormwater management.
- **Consult** the community on the draft SMPs, seeking views on the objectives of each SMP which have informed the priorities.

Through the public consultation process the wider community were informed about the draft SMPs and their role in guiding future decisions and investment related to stormwater management. A copy of the feedback received during this consultation period can be found in the What We Heard Report (Appendix L). Following review of the limited feedback received, it is considered that no further changes are required to the plan.

8.10 Summary of priorities

The summary of priorities is provided in Table 8.13.

Table 8.13 Summary of priorities

					Flood Mitigation Benefit		Water Harvesting Benefit		Water Quality Benefit		Other Benefits	
Priority	Project/ Activity Title	Capital Cost	SMA Funding Eligible	Recurrent Cost ($ / annum)	Measure used?	Quantification or Description of Benefit	Measure used?	Quantification or Description of Benefit	Rating	Qualitative Description of Benefit	Rating	Qualitative Description of Benefit
					(D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative		(V) Volumetric (Q) Qualitative		(H) – High (M) – Med (L) – Low		(H) – High (M) – Med (L) – Low	
F1 – High	Elizabeth Park windbreaks detention basin	$857,000	Y	$3,300	D	$567,000 AAD reduction (In combination with Priority F2)	Q	Runoff captured and treated in basin to be pumped to the Playford ASR scheme	L	Low flow channel will facilitate removal of sediments/gross pollutants from stormwater	L	Possibility for landscaping for improved amenity and biodiversity
F2 – High	Dwight Reserve detention basins	$761,000	Y	$4,100	D	$567,000 AAD reduction (In combination with Priority F1)	Q	-	L	Detention basin may facilitate removal of sediments/gross pollutants from stormwater	L	Possibility for landscaping for improved amenity and biodiversity
F3 – High	Elizabeth windbreaks detention basin	$500,000	Y	$4,000	D	$294,000 AAD reduction (In combination with Priorities F4, F5 and F10)	Q	-	L	Detention basin may facilitate removal of sediments/gross pollutants from stormwater	L	Possibility for landscaping for improved amenity and biodiversity
Q1 – High	Raingardens	$63,000 each	N	$300 per raingarden	Q	Minor improvement to flooding	Q	Able to infiltrate water close to the source and assist with passive irrigation of street trees	H	Large benefits if constructed in sufficient numbers across the catchment	M	Can improve amenity, reduce heat island impacts
R1 – High	Edinburgh Parks North detention basin water harvesting	$400,000	Y	$100,000	Q	Reduced catchment runoff	V	600 ML/a	M	Wetland acts as a filtering system removing sediment, nutrients and pollutants from water	H	Possibility of reducing Council usage of
R2 – High	Infiltration systems	Variable	N	Variable	Q	Minor improvement to flooding	Q	Able to infiltrate water close to the source and assist with passive irrigation of street trees	M	Large benefits if constructed in sufficient numbers across the catchment	M	Can improve amenity, reduce heat island impacts.
E1 – High	Weed management	$160,000	N	$30,000	Q	Minor improvement to flood conveyance when weeds removed from channel	Q	-	L	Nil	M	Prevents further spread of weeds
E2 – High	Revegetation and erosion management	$50,000	N	$20,000	Q	Minor improvements to flooding (unvegetated banks more susceptible to erosion)	Q	-	M	Absorption of nutrients by riparian vegetation provides improvements to water quality	L	Improved amenity value
F4 – Medium	Grenadier Road drain upgrade	$19,000	Y	$0	D	$294,000 AAD reduction (In combination with Priorities F3, F5 and F10)	Q	-	L	Nil	L	Improved public safety
F5 – Medium	Promotion Drive flood detention dam	$553,000	Y	$2,000	D	$294,000 AAD reduction (In combination with Priorities F3, F4 and F10)	Q	-	M	Dam may facilitate removal of sediments/gross pollutants from stormwater	L	Improved public safety
F6 – Medium	Education and awareness	$70,000	N	$10,000	Q	Likely to lower flood damages	Q	-	M	Improved community attitude and understanding of water quality; public better understands the implications of their actions on receiving waters	M	Public can better respond to flooding. Better community resilience to flooding.
F7 – Medium	Hogarth Road detention basins	$257,000	Y	$1,000	D	$55,000 AAD reduction (In combination with Priority F11)	Q	-	L	Detention basin may facilitate removal of sediments/gross pollutants from stormwater	L	Possibility for landscaping for improved amenity and biodiversity
Q2 – Medium	WSUD in the backyard	$20,000	N	$10,000	Q	Minor reduction in the amount of runoff generated by a site	Q	Opportunities for water reuse at an individual lot scale (e.g. rainwater tanks)	H	Infiltration and vegetative filtering. Large benefits if constructed in sufficient numbers	M	Visual amenity
F8 – Medium	Channel maintenance	$30,000	N	$10,000	Q	Minor improvements to flooding by maintaining hydraulic capacity of channels	Q	-	L	Removal of gross pollutants from channels	L	Improved amenity value
F9 – Medium	RAAF flow diversion drain	$10-$15 m	Y	$0	Q	Improvements to flooding within the RAAF base	Q	Significant water harvesting potential following diversion of drain from PFAS contamination area	H	Stormwater runoff bypasses PFAS contaminants	-	-
F15 - Medium	Review of Planning and Design Code	$10,000	N	$0	Q	Identify potential changes to the code to provide better flood mitigation requirements for new developments	Q	Nil (unless required)	L	Potential to specify water quality requirements for new developments	-	-

					Flood Mitigation Benefit		Water Harvesting Benefit		Water Quality Benefit		Other Benefits	
Priority	Project/ Activity Title	Capital Cost	SMA Funding Eligible	Recurrent Cost ($ / annum)	Measure used?	Quantification or Description of Benefit	Measure used?	Quantification or Description of Benefit	Rating	Qualitative Description of Benefit	Rating	Qualitative Description of Benefit
					(D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative		(V) Volumetric (Q) Qualitative		(H) – High (M) – Med (L) – Low		(H) – High (M) – Med (L) – Low	
A1 – Medium	Asset inspections	$30,000	N	$30,000	Q	Potentially significant improvement if an asset is identified for remediation/replacement before it fails	Q	-	M	Inspections can ensure WSUD assets are performing as originally intended	L	Improve public safety, proactively identify issue
F10 – Low/Medium	Adams Creek outlet pipe upgrade	$2.1 m	Y	$0	D	$294,000 AAD reduction (In combination with Priorities F3, F4 and F5)	Q	-	L	-	L	Improved public safety
F11 – Low/Medium	Gawler railway cross culverts	$758,000	Y	$0	D	$55,000 AAD reduction (In combination with Priority F7)	Q	-	L	-	L	Improved public safety
F12 – Not recommended	Outfall channel upgrades	Unspecified	Y	Unspecified	Q	Improvements to flooding through undeveloped land east of the Bolivar lagoons	Q	-	L	-	-	-
F13 – Low	Flood warning system	Unspecified	N	Unspecified	Q	Provide for a reduction in flood damages by giving people time to prepare for flooding	Q	-	L	-	M	Less intangible flood losses if people are able to prepare for flooding
F14 – Low	Salisbury pipe upgrades	$10.9 m	Y	$0	D	$177,000 AAD reduction	Q	-	L	-	L	Improved public safety
R3 – Low	Kaurna Park water harvesting upgrade	Unspecified	N	Unspecified	Q	Reduced catchment runoff	V	Opportunity to increase water harvesting to 690 ML/a	H	Wetland acts as a filtering system removing sediment, nutrients and pollutants from water	-	-

The works shown in Table 8.13 are currently unfunded and would need to be considered as part of Council's budgeting process.

Table 8.14 10-year capital works plan (values in millions)

Priority	Works	Playford contribution	Salisbury contribution	21/ 22	22/ 23	23/ 24	24/ 25	25/ 26	26/ 27	27/ 28	28/ 29	29/30	31/32
F1	Elizabeth Park windbreaks detention basin	100%	0%	0.43	0.43								
F2	Dwight Reserve detention basins	100%	0%			0.38	0.38						
F3	Elizabeth windbreaks detention basin	100%	0%					0.25	0.25				
Q1	Raingardens	30%	70%		0.12		0.12		0.12		0.12		0.12
R1	Edinburgh Parks North detention basin water harvesting	0%	100%							0.40	0.10	0.10	0.10
R2	Infiltration systems	50%	50%	0.10		0.10		0.10		0.10		0.10	
E1	Weed management	60%	40%	0.08	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
E2	Revegetation	60%	40%	0.05	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
F4	Grenadier Road drain upgrade	100%	0%						0.02				
F5	Promotion Drive flood detention dam	100%	0%							0.27	0.27		
F6	Education and awareness	50%	50%	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
F7	Hogarth Road detention basins	100%	0%									0.13	0.13
Q2	WSUD in the backyard	50%	50%	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
F8	Channel maintenance	50%	50%	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
A1	Asset inspections	50%	50%	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F15	Review of Planning and Design Code	100%	0%	0.01									
Total	**$5.94 million**			**0.82**	**0.74**	**0.57**	**0.59**	**0.44**	**0.48**	**0.86**	**0.58**	**0.42**	**0.44**

The works shown in Table 8.14 are currently unfunded and would need to be considered as part of Council's budgeting process.

8.11 Attainment of the proposed levels of service

The proposed strategies in Section 5 have been evaluated against the catchment objectives outlined in Section 3.

8.11.1 Service attribute 1: Flood management

The SMP has proposed many management strategies that reduce flooding within the catchment. The management strategies target the most pronounced areas of flooding and are effective in reducing flood damages across the catchment. There are areas that the proposed strategies do not address. However, these areas can be successfully investigated in the future using the detailed flood model produced for the SMP. It should be noted that the implementation of non-structural measures will help to reduce flood damages in these areas as well. Hazard mapping of the catchment confirmed that the targeted proportion of 95% of residential properties not subject to more than low flood hazard is currently met.

8.11.2 Service attribute 2: Water quality improvement and re-use

Water quality modelling has been undertaken for the catchment. The results have shown that the proposed treatment train will meet the pollution reduction targets.

It is noted that the 95th percentile concentration targets for phosphorus and nitrogen have not been met. Water quality improvement measures at the lot scale, in addition to those at the whole of catchment scale, will further assist with achieving these targets. Lot-scale modelling of water quality measures has not been undertaken, and hence the benefits from these measures have not been quantified. Additionally, non-structural measures will also provide benefits.

No direct assessment has been made in relation to the targets for turbidity or faecal coliforms which are not explicitly modelled within the MUSIC software.

In terms of water re-use, the large harvesting schemes proposed in the catchment result in a 63% reduction in runoff generated by the catchment (for the 2050 climate change scenario). Widespread rollout of WSUD measures will help to encourage infiltration of stormwater close to its source.

8.11.3 Service attribute 3: Amenity, recreation and environmental enhancement

Environmental enhancement and beneficial use of drainage reserves can be attained through the establishment of green corridors/linear parks.

8.11.4 Service attribute 4: Asset management

The SMP presents several strategies that the Councils can implement to manage their stormwater assets effectively. The strategies are focused towards ensuring identification of deteriorated assets early to enable proper planning of their replacement. Setting aside funds to implement the strategies will assist the Councils' long-term management of their assets.

8.12 Implications for adjoining catchments

The impacts of the proposed measures described within this SMP will be localised to the ACHRD catchment area. Other than a very minor potential reduction in flood flows passing westerly into the adjacent GEP catchment near the ARTC rail line in extreme rainfall events, there are no implications for adjoining catchments.

9 References

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Appendix A – Adams Creek and Greater Edinburgh Parks flood inundation modelling methodology (extract from Tonkin, 2016c)

Adams Creek and Greater Edinburgh Parks areas

Flood Mapping, Flood Hazard Mapping and Flood Damage Assessment

City of Playford
City of Salisbury

July 2016

Ref No. 20110409DR3D

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3.6 RORB modelling

The predominantly rural hills face catchments at the upstream end of the catchment were modelled using the RORB runoff routing program to produce creek inflow hydrographs at the boundary of the TUFLOW model. The layout of the RORB models can be seen in Figure 3.3.

The RORB input parameters for each model were adopted to be consistent with those of the *Dry Creek Floodplain Mapping Study* (Tonkin Consulting, 2008). The parameter values were based on calibration against gauged flow. The hydrology report that was prepared for that study received approval from the AMLR NRM Board, Salisbury Council, the Bureau of Meteorology and DPTI (David Kemp). Use of the same parameters in this study is considered to be appropriate given the close proximity and topography of the two areas. The adopted RORB input parameters are presented in the following sections.

3.6.1 Loss parameters

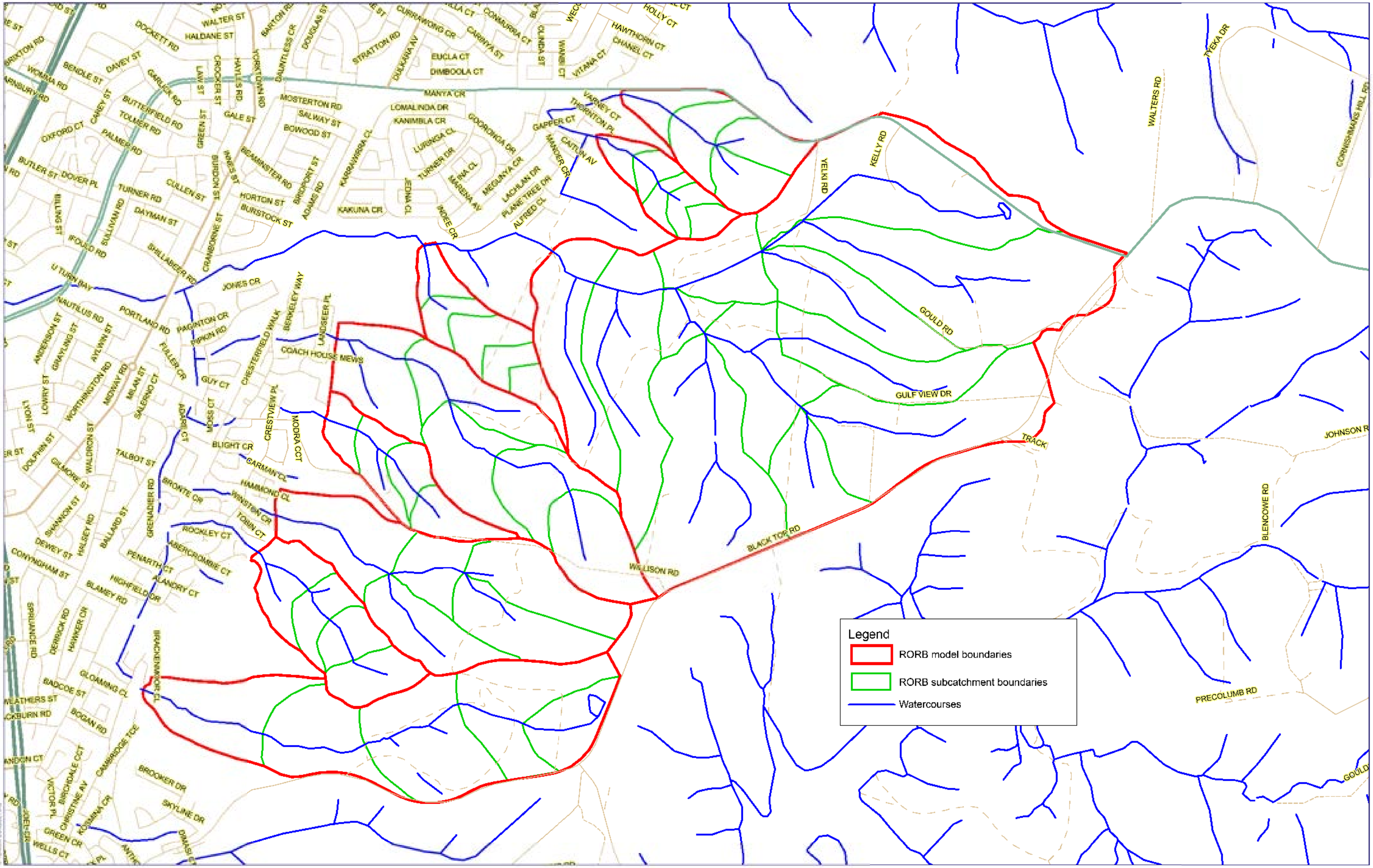
The Initial Loss–Continuing Loss model was adopted for the RORB modelling. A continuing loss of 3 mm/hr was used for all events up to the probable maximum flood (PMF) event which used a continuing loss of 1 mm/hr. The initial loss will be varied depending on the average recurrence interval (ARI) of the storm. The following loss parameters were adopted from the *Dry Creek Floodplain Mapping Study* (Tonkin Consulting, 2008).

Table 3.7 Initial losses

Average Recurrence Interval (years)	Initial loss (mm)	Continuing loss (mm/hr)
20	25	3.0
50	30	3.0
100	40	3.0
500	14	2.5
PMF	0	1.0

3.6.2 RORB modelling parameters

A value of 0.8 for the RORB storage parameter (m) has been adopted as there is no evidence to suggest that another value would be more appropriate.



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Data Acknowledgement:
Road and watercourse data supplied by PBBI Australia Pty Ltd

City of Playford

RORB CATCHMENTS

Figure 3.3

The k_c value for each catchment was derived using Equation 3.25 from AR&R (1987):

$$k_c = 0.6A^{0.67}$$

This equation applies to the south eastern area of South Australia and provides a value of k_c for catchments with an area less than 100 km^2. The resultant k_c values for each major catchment are shown in Table 3.8.

Table 3.8 RORB model k_c values

RORB model	Area (km^2)	Adopted k_c value
1	0.40	0.33
2	0.22	0.22
4	5.07	1.94
5	1.06	0.63
6	1.12	0.65
7	1.34	0.73
8	0.44	0.35
9	0.31	0.27
10	0.32	0.28

3.7 Smith Creek PMF hydrograph synthesis

Hydrographs of flood flow from Smith Creek into the study area were provided by AWE at a number of known flooding locations. These hydrographs have formed an input into the TUFLOW model. The AWE modelling excludes the PMF event, therefore, the PMF event hydrographs have been synthesized by manipulating the 500 year ARI hydrographs that were provided. The 500 year ARI hydrographs were modified as follows:

- The first 12 minutes of data was removed to allow for the minimal initial loss in the PMF event
- The time step of the 500 year ARI hydrographs was multiplied by 1.2 to elongate the duration of the hydrograph in order to simulate the expected period of time that rainfall intensity would exceed continuing losses
- The remaining flow rates were multiplied by a value of 6.5 which is approximately equivalent to the increase in rainfall intensity between the 500 year ARI and PMF events.

The above manipulation resulted in a hydrograph volume of approximately eight times the volume of the 500 year ARI event with a peak flow 6.5 times higher. This is broadly consistent with the difference in the total rainfall depth between the 500 year ARI and PMF events and is considered accurate enough for the purposes of modelling the PMF event.

4 Flood inundation modelling

4.1 Introduction

A detailed 1D–2D TUFLOW model was created for the entire study area. The model was run to simulate storm events within the study area and generate flood inundation and hazard maps.

4.2 Modelling software

The modelling was carried out using the TUFLOW computer program jointly funded and developed by WBM Oceanics Australia Pty Ltd and The University of Queensland. The program simulates depth averaged, two and one-dimensional free surface flows such as those that occur from floods and tides (WBM Oceanics Australia Pty Ltd, 2005).

TUFLOW (Two-dimensional Unsteady FLOW) has the ability to dynamically link to its 1D network component ESTRY, enabling the user to set up a model containing both 1D and 2D domains. GIS is used for much of the model setup, as well as for viewing and managing the results of TUFLOW simulations. The TUFLOW program is based on the Stelling (1984) solution scheme, which is a finite difference, alternating direction implicit scheme solving the full 2D free surface flow equations. The ESTRY component is based on a numerical solution of the unsteady momentum and continuity fluid flow equations (WBM Oceanics Australia Pty Ltd, 2005).

TUFLOW was initially developed to model tidal estuaries. However, Tonkin Consulting assisted in pioneering the use of TUFLOW for urban flood inundation mapping. The drainage network is modelled in 1D and dynamically linked at each inlet/outlet structure to the floodplain represented in 2D. This allows for the integrated modelling of the drainage network and floodplain.

The model area is divided into fixed grid cells. The model has the ability to simulate the variation in water level and flow inside each cell once information regarding the resistance to flow, topography and boundary conditions is entered.

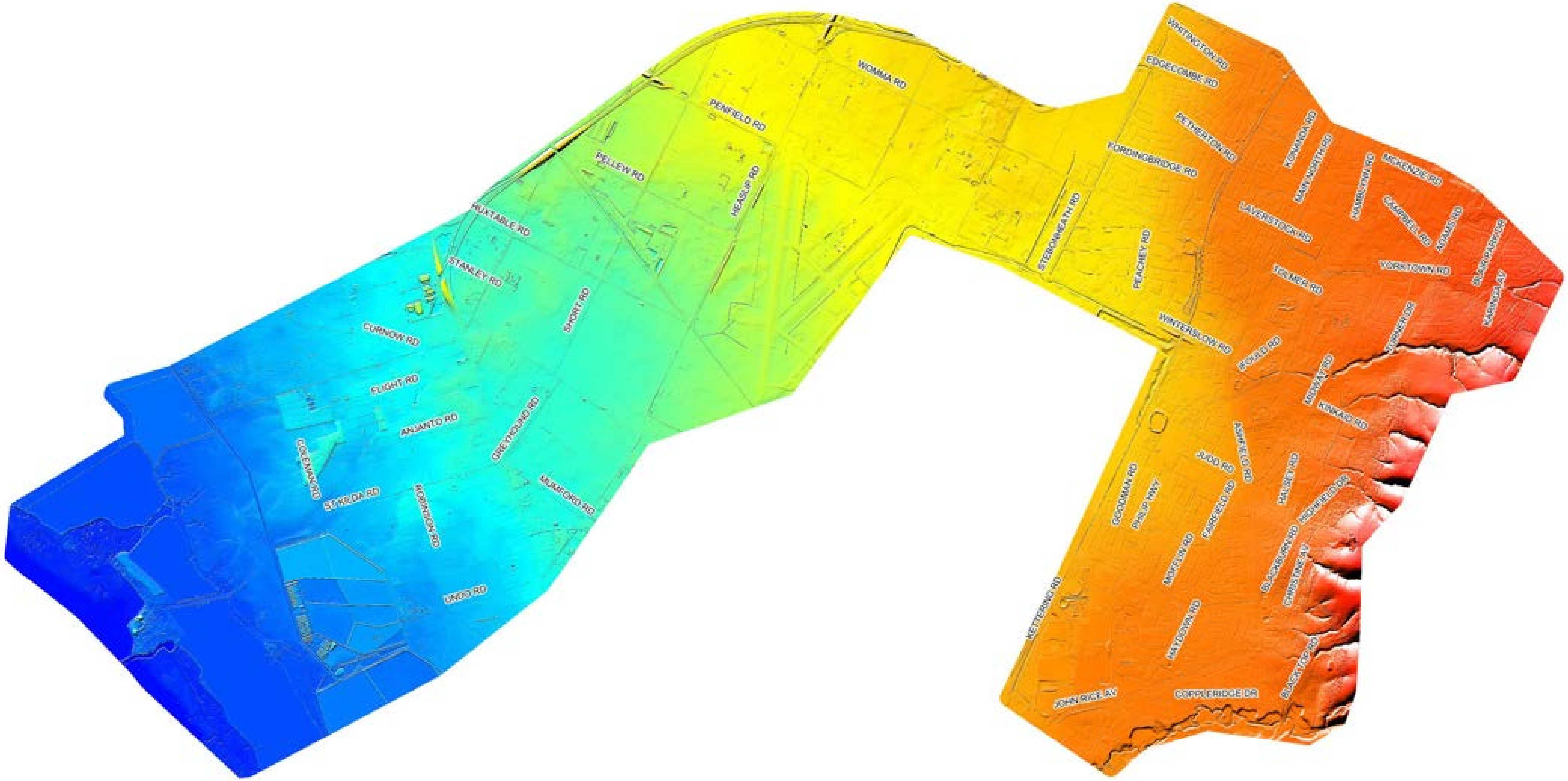
4.3 Digital elevation model

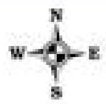
The digital elevation model (DEM) was prepared by Aerometrex using photogrammetric techniques for the study area. Breaklines were also created by Aerometrex, allowing the street kerb lines, creek and basin banks, and other sharp changes in slope to be defined. This greatly improves the definition of flow paths in the terrain and increases the accuracy of the TUFLOW model, particularly for surface flood flows within the street network.

After receipt of the DEM, modifications were made by Tonkin Consulting based on known and proposed changes to the topography not present at the time aerial photography was captured. Modifications to the DEM were made using TUFLOW Z-shape layers. Key changes to the DEM included:

- the Burton industrial estate drainage channels
- the proposed Eyre Development housing estate drainage channels
- proposed large flood detention basins at the north east corner of the DSTO precinct

The DEM for the study area (before modification by TUFLOW) is presented in Figure 4.1.





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Date: 13/02/2015
Drawn: TAK

Data Acknowledgement:
Road data supplied by PBBI Australia Pty Ltd
DEM supplied by Aerometrex

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DIGITAL ELEVATION MODEL

Figure 4.1

4.4 TUFLOW model setup

4.4.1 2D cell size

Determining an appropriate 2D cell size to be used by TUFLOW requires a compromise between the resolution of flood mapping and the simulation time and memory required to run the models. Smaller 2D cell sizes more accurately reproduce detailed topography and the hydraulic behaviour, but significantly increase the amount of memory and computational power required to run the model. An understanding of the specific requirements for each study is needed in order to select an appropriate 2D cell size.

A cell size of 4 m is considered by Tonkin Consulting as a good compromise between resolution and computational power and has been used for many studies previously undertaken by Tonkin Consulting. A cell size of 4 m was considered suitable to adequately represent the hydraulic behaviour of the rural areas and surface flood flows within the urban street network.

4.4.2 Computational time step

The selection of an appropriate time step for the 2D domain of TUFLOW is critically important to the accuracy of the model output. Time steps that are too large may result in overestimation of the derivatives within the model which decreases the numerical accuracy of the computations. The choice of a smaller time step prevents numerical diffusion and increases the accuracy of results but also increases the simulation time of models. An appropriate time step will balance simulation times with the model's stability and numerical accuracy. A 2D domain time step of 1 second was adopted for all modelled events. This achieved an acceptable accuracy in the model results. Testing revealed that larger time steps resulted in instabilities and poor conservation of mass (i.e. low accuracy).

Ninety nine percent of computational effort is attributed to solving the 2D surface flow equations and hence the 1D domain time step has a negligible impact on simulation times. A time step of 0.1 s was used for the 1D domain; greatly improving the stability of the models.

4.4.3 Boundary conditions

Where shallow sheet flow was expected to reach a model boundary, the boundary conditions at that location was set to allow flow to freely leave the model. For deeper flows, the boundary condition was set to represent the downstream hydraulic conditions using an automatically generated stage–discharge relationship based on the topography and expected hydraulic grade.

Directly adjacent to an inflow point, the model boundary was set to prevent flow from immediately leaving the model.

Around the lower boundary of the model a constant sea level boundary condition was set at 1.4 mAHD. This corresponds to the Mean High Water Springs (MHWS) tide height of 0.9 mAHD in Gulf St Vincent with an additional increase of 0.5 m to represent predicted sea level rise for 2050. Given the separation between the catchment and the sea, it is not expected that the results of the modelling will be sensitive to the adopted sea level boundary condition.

4.4.4 Initial conditions

An initial water level was set to match the sea level boundary conditions.

4.4.5 Inflow boundary conditions

Inflow hydrographs were generated for each ARI and duration of storm event analysed, as outlined in Section 3.1. The inflows for each sub-catchment were applied to each inlet pit/grate/headwall throughout the catchment. Inlet capacity tables (DRAINS Transport SA inlet capacity tables) were used to provide an approximate inlet capacity for each single and double side entry pit and grate. This allowed the inflows to pass directly into the drainage network until the pit capacity or pipe capacity was exceeded, with the excess spilling into the street network (2D floodplain).

Where no drainage infrastructure was present within the sub-catchment (i.e. creek channels, basins, wetlands and some of the north-western agricultural area), the inflow was applied directly over regions of the 2D model surface. Flow is initially applied to the lowest grid cell in the region. As the flood level increases the inflow is distributed over the flooded area.

Inflow hydrographs for the creeks along the upstream boundary of the study area were extracted from the RORB models (see Section 3.6).

Flows spilling from Smith Creek were added to the model at three locations. Hydrographs for these locations (up to and including the 500 year ARI event) were provided by AWE who were responsible for the flood modelling of the Smith Creek Catchment. The PMF event hydrographs were synthesized by Tonkin Consulting (as outlined in Section 3.7).

4.4.6 Model adjustments for 500 year ARI and PMF events

Due to the large volume of water present in the 500 year ARI and PMF events, the TUFLOW model initially experienced instabilities and unacceptably high mass balance errors which required addressing before the results could be accepted. The following adjustments were made to address these issues:

- In the 500 year ARI event, small open channels, represented as 1D network elements, exhibiting oscillatory flows were identified as the cause of the large mass error. These elements were removed from the 1D domain and represented in the 2D domain instead. This was possible because the conveyance of the channels was significantly less than the surrounding surface flows.
- In the PMF event, instabilities in the 2D domain caused by violation of the Courant condition (due to very high velocities) required lowering the computational time step to 0.5 s.
- In both the 500 year ARI and PMF events, the railway embankment near Winterslow Road is overtopped and experiences weir flow. The DEM in this location is ‘bumpy’ because each railway line and cess drain is represented in the DEM. To stabilise the model and reduce mass errors the DEM over the top of the railway was smoothed to reduce rapid changes in ground surface level.

The above adjustments allowed the models to run to completion with acceptable levels of mass balance error (less than ±3%).

4.5 Existing stormwater drainage infrastructure

4.5.1 Modelling of the pipe network

The drainage network consists of an underground drainage network and systems of open channels, discharging to the Little Para River, Helps Road open drain and Gulf St Vincent. There are also a number of wetlands and detention basins within the drainage network.

Base drainage infrastructure data (drains and inlet structures) was provided by the City of Playford. This data was extensively reviewed and updated to provide an accurate model of the drainage infrastructure within the study area. As part of the review and updating of the stormwater network data, many individual pits (SEP’s, grates, headwalls, etc) were moved to match their actual location (where they were seen to have an impact on the modelling). The drainage network was then updated to match the pit locations.

Where previously unidentified drains were added or there were uncertainties within the drainage database, locations and sizes were discussed with Council and either confirmed on site or taken from design drawings.

In rural areas, most properties have an elevated driveway that crosses over a roadside swale with a small pipe or box culvert to maintain the flow of water down the swale. These crossings were not modelled individually due to two reasons: lack of available GIS data; evidence that the crossings are poorly maintained (i.e. blocked by silt and other materials) leading to little to no conveyance through the conduit. The swales have been modelled but the individual driveway crossings have not.

Invert elevations for the underground drainage was absent from the Council's GIS data. Invert elevations were instead created based on the surface level interpolated from the DEM. These calculated inverts were then reviewed and manipulated to ensure all drainage networks graded downhill. This resulted in invert data to an acceptable level of accuracy for flood mapping.

In addition to the above, the drainage network was checked as follows:

- Pipe diameters and box culvert sizes were reviewed to check for consistency with standard dimensions and that sizes generally increased in the downstream direction.
- Checks were carried out to ensure all drains were digitised in the downstream direction. For flood modelling it is preferable that drains be drawn in the downstream direction, so that flow results are positive in the downstream direction.
- Checks were made to ensure connectivity of the drainage network.

This review and modifications resulted in a greatly improved GIS database of drainage infrastructure for the study area, and allowed the TUFLOW model to represent the drainage infrastructure to an appropriate level of accuracy for the flood mapping study.

4.5.2 Modelling of inlet pits

Inlet pits were modelled using head-flow relationships to provide a good estimate of the inlet capacity of each pit. The head-flow relationships adopted were based on standard “Transport SA” pit capacity tables utilised by the DRAINS software package. Different curves were entered for single and double side entry pits (SEPs) as well as grated inlet pits (GIPs).

4.5.3 Modelling of pump stations

A single pump station at Midway Road was included in the model and transfers small amounts of water into the Olive Grove Reserve wetland.

4.5.4 Siphons

Two inverted siphons beneath the Bolivar Sewage Treatment Works outfall channel were modelled based on technical drawings sourced from SA Water.

4.5.5 Modelling of open channels

There is a large network of open channels across the study area. While the larger of these channels can be adequately represented within the 2D model domain, the smaller channels were modelled as 1D channel structures with cross section data to ensure they were represented accurately within the TUFLOW model.

4.5.6 Weir structures

A number of weirs were modelled at key detention basins to ensure stability of the model.

4.5.7 Gutter flows

While the grid cell size was demonstrated to provide sufficient detail to model the urban environment in the flatter areas, errors were identified in the hills face region. It was found that where roads ran across the hills face, the model resolution was not sufficient to accurately represent the kerb profile. This resulted in flow travelling downhill rather than travelling along the road kerb. To counteract this, the cells on the lower side of the roads in the hills area were artificially raised to approximately 0.15 m above the closest road level. This pushed low flows along the road kerbs and allowed for the kerb capacity to be appropriately represented in the model. This was found to only affect the area to the east of a line coincident with Adams Road and Blackburn Road.

4.5.8 Allowance for blockages

During large storm events, objects could be swept into inlet pits, headwalls and creek channels, exacerbating flooding in the local area. Siltation could also reduce the capacity of the stormwater network exacerbating flooding in the local area. Due to the broad scale objective of this flood study, no specific allowance has been made to account for blockages that may occur during storm events.

4.6 Bed resistance

The TUFLOW model utilises a GIS layer of roughness coefficients (Manning's n values) to define the bed resistance used in calculating the flow and hence the water depth at any location within the model domain.

Roughness values of urban development were based on cadastral information and aerial photography. Buildings were generally modelled using high bed resistance values applied to residential and commercial areas. Roughness coefficients were selected based on current conditions. Figure 4.2 provides an example of how the roughness coefficients are applied across urban areas.

The Manning's *n* roughness coefficients used in modelling are specified in Table 4.1. These values were adopted based on literature as well as the experience of Tonkin Consulting.

Table 4.1 Adopted bed resistance parameters

Land Use	Manning's n
Houses/Residential areas, obstructions to flow	0.200
Medium to high density residential and commercial areas	0.300
Parklands with scattered trees	0.045
Grassed areas and bare ground	0.035
Roads (including verges)	0.030
Unlined creek channels	0.040-0.065
Lined concrete channels and box culverts	0.013
Concrete pipes	0.011

Figure 4.2 Example of Manning's 'n' roughness coefficient regions

4.7 Modelling uncertainty

While every care has been taken in preparation of the TUFLOW model and the choice of the adopted parameters, all hydrological and hydraulic modelling has an inherent level of uncertainty. This is due to the number of factors including the following:

- The accuracy and resolution of the DEM used and the interpretation of this information by the hydraulic model
- Dynamic changes to topography due to erosion or deposition of soil during a flood event; which can lead to changes in the distribution of flow. These processes have not been included in this model.
- Uncertainty in the rainfall pattern and catchment conditions prior to a flood. Actual flood events are dependent on the antecedent moisture conditions prior to rainfall, initial detention storage levels at the beginning of rainfall runoff and the intensity and uniformity of the rainfall event itself. The floods modelled by this study are based on design storm bursts which attempt to reproduce the expected average temporal pattern of a storm burst within specified rainfall zones (see AR&R for greater explanation). As such, individual rainfall events may exhibit a differing temporal pattern than those modelled.
- Estimation of input parameters to the model (such as runoff coefficients, times of concentrations, Manning's roughness, entry and exit losses).

4.8 TUFLOW runs

4.8.1 Events modelled

Five different flood events were modelled for the study area:

- 20 year ARI flood event
- 50 year ARI flood event
- 100 year ARI flood event
- 500 year ARI flood event
- PMF event

For each flood event, eight different storm durations were modelled in order to obtain the peak flood level at different points within the catchment; the durations modelled were:

- 0.5 hours
- 1 hour
- 3 hours
- 6 hours
- 9 hours
- 12 hours
- 24 hours
- 36 hours

A total of 40 sets of inflow hydrographs and 40 model runs were carried out to produce a complete set of flood inundation maps.

Appendix B – Little Para and Helps Road Drain flood inundation modelling methodology (extract from Tonkin, 2018b)

Little Para & Helps Rd Drain Catchments

Floodplain Mapping & Stormwater Management Study

City of Salisbury

November 2018

Ref No. 20110409FR1D

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5 Flood Inundation Modelling

5.1 Introduction

A detailed 1D/2D TUFLOW model was created for the entire study area. The models were run within the TUFLOW software package to simulate storm events within the study area and generate flood inundation and hazard maps.

5.2 Modelling Software

The modelling was carried out using the TUFLOW computer program jointly funded and developed by WBM Oceanics Australia Pty Ltd and The University of Queensland. The program simulates depth averaged, two and one-dimensional free surface flows such as those that occur from floods and tides (WBM Oceanics Australia Pty Ltd, 2005).

TUFLOW (Two-dimensional Unsteady FLOW) has the ability to dynamically link to its 1D network component ESTRY, enabling the user to set up a model containing both 1D and 2D domains. GIS is used for much of the model setup, as well as for viewing and managing the results of TUFLOW simulations. The TUFLOW program 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 component is based on a numerical solution of the unsteady momentum and continuity fluid flow equations (WBM Oceanics Australia Pty Ltd, 2005).

TUFLOW was initially developed to model tidal estuaries. However, Tonkin Consulting assisted in pioneering the use of TUFLOW for urban flood inundation mapping. The drainage network is modelled in 1D and dynamically linked at each inlet/outlet structure to the 2D floodplain. This allows for the integrated modelling of the drainage network and floodplain.

The model area is divided into fixed rectangular cells. The model has the ability to simulate the variation in water level and flow inside each cell once information regarding the ground resistance, topography and boundary conditions is entered.

5.3 Digital Terrain Model

The Digital Terrain Model (DTM) was prepared by Aerometrex using photogrammetric techniques for the study area. The aerial photography was captured during February 2008 at a 15 cm pixel resolution.

The aerial photography was triangulated and calibrated to ground control points (captured by GPS to an accuracy of +/-3 cm). Breaklines were created by Aerometrex, allowing the street kerb lines and creek/basin banks, etc. to be defined. This greatly improves the TUFLOW model accuracy for surface flood flows within the street network, etc.

The DTM was then processed to produce the following survey products:

- A regular grid of levels across each Study Area (at 3 m centres),
- Break lines along tops and bottoms of kerbs, valley drains, road crowns, creek banks and basins, etc. where necessary to adequately define the surface shape,
- Contours at 0.5m intervals.

This DTM was triangulated and TUFLOW z-points were generated at twice the 2D cell size for each model. Elevations were assigned at the centres, corners and mid-sides of each cell, enabling interaction with surrounding cells.

When the digital terrain model was compared to recent aerial photography, it was found that the extensive drainage upgrades to the Edinburgh Defence Science and Technology Organisation (DSTO) site were not represented in the DTM data. Additional DTM data was obtained for this area using aerial photography that was captured during January 2012 at a 10 cm pixel resolution.

The original area of DTM coverage was also extended to include the open channel and detention basins in the north-western corner of the DSTO site, allowing the basin and associated open channel to be included in the model.

The triangulated DTM for the study area is presented in Figure 5.1.

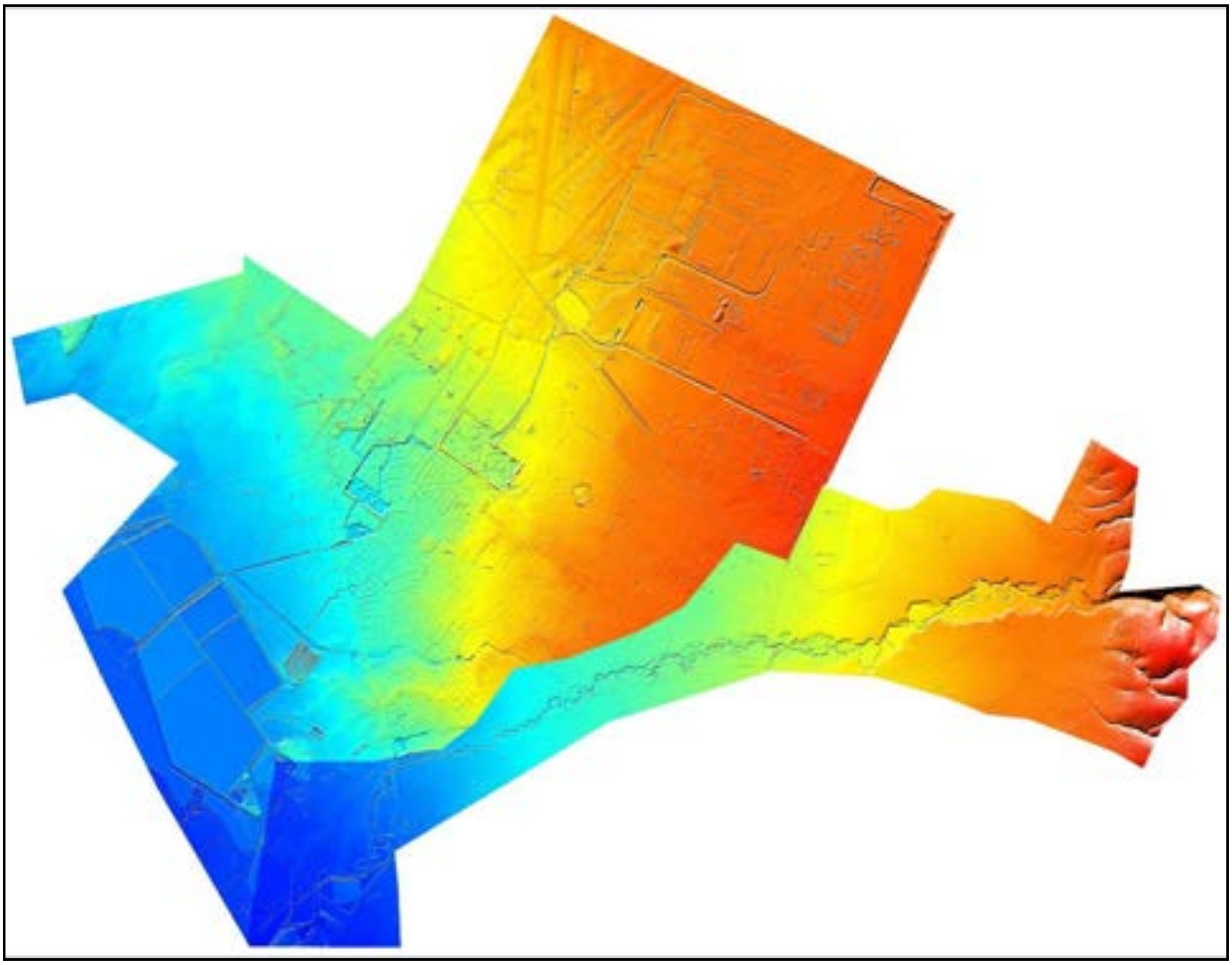


Figure 5.1 Little Para and Helps Road Digital Terrain Models

5.4 Existing Stormwater Drainage Infrastructure

The drainage network consisted of the underground drainage network and systems of open channels, discharging to the Little Para River and Helps Road open drain. There are also a number of wetlands and detention basins within the drainage network.

The drainage infrastructure data (drains and inlet structures) used for modelling was provided by the City of Salisbury. While the data set could have been used as it was, it was extensively reviewed and updated to provide an accurate model that included all drainage infrastructure within the study area. As part of the review and updating of the stormwater drainage infrastructure data, many individual pits (SEP's, grates, headwalls, etc.) were updated to match their actual location (where they were seen to have an impact on the modelling).

The drainage network was then updated to match the pit locations. Where previously unidentified drains were added or there were uncertainties within the drainage database, locations and sizes were discussed with Council and either confirmed on site or taken from design drawings.

For a large percentage of the drainage data provided, invert information was not available. Where invert information was not available, inverts were created based on the DTM surface level with 0.6 m cover, and then reviewed to ensure all drainage networks graded downhill. This resulted in invert data to an acceptable level of accuracy for the floodplain mapping study.

In addition to the above, the drainage information was checked for consistency as follows:

- Pipe diameters and box culvert sizes were reviewed to check for consistency and that they were increasing in the downstream direction.
- For flood modelling all drains must be drawn in the downstream direction, so that the start and end inverts are applied at the correct end of the pipe & the flow results are positive values. Checks were carried out to ensure all drains were digitised in the correct direction.
- Checks were also carried out to ensure all drains snapped correctly at nodes.

In addition to reviewing the existing network database, the following drainage infrastructure projects, developments and detention basins were added to the flood model from construction drawings:

- Burton West Industrial Drain
- Edinburgh Parks Detention Basin
- International Avenue to Waterloo Corner Road Stormwater Drainage Swale
- McCormack Crescent Detention Basins
- Castle Drive Detention Basins, including open channel from Waterloo Corner Road
- Helps Road channel culverts and Edinburgh Road and Diment Road
- Little Para Overflow Channel upstream diversion weir structure
- Walpole Road Levee Bank

This review and updating resulted in a greatly improved GIS database of drainage infrastructure for the study area, and allowed the TUFLOW model to represent the drainage infrastructure to an appropriate level of accuracy for the floodplain mapping study.

5.4.1 Modelling of Inlet Pits

Inlet pits were modelled using head-flow relationships to provide a good estimate of the inlet capacity of each pit. The head-flow relationships adopted were based on standard “Transport SA” pit capacity tables utilised by the DRAINS software package. Different curves were entered for single and double side entry pits (SEP’s) and grates. Site visits allowed the pit type data to be updated to the inlet pit database.

5.4.2 Modelling of Open Channels

There is a large network of open channels across the DSTO site and the Helps Road Catchment. While the larger of these channels was adequately represented within the 2D model domain, the smaller channels were input as 1D channel structures with cross section data to ensure they were modelled accurately within the TUFLOW model.

During the PMF model runs, the 1D open channels were removed from the model, as they cause instabilities when water level is much higher than the channel top of bank. For the PMF model runs, the 2D topography was used for all open channels, which was considered acceptable given the extent and depth of the PMF floodplain.

5.4.3 Modelling of Pump Stations

There is a pump station at the Salisbury Highway rail corridor underpass that was included in the model. Details of the pump station were not available. Following discussions with Council, a pump rate of 0.5 m^3/s was assumed. While not modelled in detail, this allowed the underpass drainage to be simulated within the floodplain model.

5.4.4 Little Para Off-take Weir

There is a v-notch weir inline in the Little Para River approximately 200 m downstream of Burton Road, which is designed to throttle peak flows down the main river channel causing flood flows to spill into the Little Para overflow channel. This weir was modelled as a 1D weir structure with a weir capacity reference table. The TUFLOW model compared the upstream and downstream depths in real time and used the lookup table to assign a weir flow rate based on the upstream and downstream conditions. The weir capacity reference table was based on the submerged weir equations that were used in the design of the weir structure (Tonkin Consulting, 2005).

5.5 Modelling Parameters

5.5.1 2D Cell Size

Determining an appropriate 2D cell size to be used by TUFLOW requires a compromise between the resolution of floodplain mapping and the computer time and memory required to run the models. Smaller 2D cell sizes more accurately reproduce detailed topography and the hydraulic behaviour, but significantly increase the amount of memory and computational power required to run the model. An understanding of the specific requirements for each study is needed in order to select an appropriate 2D cell size.

A cell size of 4 m is considered an average value for many studies previously undertaken by Tonkin Consulting as a good compromise between resolution and computational power. A cell size of 4 m was considered suitable to adequately represent the hydraulic behaviour of the Little Para River and surface flood flows within the urban street network.

A 4 m cell size was adopted for the Little Para Flood mapping study. This was made possible by splitting the study area into two models to still achieve acceptable model run times. The natural divide created by the freight rail line that runs along the western side of the DSTO area was used to divide the two models.

5.5.2 Gutter Flows

While the 4 m cell size was demonstrated to provide sufficient detail to model the urban environment in the flatter areas, errors were identified in the hills face region. It was found that where roads ran across the hills face, the model resolution was not sufficient to accurately represent the kerb profile. This resulted in flow travelling downhill rather than travelling along the road kerb. To counteract this, the cells on the lower side of the roads in the hills areas were artificially raised to approximately 0.15 m above the closest road level. This pushed low flows along the road kerbs and allowed for the kerb capacity to be appropriately represented in the model. This was found to only affect the area to the east of Main North Road.

5.5.3 Roughness Coefficients

The TUFLOW model utilises a GIS layer of roughness coefficients (Manning's n values) to define the bed resistance used in calculating the flow and hence the water depth at any location within the model domain. In GIS, the aerial photograph was used to define roughness coefficient regions throughout the model domain.

The Little Para River and other main open channels were visually assessed during site visits to provide a good estimation of the roughness for each section of the channel.

Roughness values of urban development were based on cadastral information and aerial photography. Building footprints were not taken into account meaning that within the model it is possible for water to flow through buildings. The high bed resistance values applied to residential and commercial areas make an allowance for the obstructions created by buildings. Figure 5.2 provides an example of how the roughness coefficients are applied across urban areas.

Figure 5.2 Example of Roughness Coefficient regions

The Manning's n roughness coefficients used in modelling are specified in Table 5.1. These values were adopted based on literature as well as the experience of Tonkin Consulting and WBM engineers.

Table 5.1 Adopted Resistance Parameters

Land Use	Manning's n
Houses/Residential areas, obstructions to flow	0.200
Medium density residential and commercial	0.300
Parklands with scattered trees	0.045
Grassed areas and bare ground	0.035
Roads (including verges)	0.030
Creek Channels	0.04-0.065
Concrete channels & box culverts	0.013
Concrete Pipes	0.011

5.5.4 Time Step

The selection of a time step for the 2D domain of TUFLOW is important as it is inversely proportional to the running time of the model. Larger time steps allow iterations to "bounce" which decreases the accuracy of results and possibly leads to model instabilities. The choice of a smaller time step increases the accuracy of results and also increases the model running time.

A small 2D domain time step of 1 second was adopted for all modelled events. This achieved a high accuracy in the model results while still achieving acceptable model run times. 99% of the computational effort is in solving the 2D surface flow equations and hence the 1D domain time step has a negligible impact on simulation times. A small 1D domain time step of 0.1 second was used, greatly improving the 1D network stability of the models.

5.5.5 Inflows

Inflow hydrographs were generated for each ARI and duration storm event to be analysed, as outlined in Section 4.1. The inflows for each sub-catchment were applied to each inlet pit/grate/headwall throughout the catchment. Inlet capacity tables (DRAINS Transport SA inlet capacity tables) were used to provide an approximate inlet capacity for each single and double side entry pit and grate. This allowed the inflows to pass directly into the drainage network until the pit capacity or HGL levels were exceeded, with the excess spilling into the street network (2D floodplain).

Where no drainage infrastructure was present within the sub-catchment (i.e. creek channels, basins, wetlands and some of the north-western agricultural area), the inflow was applied directly over regions of the 2D model surface. Flow is initially applied to the lowest grid cell in the region, and then spreads as the flood level increases.

Inflow hydrographs for the creeks along the upstream boundary of the study area were extracted from the RORB models (see Section 4.3) and applied as inflow regions in the creek channels.

No spills were modelled from the Little Para Reservoir except for long duration 500 year ARI flows and during the PMF, as outlined in Section 4.4.

There are several drainage networks along the southern side of the Little Para River that extend beyond the study area. Pipe inflows for these drainage networks were extracted from the Salisbury West flood modelling project (Tonkin Consulting, 2011) and applied to the drainage network at the point where they entered the study area.

5.5.6 Boundary Conditions

Where shallow flow reached a model boundary, the topography was assessed. If the flows were expected to leave the study area then boundary conditions were set such that the flow would freely leave the model. At other locations along the model boundary (i.e. directly adjacent to an inflow point) the model boundary was glass walled to prevent flow from leaving the model.

Around the lower boundary of the model a constant sea level boundary condition was set at 1.4 mAHD. This corresponded to the Mean High Water Springs (MHWS) level of 0.9 m AHD in the Gulf St Vincent with an allowance of 0.5 m sea level rise for the long-term scenario. The hydraulic grade line at the Little Para outlet during high flow events is well above the mean sea level and is not considered to be sensitive to any expected rise in sea level.

5.6 Modelling Assumptions

While every care has been taken in preparation of the TUFLOW model and the choice of the adopted parameters, all hydrological and hydraulic modelling has an inherent level of uncertainty. This is due to the number of factors including the following:

- The accuracy and resolution of the DTM used and the interpretation of this information by the hydraulic model
- Roughness coefficients were applied to the creek channels and culverts based on the current conditions. No allowance was made for any blockage that may occur during storm events. During large storm events, objects could be swept into inlet pits, headwalls and creek channels, exacerbating flooding in the local area. Siltation could also reduce the capacity or form a blockage to the drainage network, exacerbating flooding in the local area.

- The floodplain model does not provide for dynamic changes to the DTM due to erosion that can occur and possibly change the distribution of flow by altering flow paths.
- Actual flood events are dependent on both the antecedent moisture conditions, initial detention storage levels and the intensity and uniformity of the rainfall event
- The assumptions in the input parameters to the model (such as runoff coefficients, times of concentrations, Manning's roughness, entry and exit losses).

5.7 TUFLOW Runs

5.7.1 Events Modelled

Design storms for five different Average Recurrence Intervals (ARI) were modelled for the study area. For each ARI, various storm durations were modelled in order to obtain the peak flood level at different points within the catchment. Table 5.2 outlines the ARI's and durations that were run.

Table 5.2 Modelled ARI's and storm durations

Event	Storm Durations Modelled
20 year ARI Long-term	0.5hr, 1hr, 3hr, 6hr, 9hr, 12hr, 24hr, 36hr
50 year ARI Long-term	0.5hr, 1hr, 3hr, 6hr, 9hr, 12hr, 24hr, 36hr
100 year ARI Long-term	0.5hr, 1hr, 3hr, 6hr, 9hr, 12hr, 24hr, 36hr
500 year ARI Long-term	0.5hr, 1hr, 3hr, 6hr, 9hr, 12hr, 24hr, 36hr
PMF Long-term	0.5hr, 1hr, 3hr, 6hr, 9hr, 12hr, 24hr, 36hr

This resulted in 40 sets of inflow hydrographs and 40 model runs being carried out to produce a set of flood inundation maps.

5.7.2 Flood Inundation Mapping

For each model run, flood depths and levels (AHD) were output for each time step. Upon completion of each model run, the maximum flood depths were calculated & outputted into a GIS layer. For each ARI, the GIS results for each duration were then spliced together, combining the upstream and downstream models and providing an umbrella floodplain map of the maximum flood depth.

5.7.3 Flood Hazard Mapping

For the 20 and 100 year ARI model runs, flood hazard categories were output. For each ARI, the GIS results for each duration were then spliced together combining the upstream and downstream models and providing an umbrella hazard map of the maximum hazard category.

The hazard categories were defined as set out in the SCARM Report 73 (CSIRO, 2000). The hazard categories are presented in Figure 5.3.

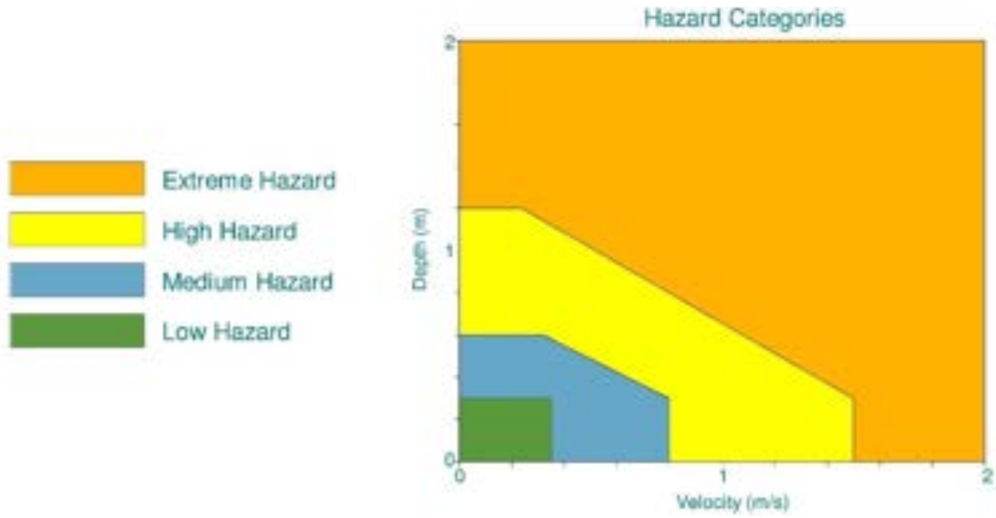
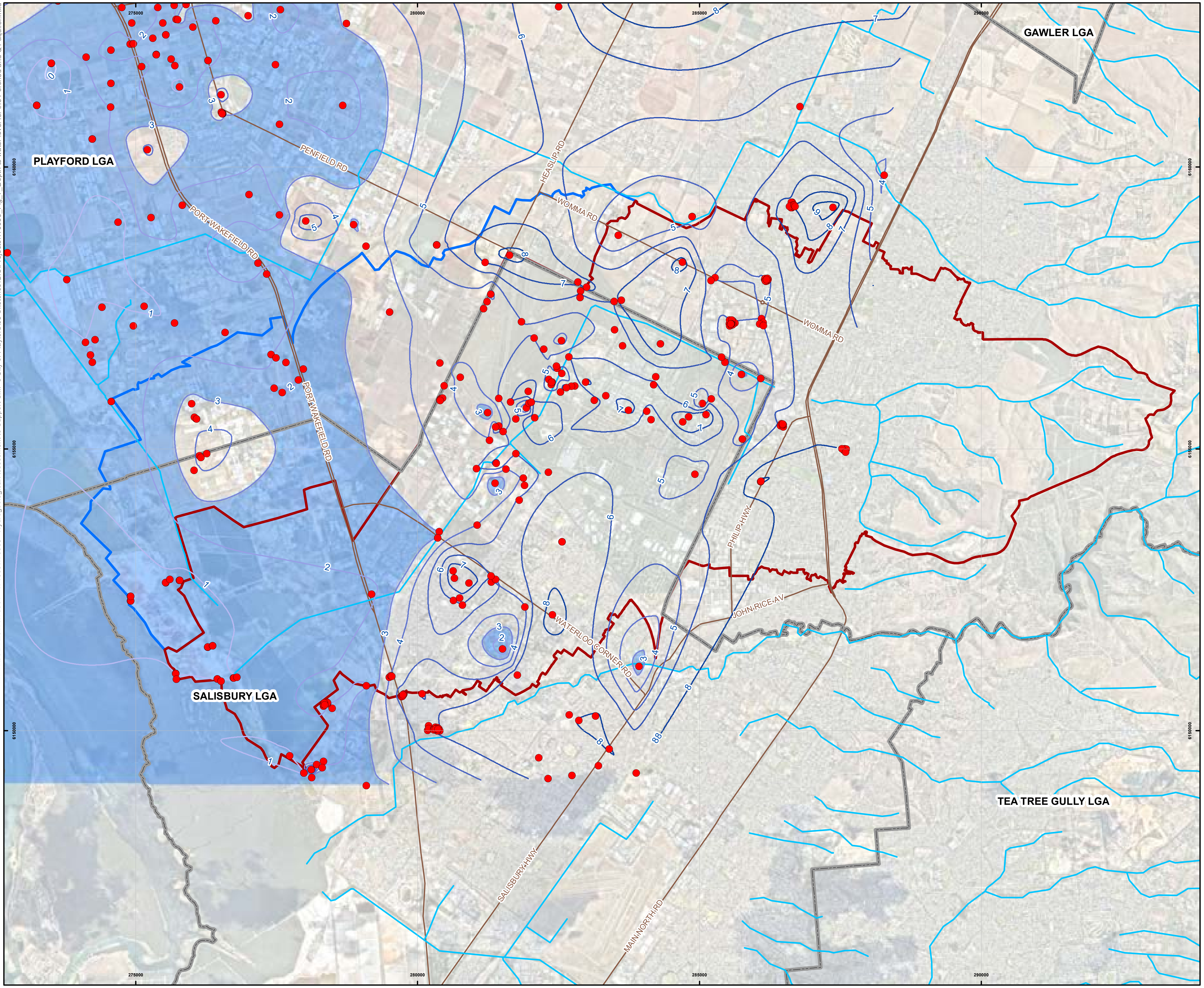
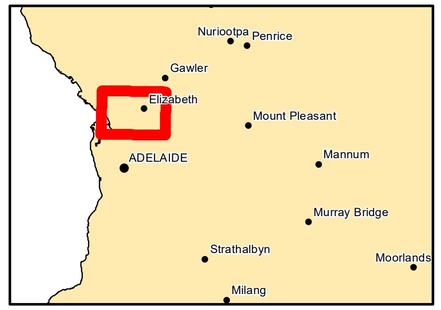


Figure 5.3 Hazard Categories

Appendix C – Depth to groundwater level (WGA, 2018)



Document Path: K:\JOBS\2017\170901 - 171000\170930 - Hydrogeological Assessment to Support SMP's City of Playford\05 Sketches\GIS\Projects\170930_Fig_7_Depth to water level for the Perched and Q1 aquifer.mxd



LEGEND

- Well
- Main Highway
- Watercourse
- LGA Boundary

Catchments

- Greater Edinburgh Parks Catchment
- Helps Rd/Adam's Creek Catchment
- Depth to Groundwater => 3m

Standing Water Level (m)

0, 1, 2, 3, 4, 5, 6, 7, 8, 9

N

0 1,000 2,000 3,000 m

Scale 1:65,000 @ A4

Coordinate System: GDA 1994 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure 7

Hydrogeological Assessment to Support SMP's City of Playford

Depth to Water Level for the Perched and Q1 Aquifer

Appendix D – Flood maps

Map number	Map name
1	20% AEP flood depth long term 2050 scenario
2	5% AEP flood depth long term 2050 scenario
3	2% AEP flood depth long term 2050 scenario
4	1% AEP flood depth long term 2050 scenario
5	0.2% AEP flood depth long term 2050 scenario
6	1% AEP flood hazard long term 2050 scenario
7	0.2% AEP flood hazard long term 2050 scenario
8	20% AEP flood depth long term 2090 scenario
9	5% AEP flood depth long term 2090 scenario
10	2% AEP flood depth long term 2090 scenario
11	1% AEP flood depth long term 2090 scenario
12	0.2% AEP flood depth long term 2090 scenario
13	1% AEP flood hazard long term 2090 scenario
14	0.2% AEP flood hazard long term 2090 scenario
15	20% AEP flood depth 2050 mitigation scenario
16	5% AEP flood depth 2050 mitigation scenario
17	2% AEP flood depth 2050 mitigation scenario
18	1% AEP flood depth 2050 mitigation scenario
19	0.2% AEP flood depth 2050 mitigation scenario
20	1% AEP flood hazard 2050 mitigation scenario
21	0.2% AEP flood hazard 2050 mitigation scenario
22	20% AEP difference map 2050 mitigation scenario
23	5% AEP difference map 2050 mitigation scenario
24	2% AEP difference map 2050 mitigation scenario
25	1% AEP difference map 2050 mitigation scenario
26	0.2% AEP difference map 2050 mitigation scenario

Disclaimer

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- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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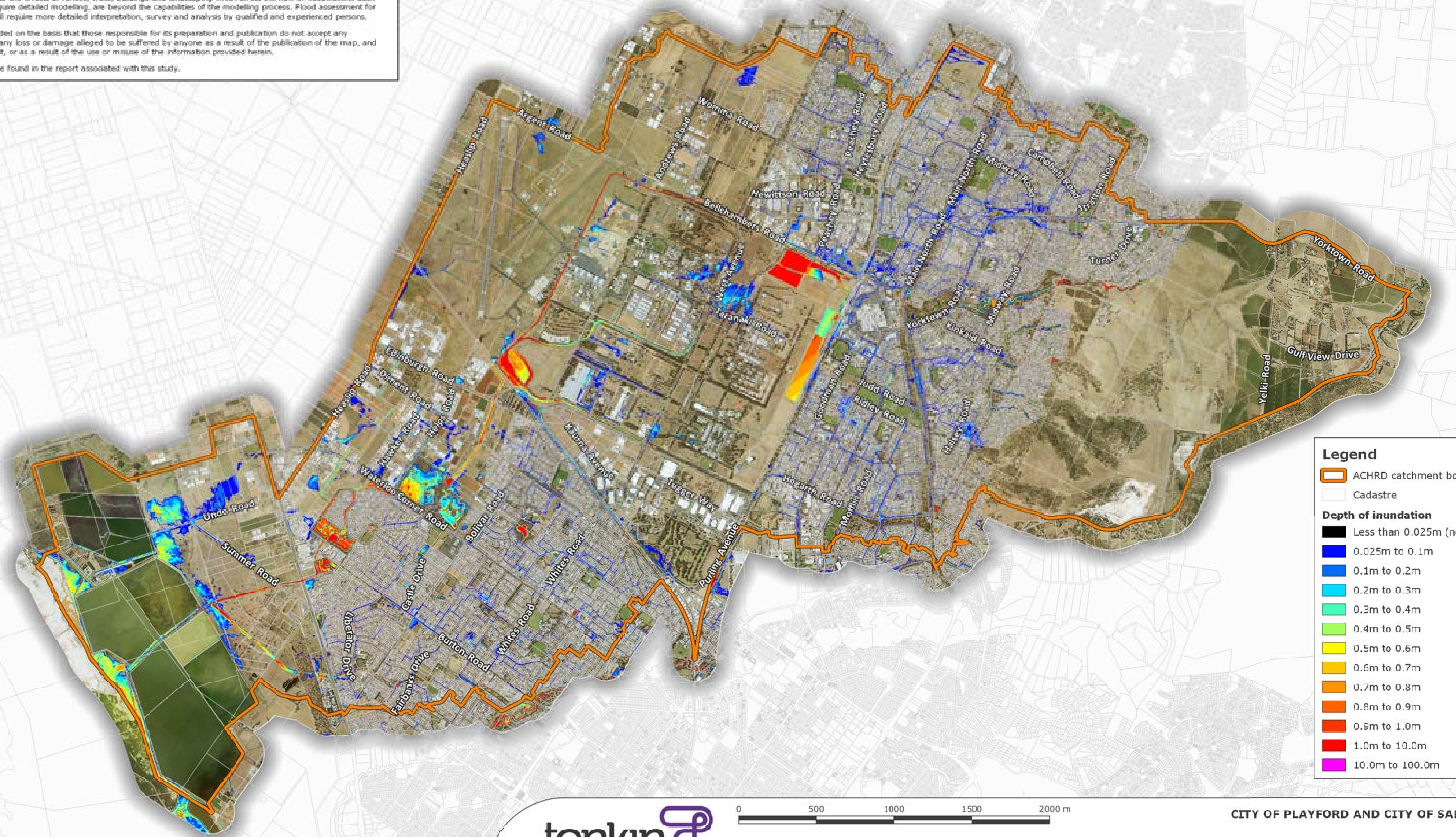
More detail can be found in the report associated with this study.



Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

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Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
20% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Map 1

Disclaimer

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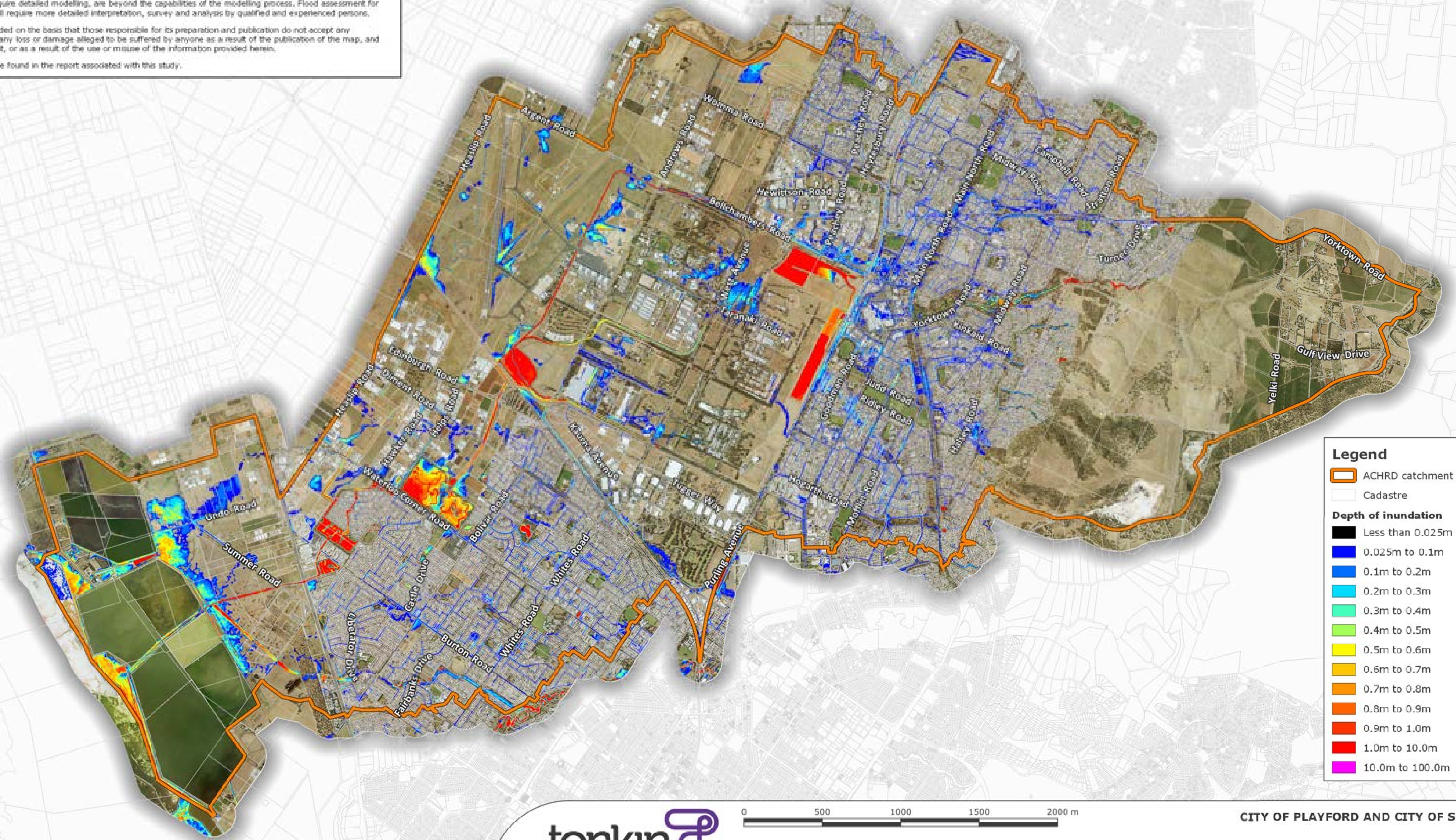

Legend

ACHRD catchment boundary	
Cadastre	
Depth of inundation	
Less than 0.025m (not shown)	
0.025m to 0.1m	
0.1m to 0.2m	
0.2m to 0.3m	
0.3m to 0.4m	
0.4m to 0.5m	
0.5m to 0.6m	
0.6m to 0.7m	
0.7m to 0.8m	
0.8m to 0.9m	
0.9m to 1.0m	
1.0m to 10.0m	
10.0m to 100.0m	

0 500 1000 1500 2000 m

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
5% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Map 2

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
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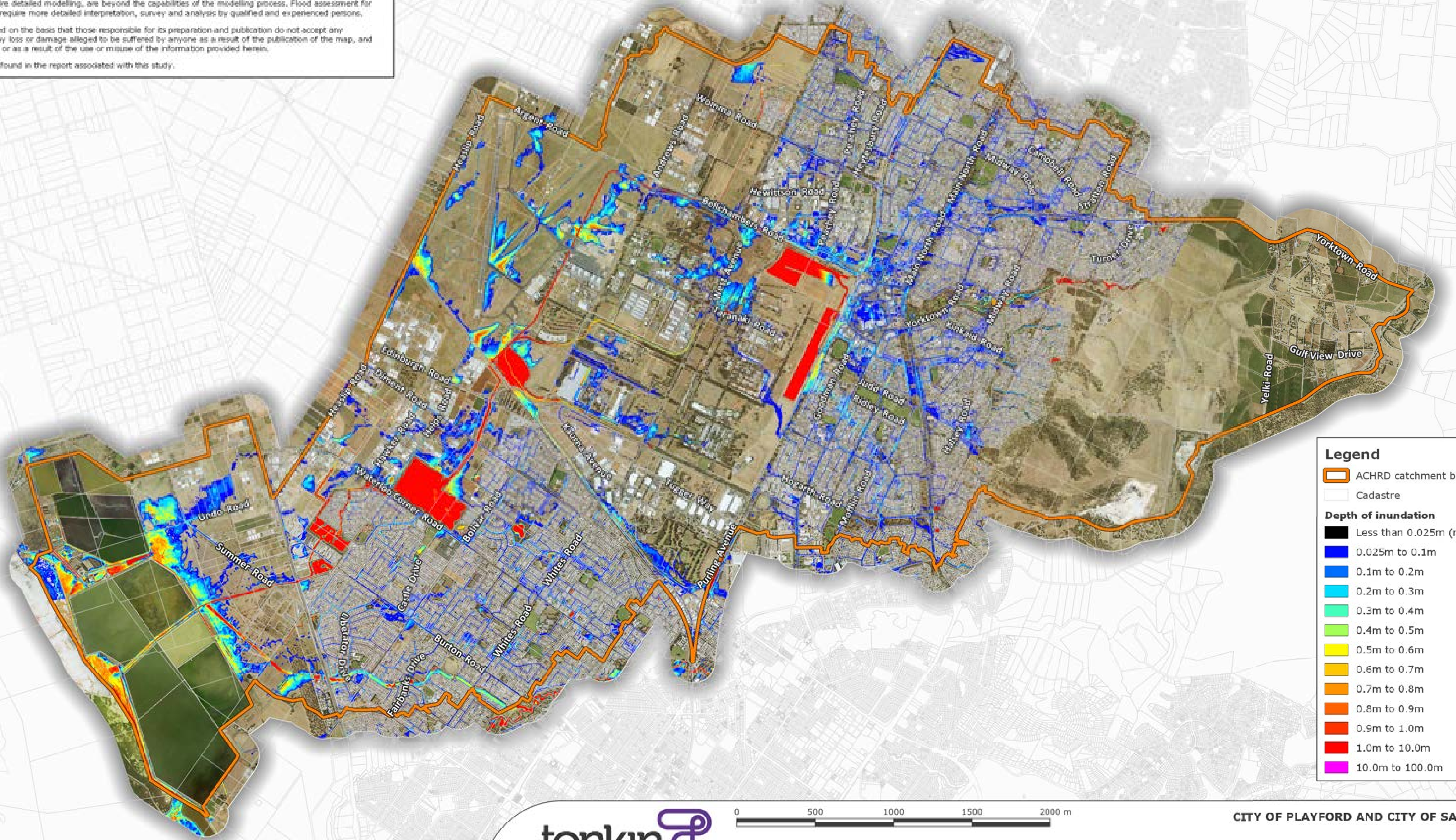

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
2% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Map 3

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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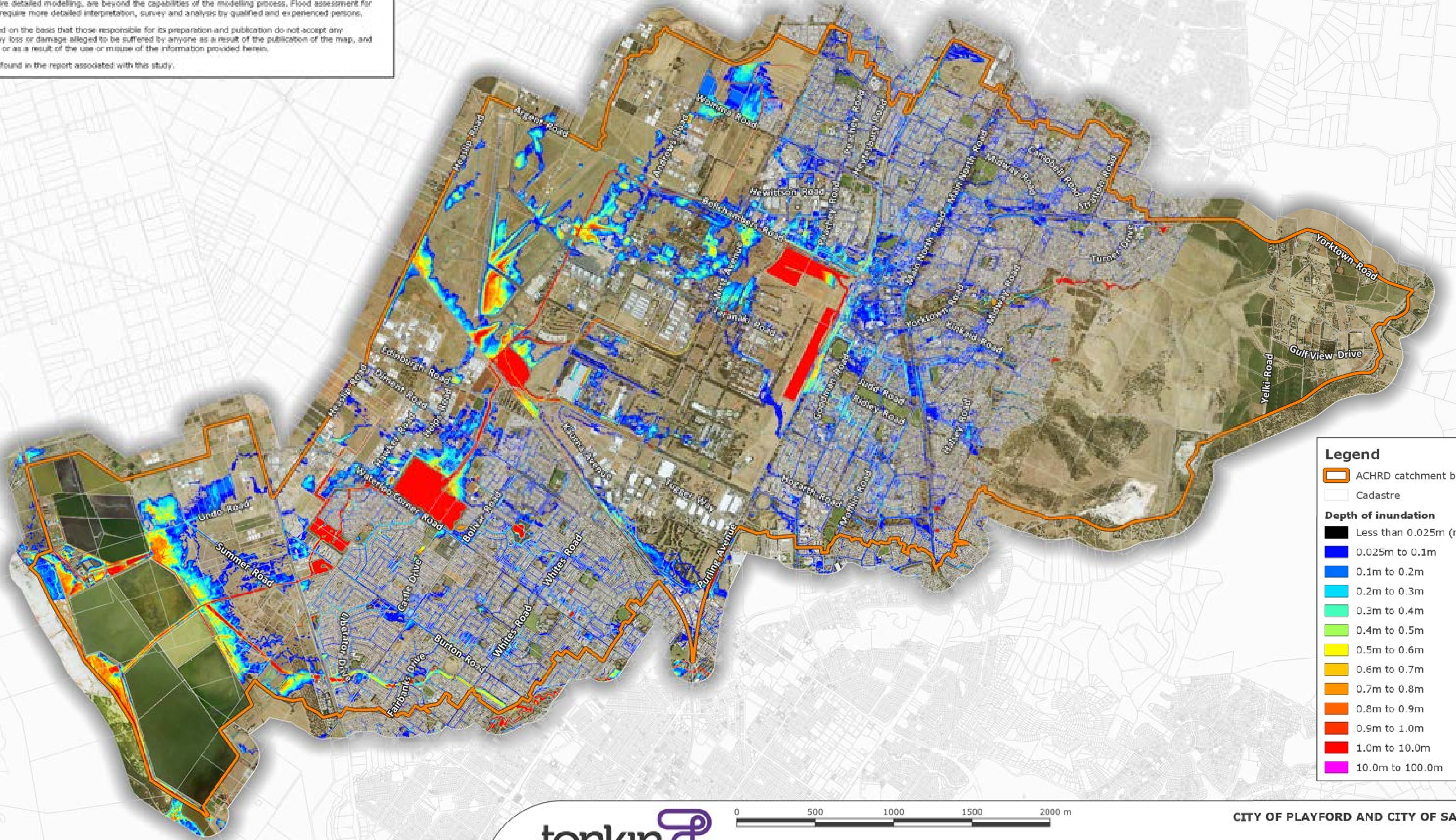

Legend

ACHRD catchment boundary

Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Map 4

Disclaimer

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- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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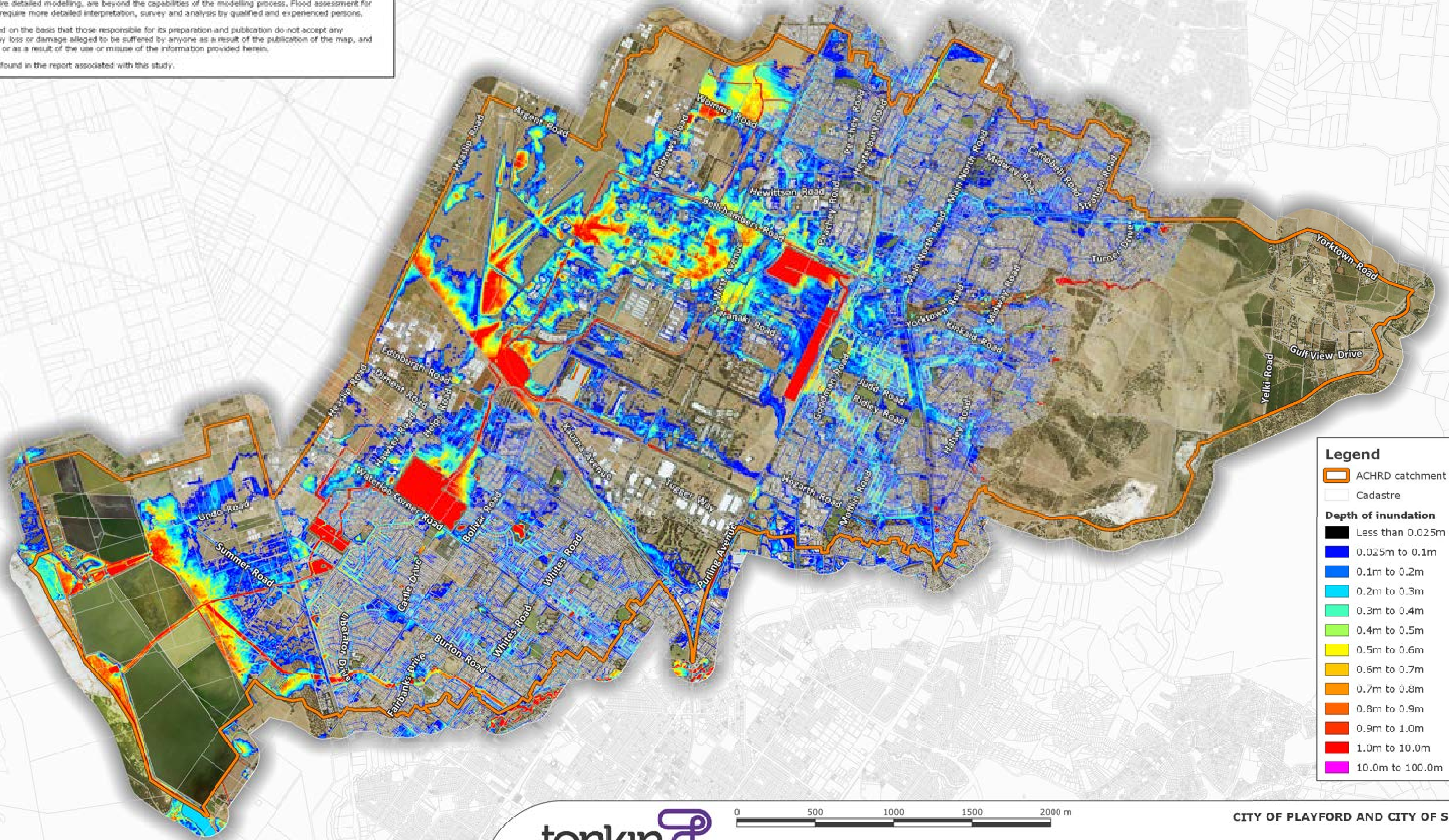

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

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Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD DEPTH LONG TERM 2050 SCENARIO

Map 5

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD HAZARD LONG TERM 2050 SCENARIO

CITY OF PLAYFORD AND CITY OF SALISBURY

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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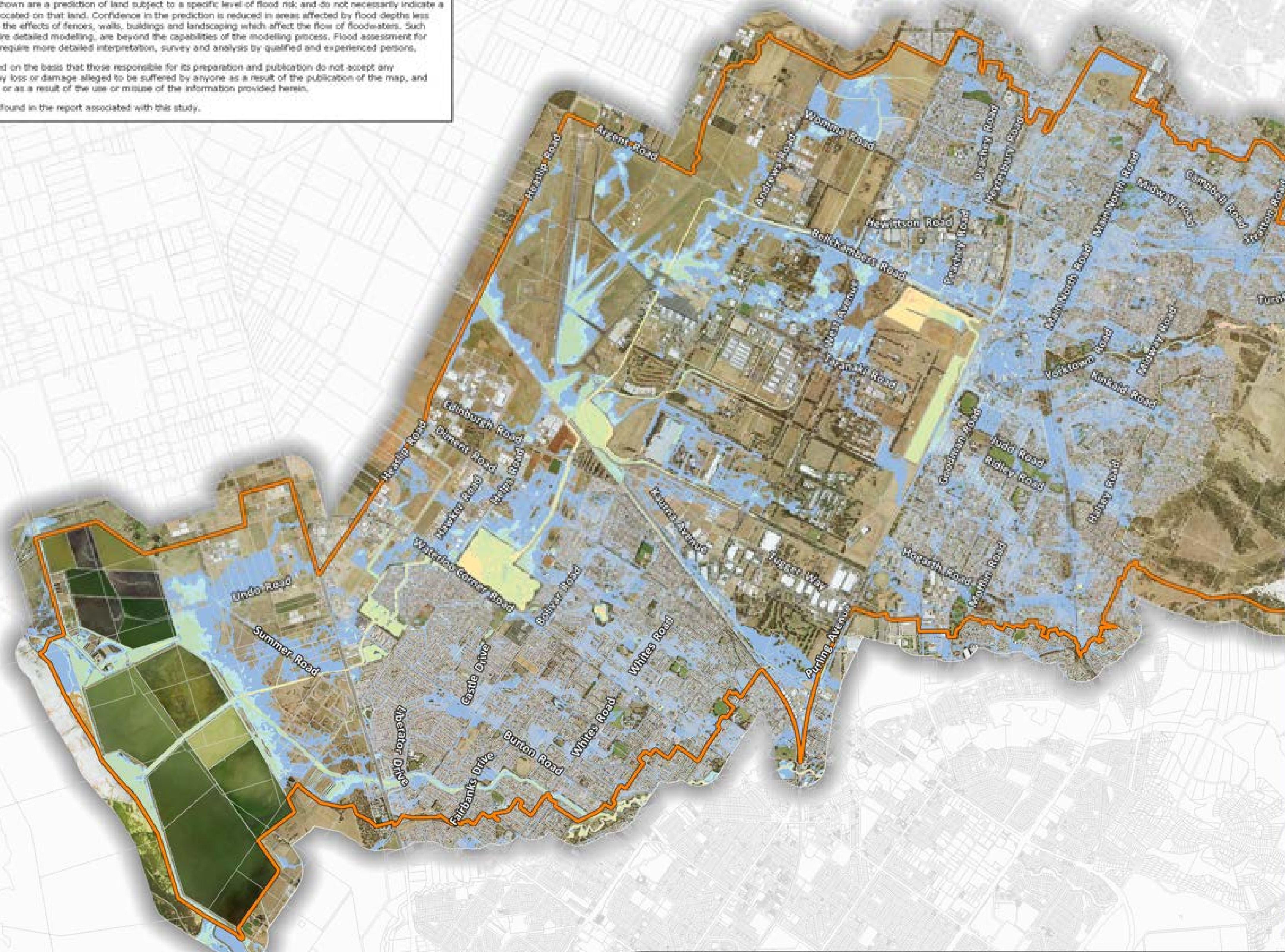
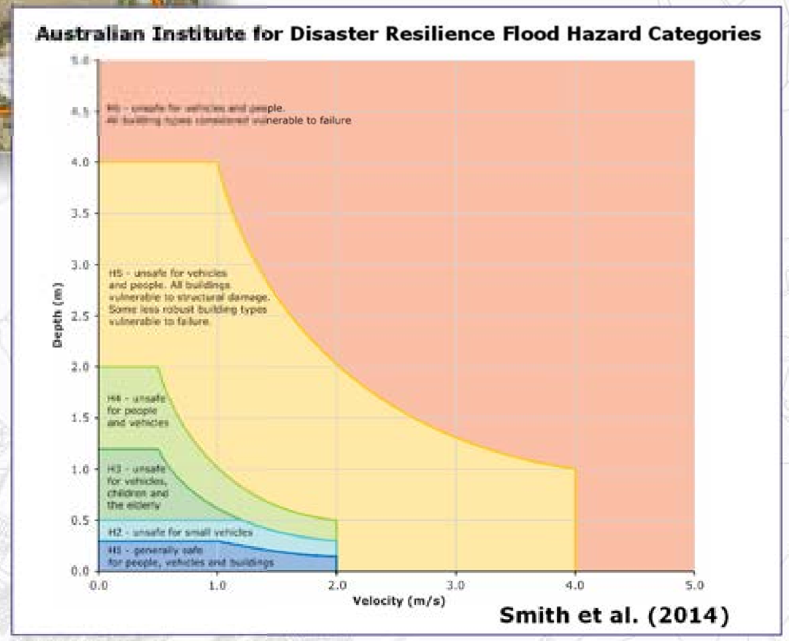


Legend

- ACHRD catchment boundary
- Cadastre

Flood hazard category

- No Hazard
- H1
- H2
- H3
- H4
- H5
- H6



0 1000 2000 3000 4000 m

tonkin

Job Number:	20170712
Filename:	20170712GQ003A
Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

Map 6

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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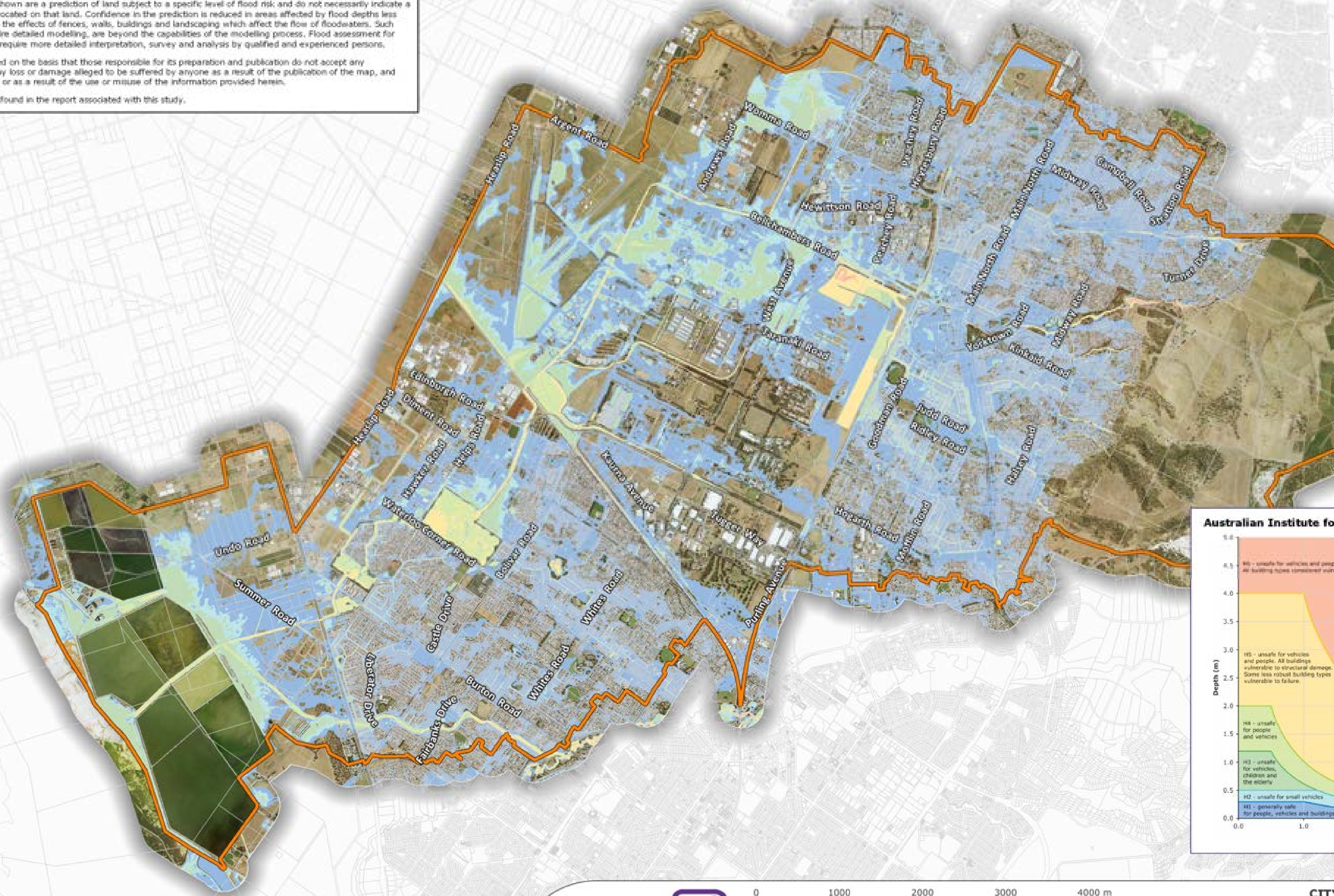
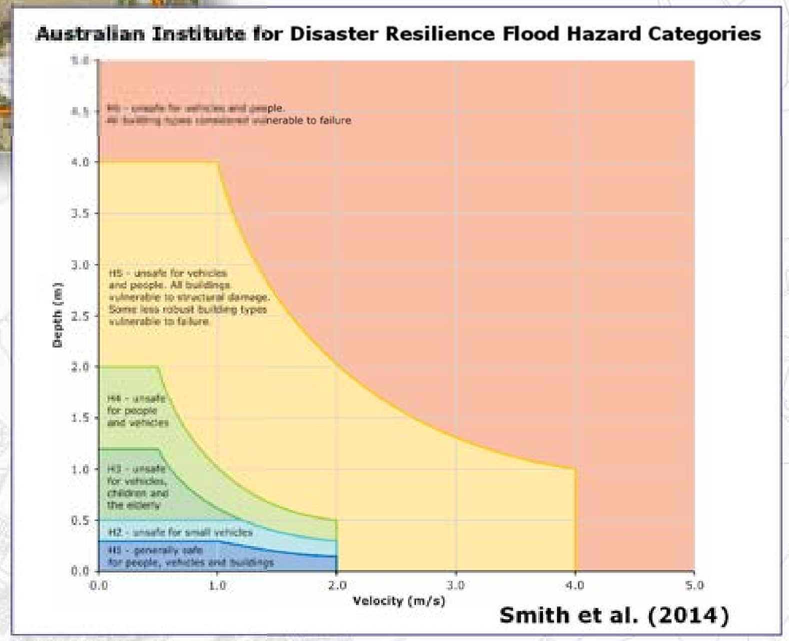


Legend

- ACHRD catchment boundary
- Cadastre

Flood hazard category

- No Hazard
- H1
- H2
- H3
- H4
- H5
- H6



0 1000 2000 3000 4000 m

tonkin

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD HAZARD LONG TERM 2050 SCENARIO

Job Number:	20170712
Filename:	20170712GQ003A
Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

Map 7

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

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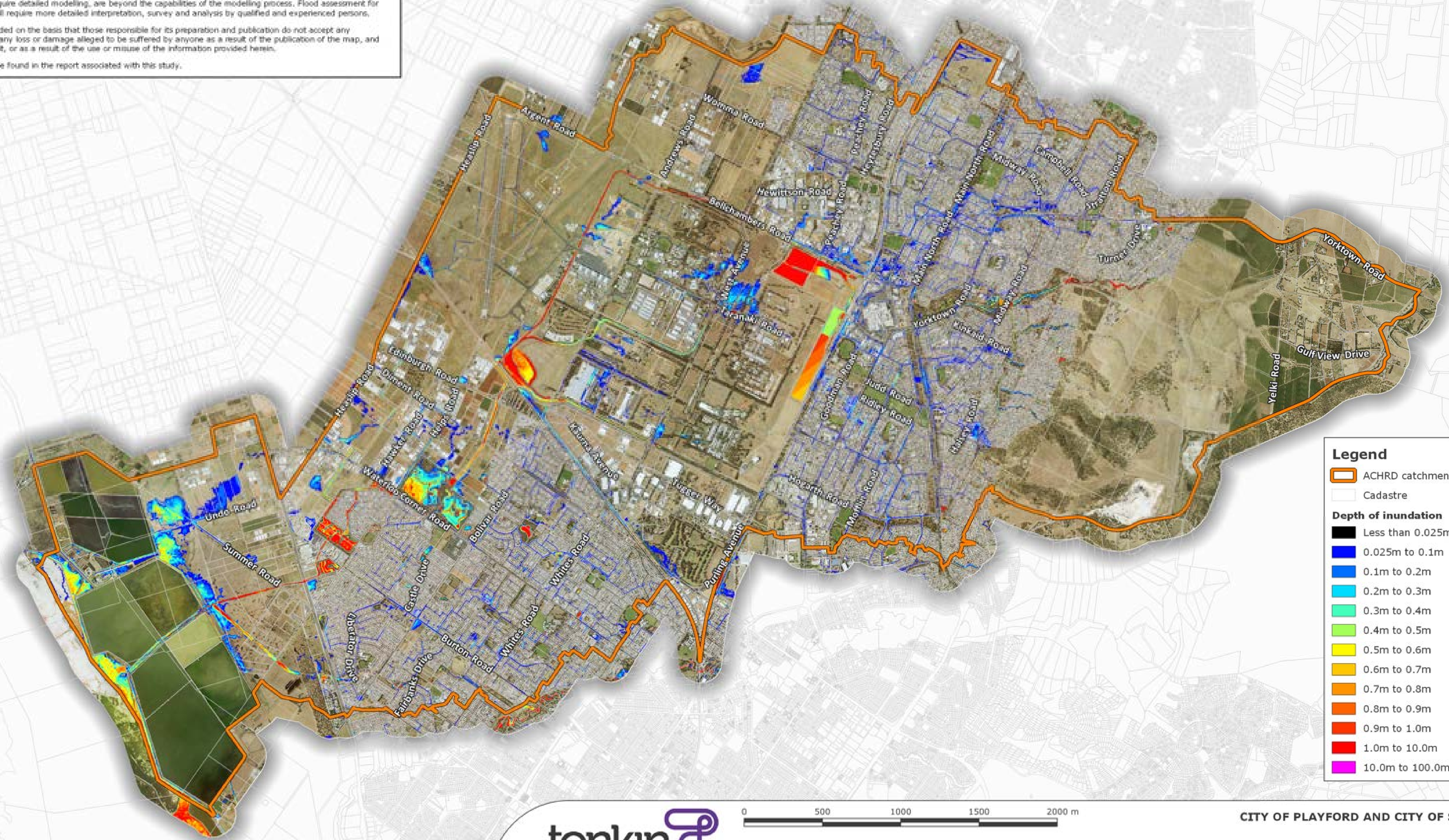

Legend

	ACHRD catchment boundary
	Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

tonkin

Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
20% AEP FLOOD DEPTH LONG TERM 2090 SCENARIO

Map 8

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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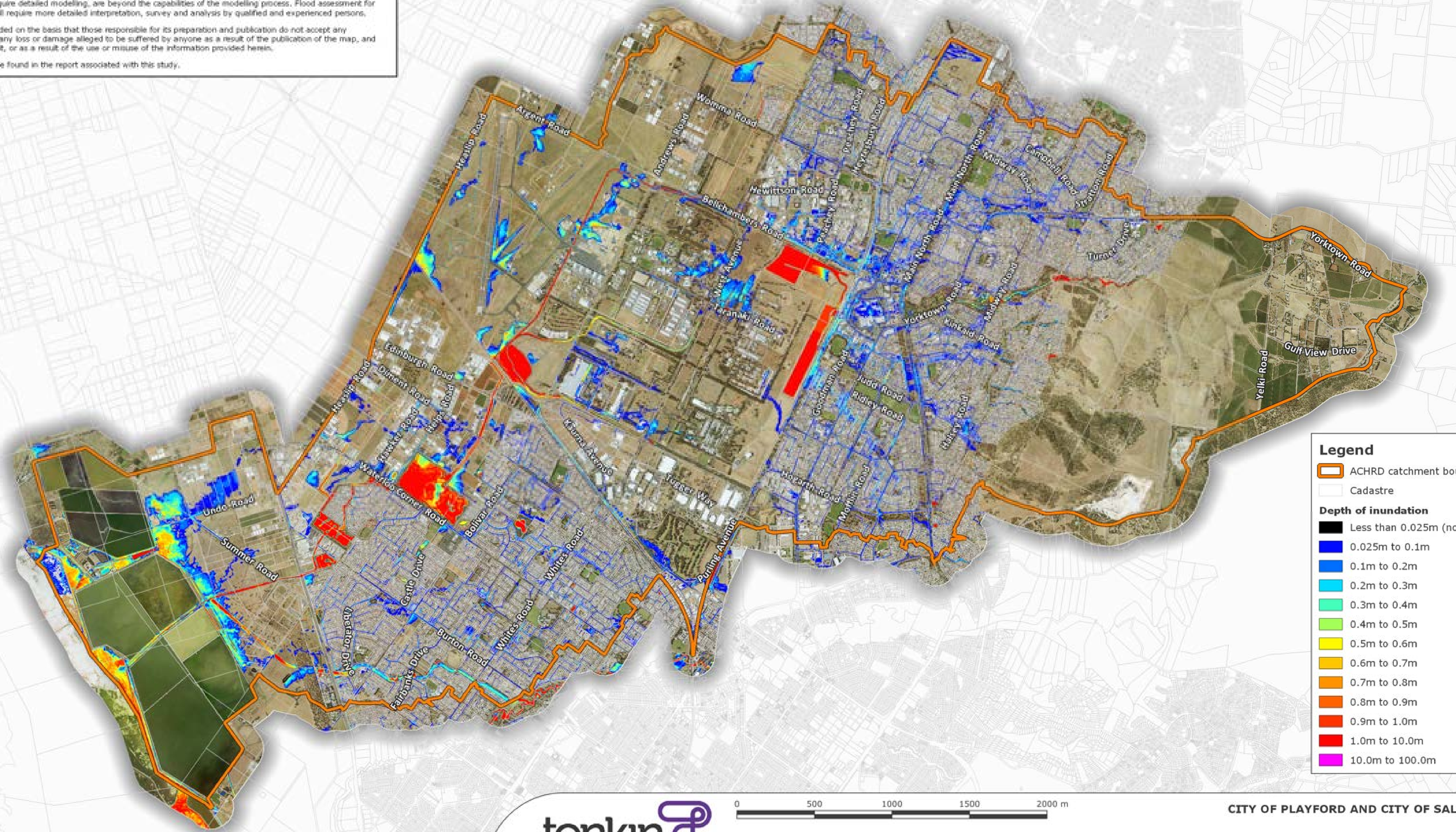

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

N

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Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
5% AEP FLOOD DEPTH LONG TERM 2090 SCENARIO

Map 9

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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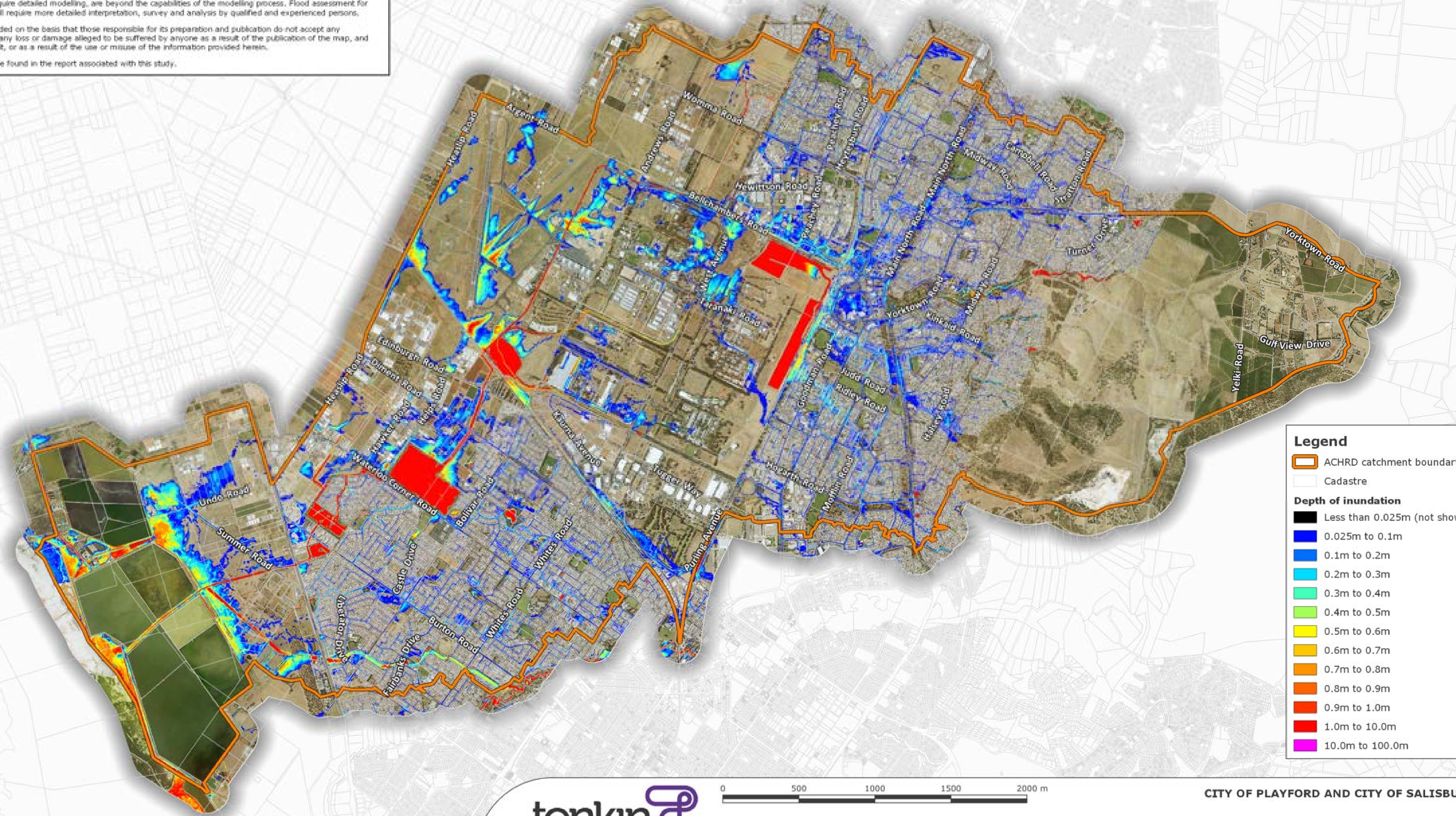

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

N

tonkin

Job Number:	20170712
Filename:	20170712GQ003A
Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
2% AEP FLOOD DEPTH LONG TERM 2090 SCENARIO

Map 10

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

- Floods with a different Annual Exceedance Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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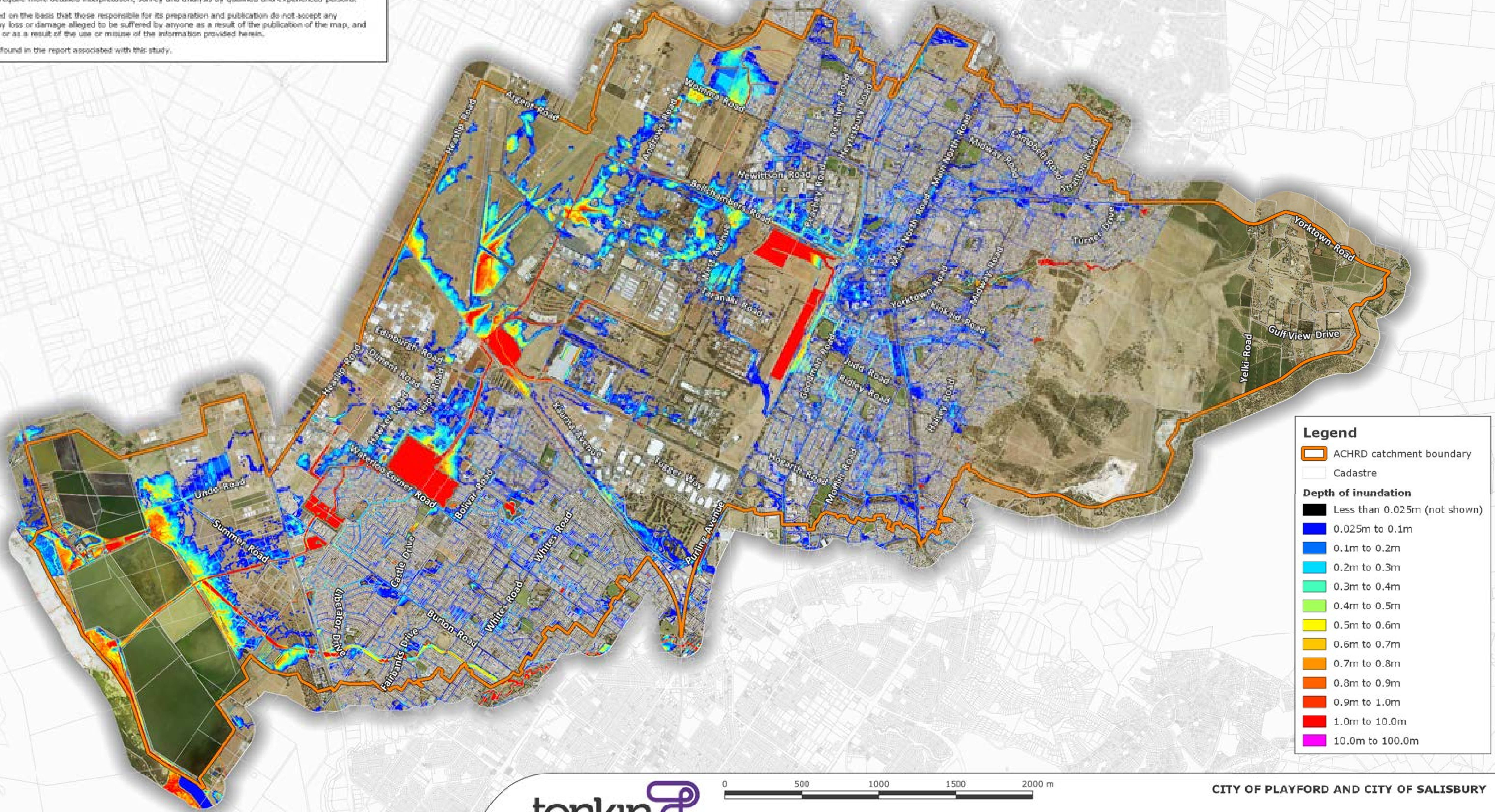

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Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD DEPTH LONG TERM 2090 SCENARIO

Map 11

Disclaimer

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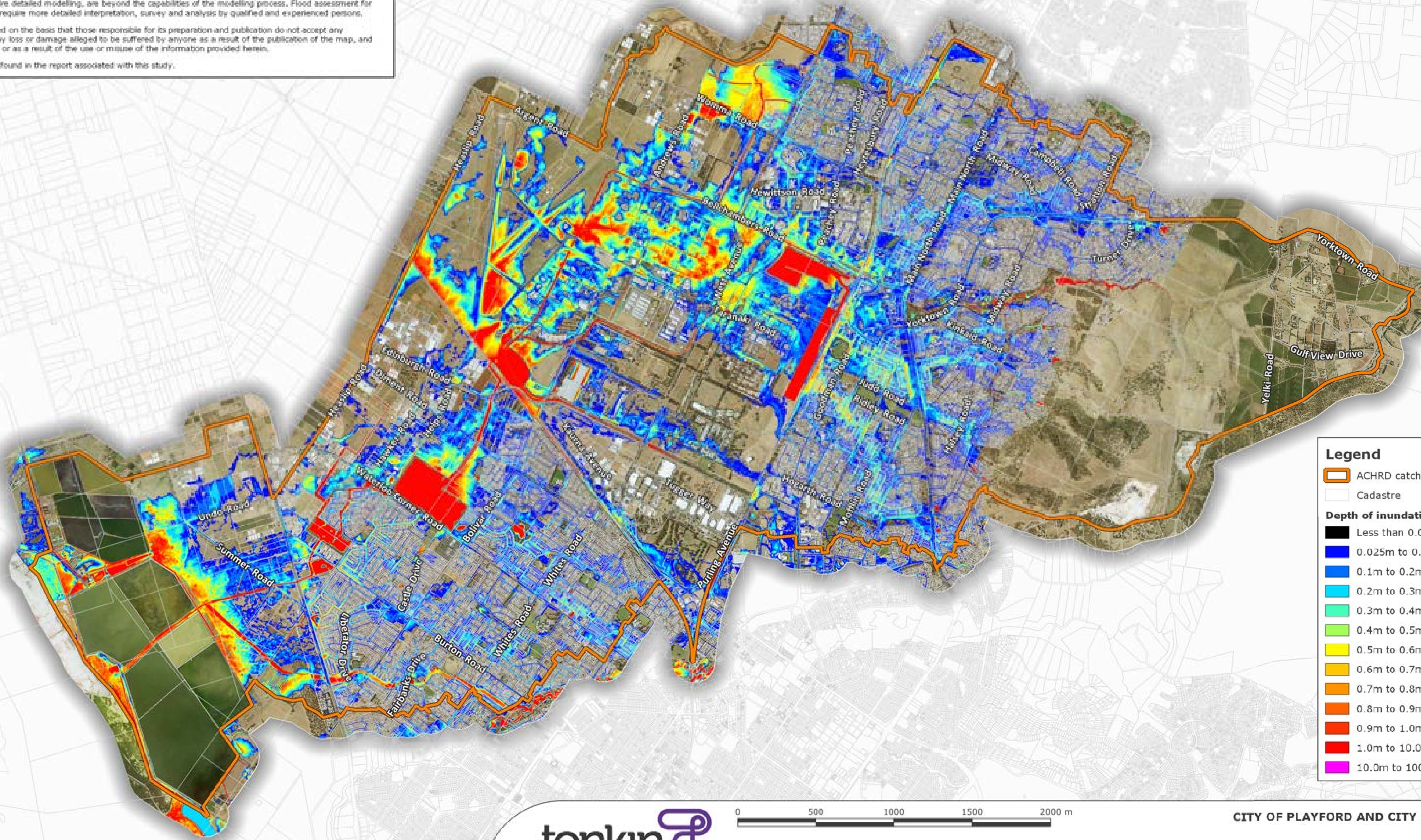

Legend

	ACHRD catchment boundary
	Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

N

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Job Number:	20170712
Filename:	20170712GQ003A
Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD DEPTH LONG TERM 2090 SCENARIO

Map 12

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

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More detail can be found in the report associated with this study.

Legend

- ACHRD catchment boundary
- Cadastre

Flood hazard category

- No Hazard
- H1
- H2
- H3
- H4
- H5
- H6

tonkin

0 1000 2000 3000 4000 m

Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD HAZARD LONG TERM 2090 SCENARIO

Map 13

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown 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:

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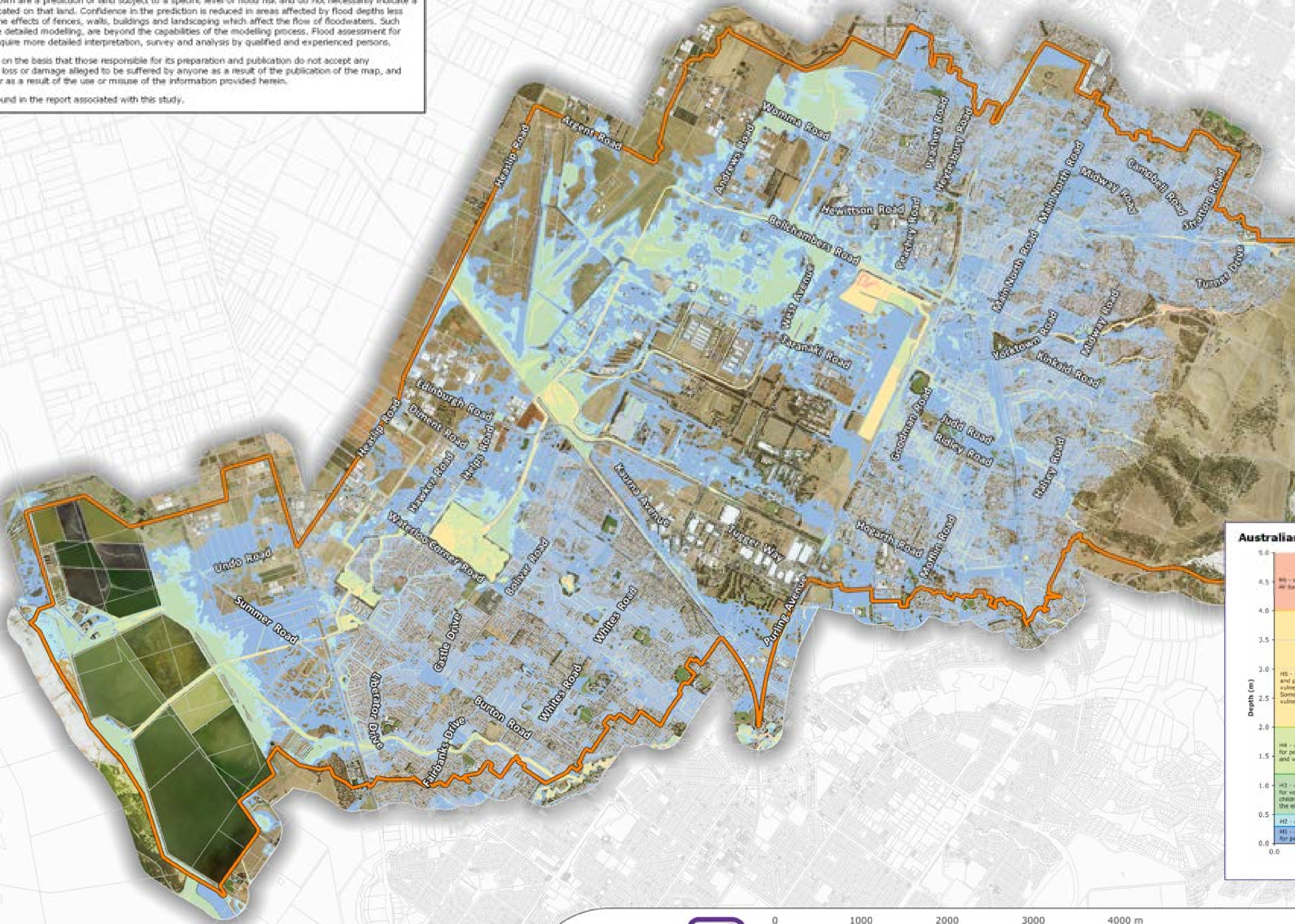
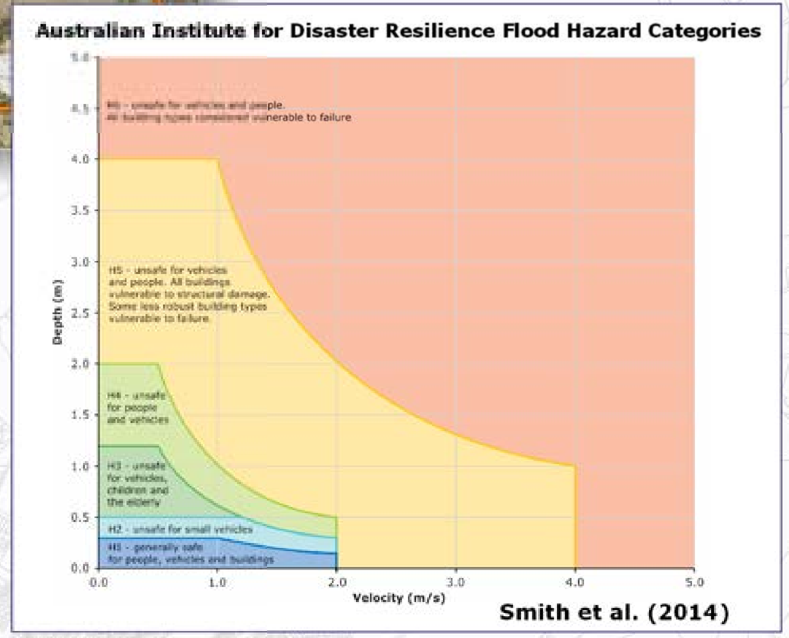


Legend



0 1000 2000 3000 4000 m

tonkin

Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

N

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD HAZARD LONG TERM 2090 SCENARIO

Map 14

Disclaimer

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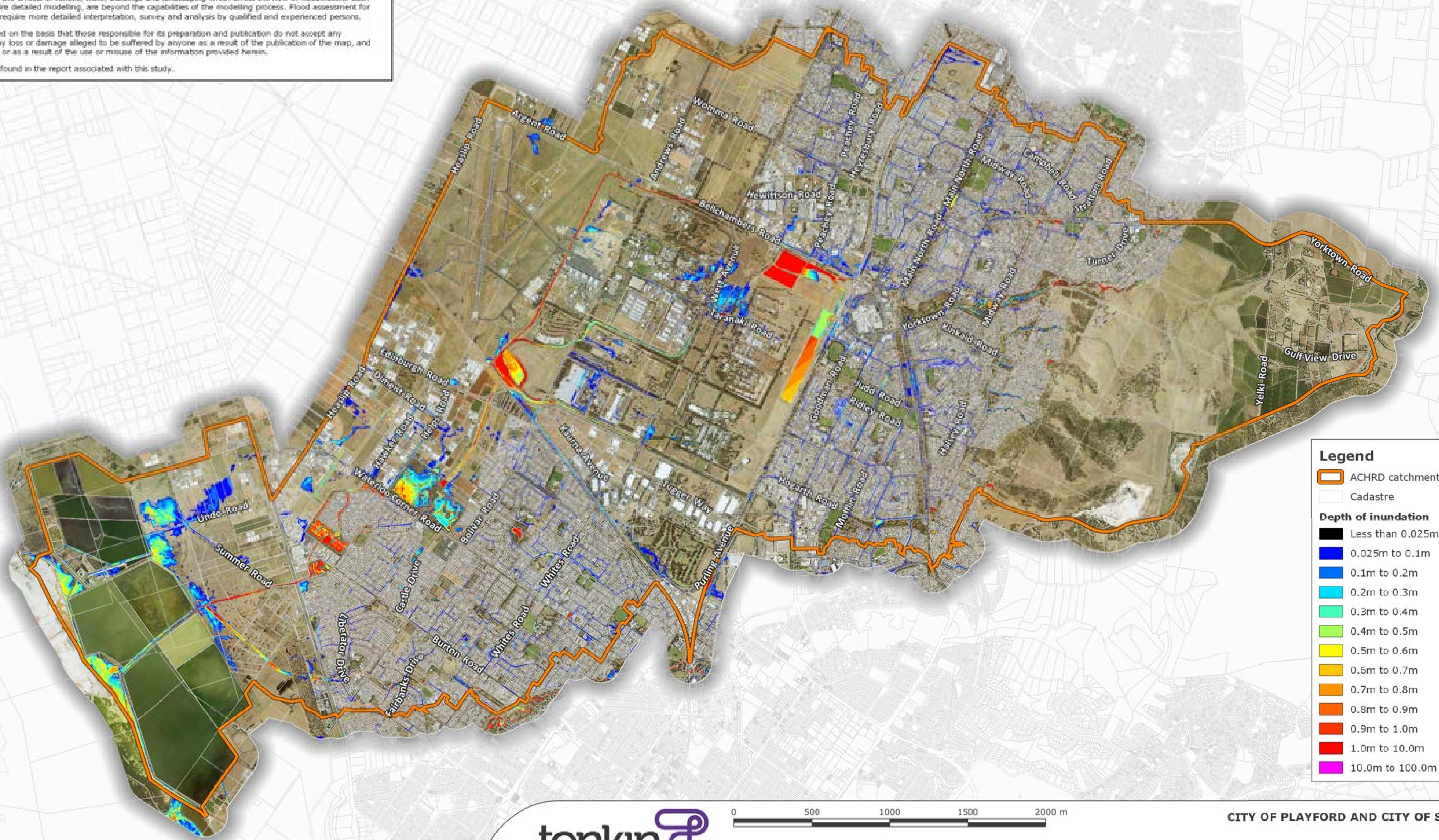

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

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Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
20% AEP FLOOD DEPTH 2050 MITIGATION SCENARIO

Disclaimer

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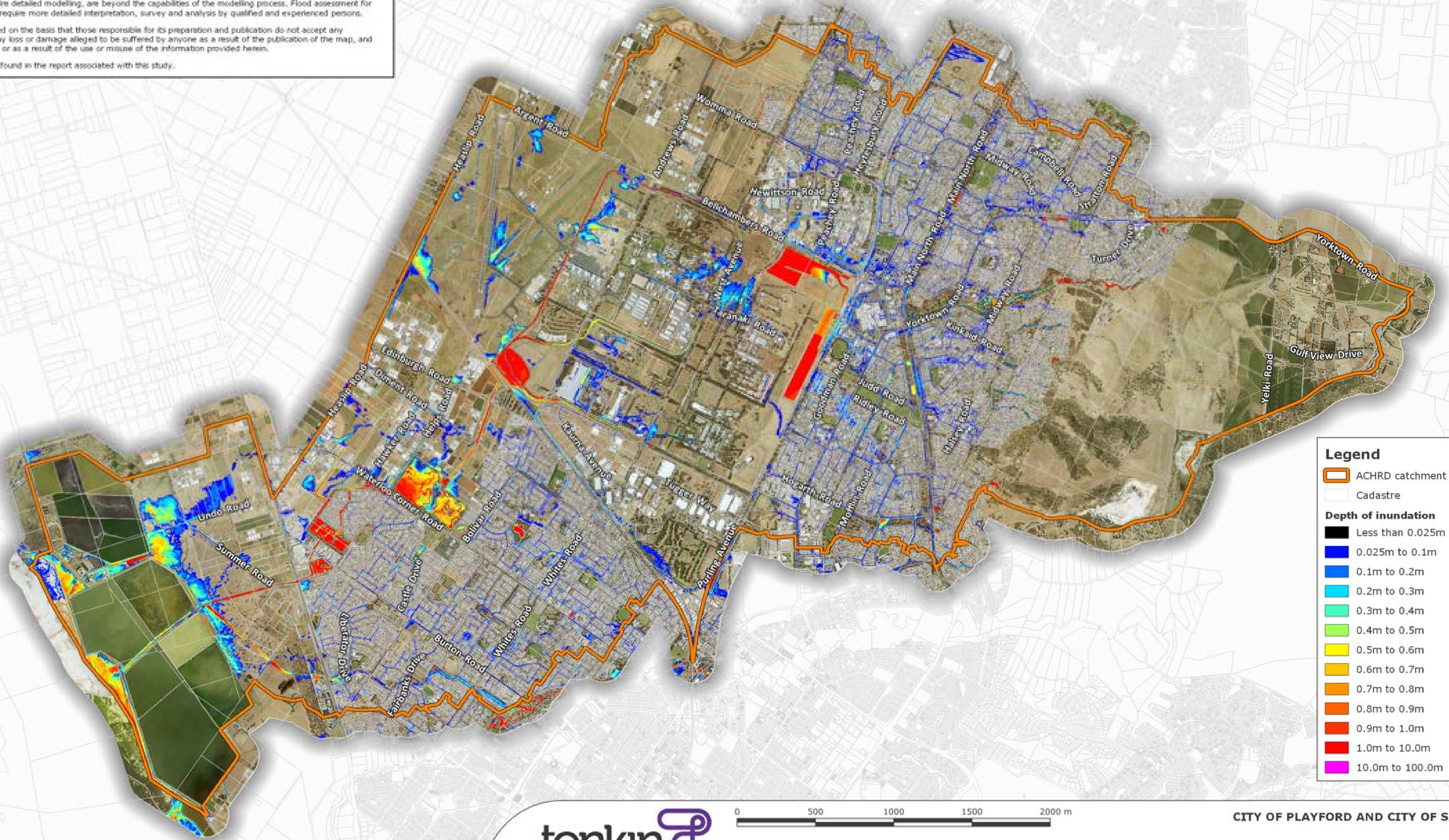

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

N

tonkin

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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
5% AEP FLOOD DEPTH 2050 MITIGATION SCENARIO

Map 16

Disclaimer

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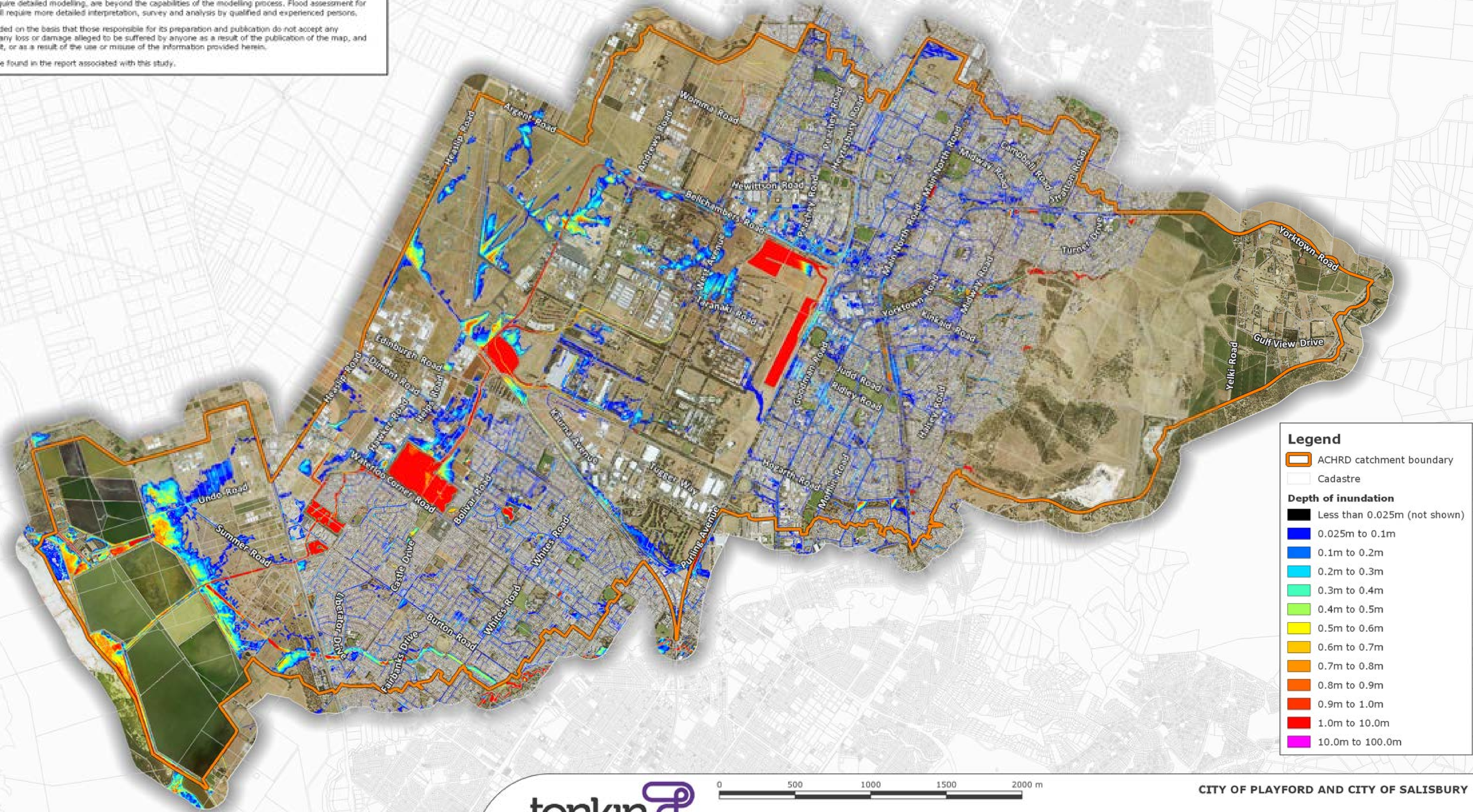
More detail can be found in the report associated with this study.



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Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
2% AEP FLOOD DEPTH 2050 MITIGATION SCENARIO

Map 17

Disclaimer

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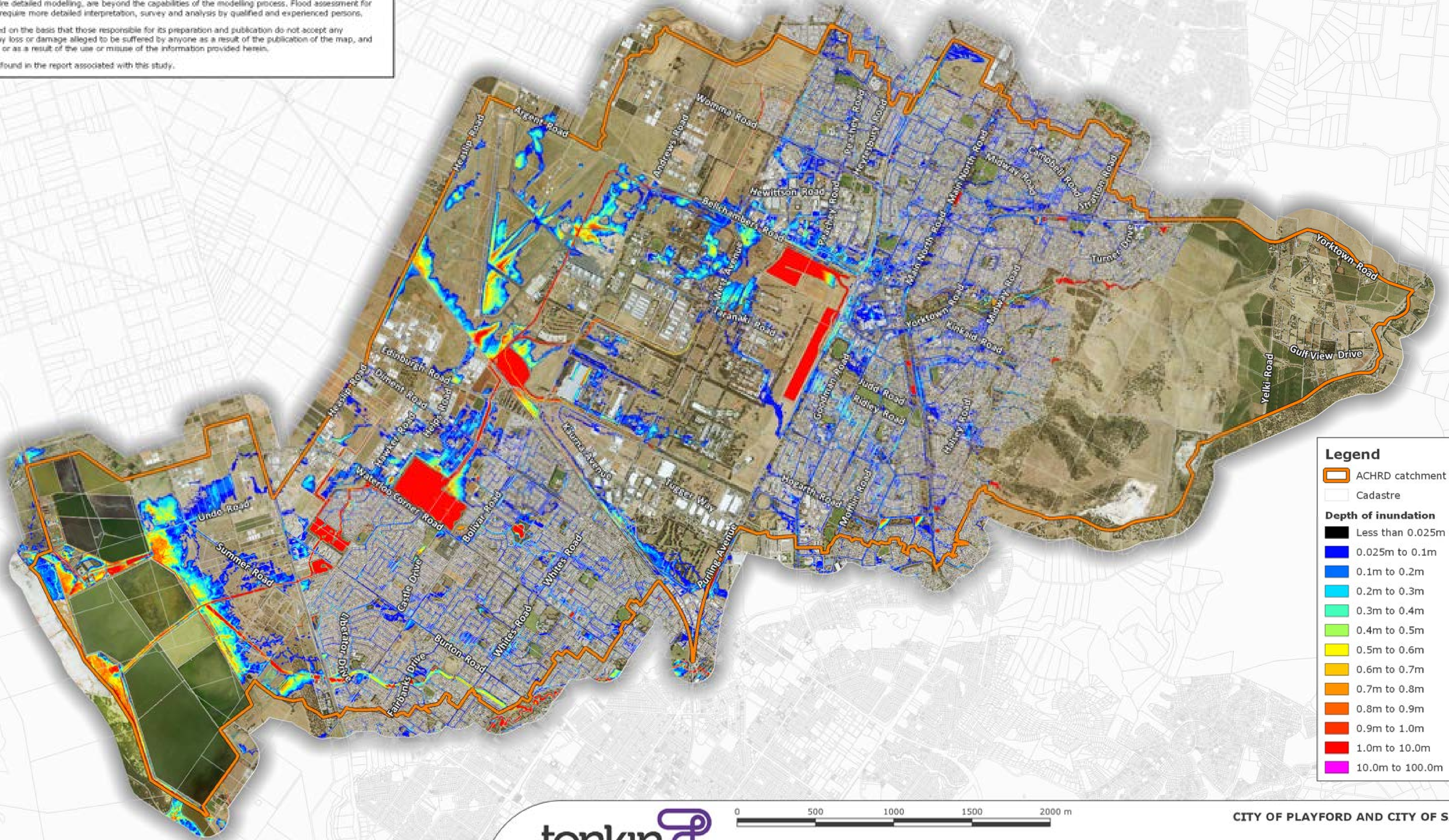

Legend

- ACHRD catchment boundary
- Cadastre

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 10.0m
- 10.0m to 100.0m

0 500 1000 1500 2000 m

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Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
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CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD DEPTH 2050 MITIGATION SCENARIO

Map 18

Disclaimer

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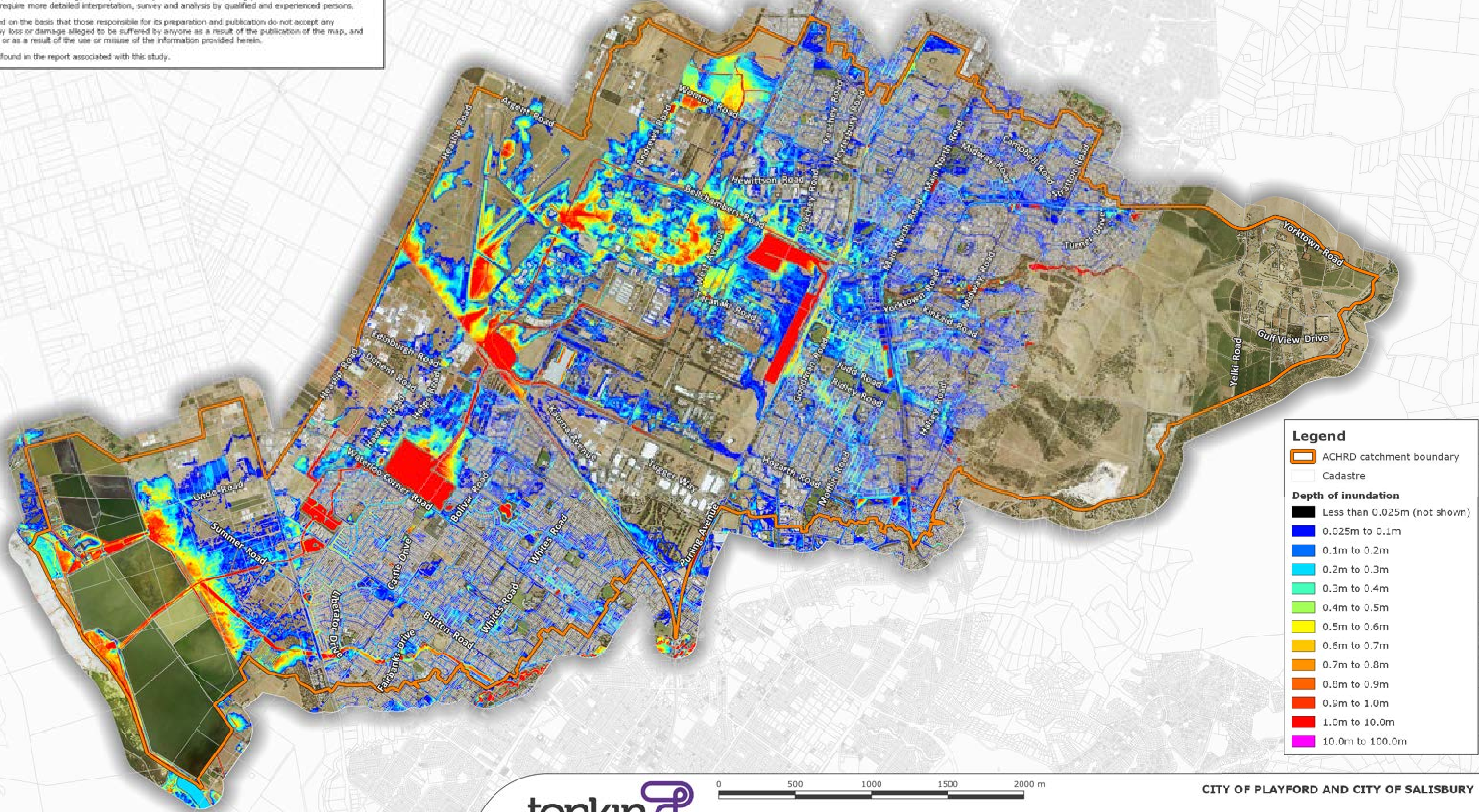

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Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD DEPTH 2050 MITIGATION SCENARIO

Map 19

Disclaimer

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Legend

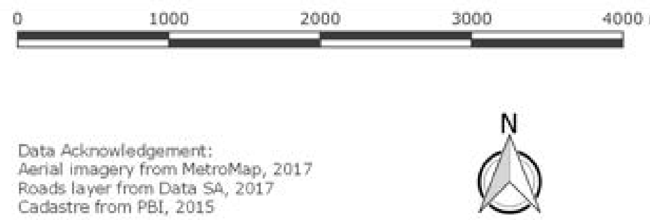
- ACHRD catchment boundary
- Cadastre

Flood hazard category

- No Hazard
- H1
- H2
- H3
- H4
- H5
- H6

Australian Institute for Disaster Resilience Flood Hazard Categories

Smith et al. (2014)



tonkin

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Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP FLOOD HAZARD 2050 MITIGATION SCENARIO

Map 20

Disclaimer

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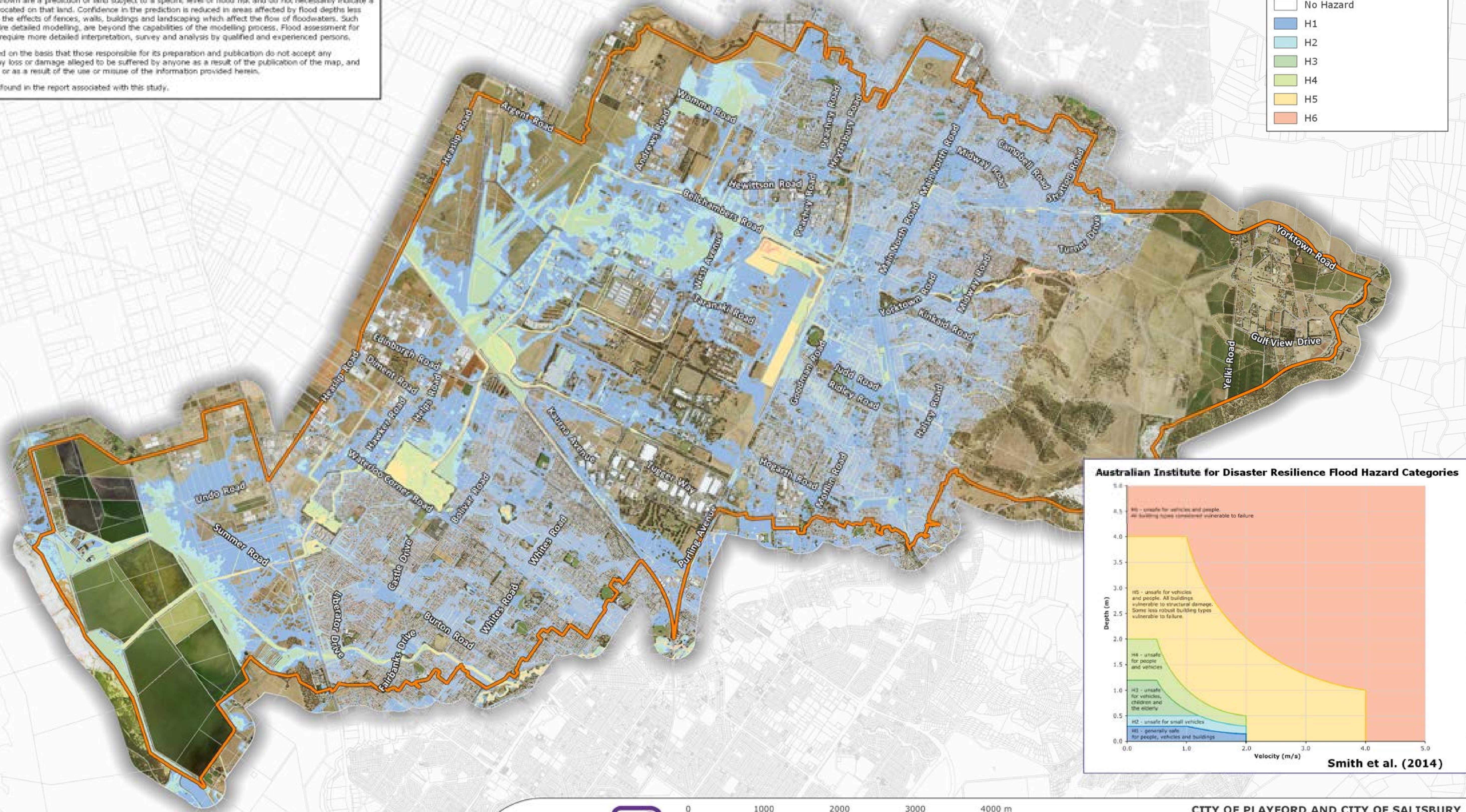
Legend

- ACHRD catchment boundary
- Cadastre

Flood hazard category

- No Hazard
- H1
- H2
- H3
- H4
- H5
- H6



0 1000 2000 3000 4000 m

N

tonkin

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Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP FLOOD HAZARD 2050 MITIGATION SCENARIO

Map 21

Disclaimer

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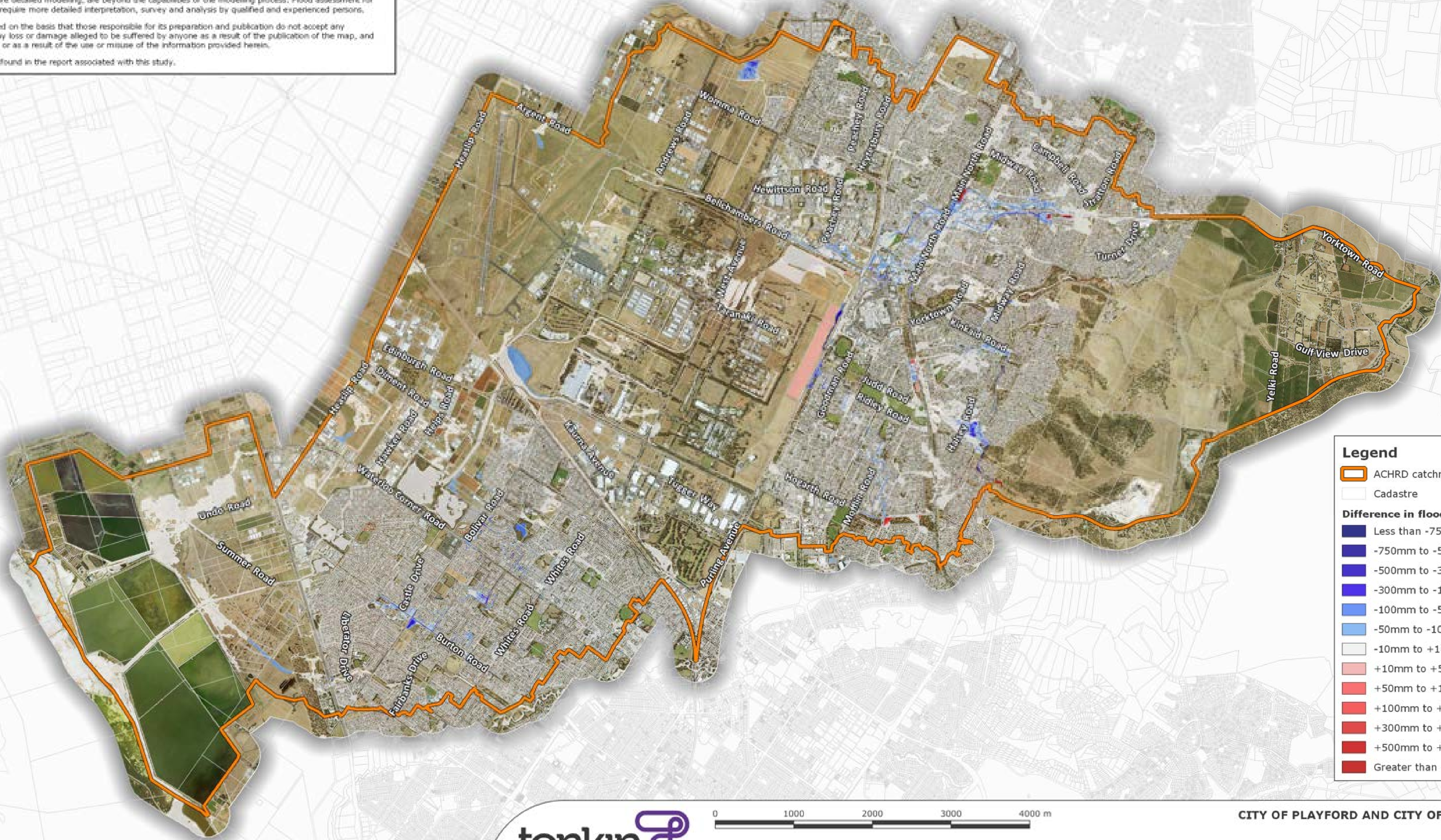

Legend

- ACHRD catchment boundary
- Cadastre

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1000 2000 3000 4000 m

N

tonkin

Job Number:	20170712
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Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
20% AEP DIFFERENCE MAP 2050 MITIGATION SCENARIO

Map 22

Disclaimer

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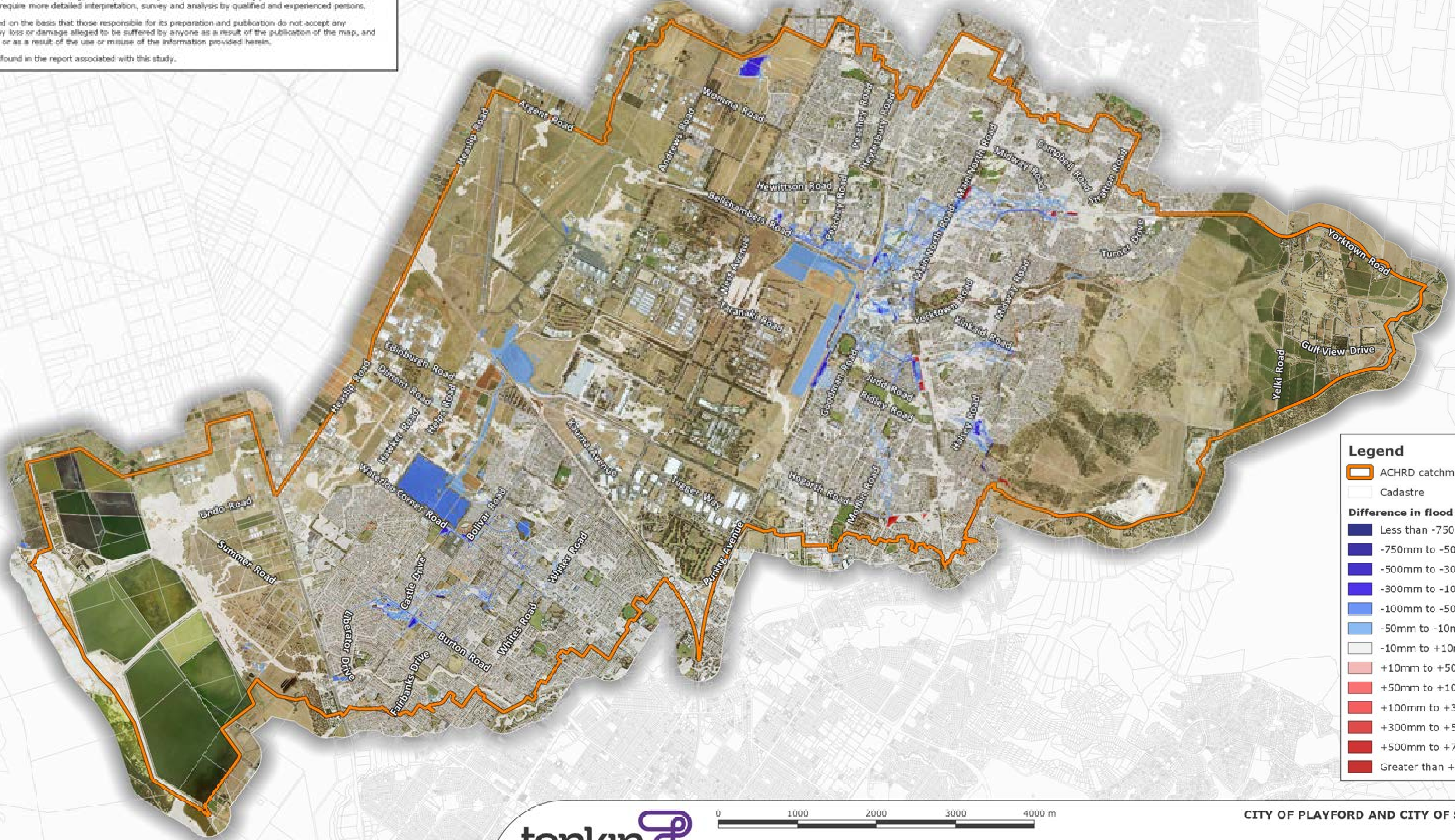

Legend

- ACHRD catchment boundary
- Cadastre

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1000 2000 3000 4000 m

N

tonkin

Job Number:	20170712
Filename:	20170712GQ003A
Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
Aerial imagery from MetroMap, 2017
Roads layer from Data SA, 2017
Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
5% AEP DIFFERENCE MAP 2050 MITIGATION SCENARIO

Map 23

Disclaimer

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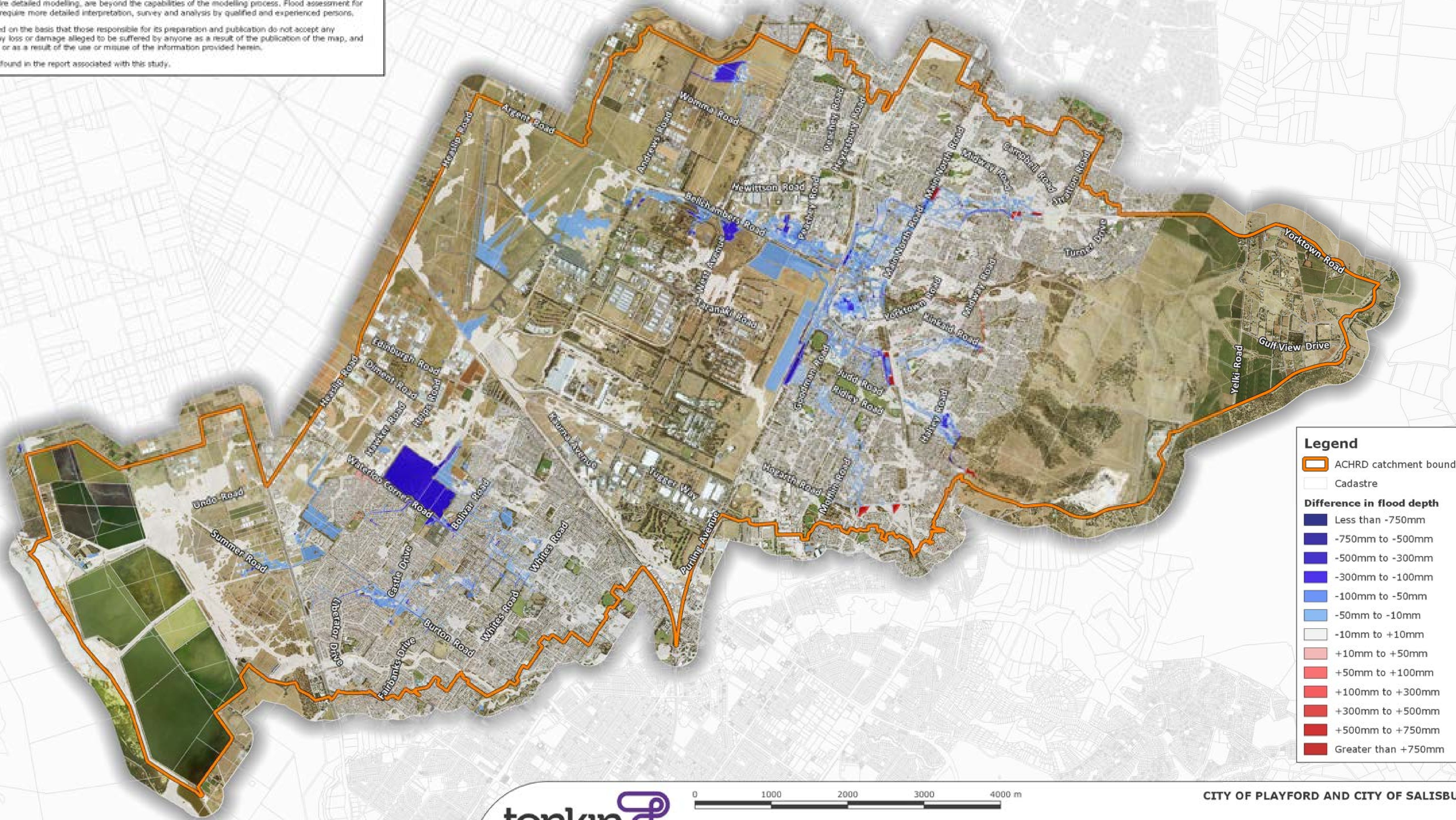

Legend

ACHRD catchment boundary	
Cadastre	
Difference in flood depth	
Less than -750mm	
-750mm to -500mm	
-500mm to -300mm	
-300mm to -100mm	
-100mm to -50mm	
-50mm to -10mm	
-10mm to +10mm	
+10mm to +50mm	
+50mm to +100mm	
+100mm to +300mm	
+300mm to +500mm	
+500mm to +750mm	
Greater than +750mm	

0 1000 2000 3000 4000 m

tonkin

Job Number: 20170712
Filename: 20170712GQ003A
Revision: A
Date: 2019-10-17
Drawn: MM

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Cadastre from PBI, 2015

N

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
2% AEP DIFFERENCE MAP 2050 MITIGATION SCENARIO

Map 24

Disclaimer

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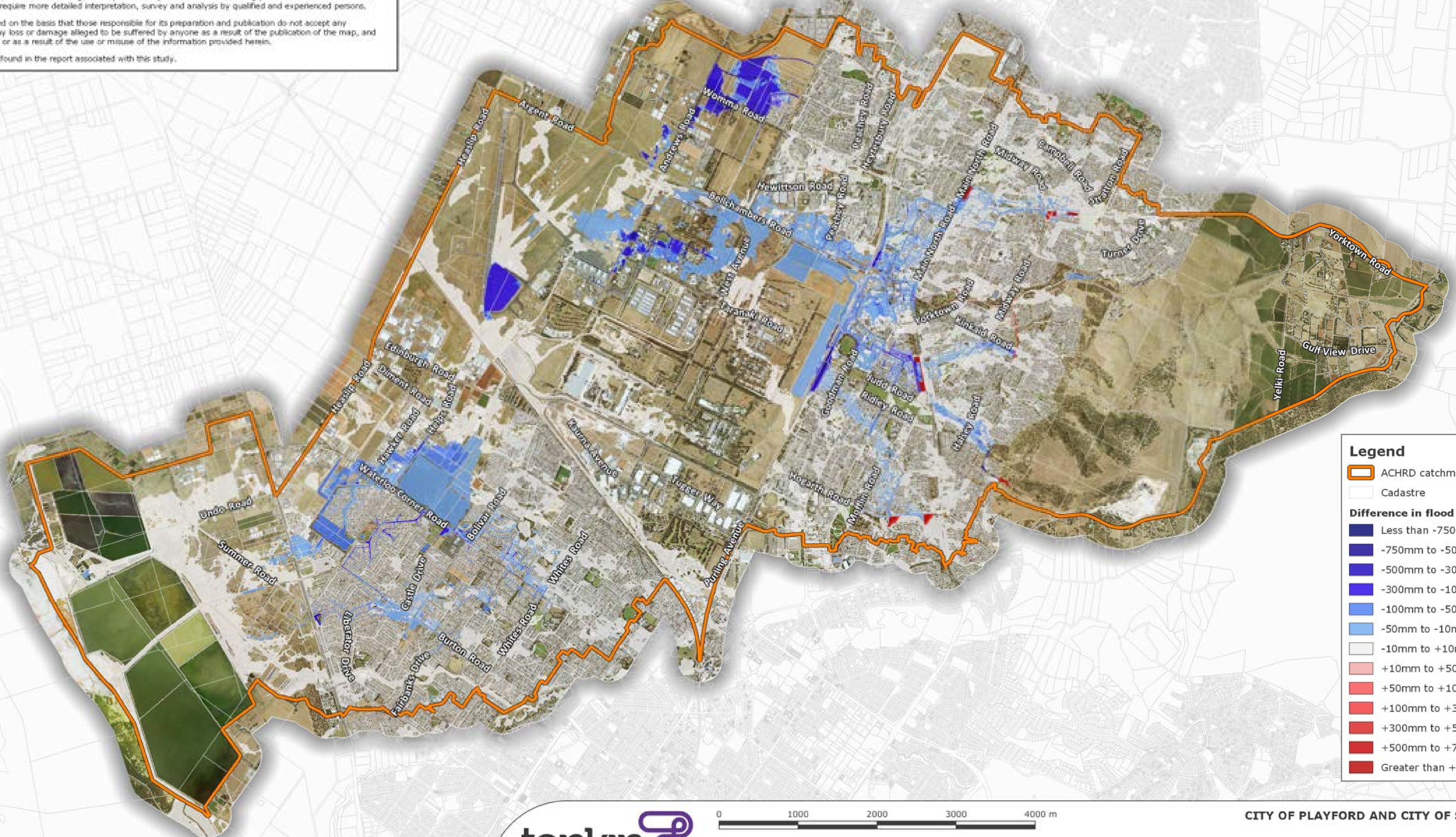

Legend

- ACHRD catchment boundary
- Cadastre

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1000 2000 3000 4000 m

N

tonkin

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Revision: A
Date: 2019-10-17
Drawn: MM

Data Acknowledgement:
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Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
1% AEP DIFFERENCE MAP 2050 MITIGATION SCENARIO

Map 25

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Revision:	A
Date:	2019-10-17
Drawn:	MM

Data Acknowledgement:
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Cadastre from PBI, 2015

CITY OF PLAYFORD AND CITY OF SALISBURY

ADAMS CREEK AND HELPS ROAD DRAIN CATCHMENT
0.2% AEP DIFFERENCE MAP 2050 MITIGATION SCENARIO

Map 26

Appendix E – 1% AEP flood depth and hazard maps (existing development scenario)

Disclaimer

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tonkin

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Filename: 20120712GQ004RevA
Revision: A
Date: 2020-03-10
Drawn: Dylan Bone

Data Acknowledgement:
Aerial from MetroMap, 2017
Background data from DataSA, 2019

City of Playford

Adams Creek, Helps Road Drain and Greater Edinburgh Parks Catchment
1% AEP Flood Hazard - Existing Development Scenario

Map 2

Appendix F – Water quality modelling setup

Water Quality Modelling Setup

Adams Creek and Helps Road Drain Catchment and Greater Edinburgh Parks Stormwater Management Plans

City of Playford and City of Salisbury

12 May 2021
Ref: 20170712R008Rev2

tonkin
Building exceptional outcomes together

Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
0	For use	MM	TAK	TAK	17 Oct 2019
1	Catchments updated	MM	TAK	TAK	11 May 2020
2	Description of rainfall data provided	MM	TAK	TAK	12 May 2021

Contents

Project: Water Quality Modelling Setup | Adams Creek and Helps Road Drain Catchment and Greater Edinburgh Parks Stormwater Management Plans
Client: City of Playford and City of Salisbury
Ref: 20170712R008Rev2

Tables

Figure

1 Introduction

This report describes the background to the water quality modelling undertaken as part of the Adams Creek and Helps Road drain (ACHRD) catchment and Greater Edinburgh Parks (GEP) stormwater management plans (SMP).

The stated water quality objectives for the study areas reflect South Australia's state wide performance targets for stormwater runoff quality (Department of Environment, Water and Natural Resources, 2013), as follows:

- 80% reduction in average annual total suspended solids
- 60% reduction in average annual total phosphorous
- 45% reduction in average annual total nitrogen, and
- 90% reduction in litter/gross pollutants.

The primary pollutants carried by stormwater within the study area are likely to be sediments (TSS), nutrients (TP and TN), pathogens, oxygen demanding substances and gross pollutants (GP).

The quality of runoff from the study areas was modelled using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC).

There are currently no official guidelines for the use of MUSIC in South Australia. The adopted approach to modelling is therefore based on the recommendations made by the Goyder Institute in their report (Myers et al. 2015) which reviewed the use of MUSIC for the development of stormwater management plans. The report includes a comprehensive review of guidelines for the use of MUSIC in other regions and makes recommendations for MUSIC simulations in South Australia.

2 Model development

2.1 Inputs

Development of a MUSIC model requires the following data:

- Meteorological data
- Source node (catchment) data
- Definition of drainage links
- Water quality improvement measures.

2.2 Meteorological data

Review of the Bureau of Meteorology's weather station directory identified two stations within 25 km of the study area that have rainfall totals at six-minute intervals. The available data is summarised in Table 2.1.

Table 2.1 Summary of rainfall data available for MUSIC modelling

Station	Station number	Length of data record
Roseworthy AWS	023122	1/5/1999 to 30/6/2010
Edinburgh RAAF	023083	13/11/1979 to 31/3/2010

Review of the available six-minute data identified gaps in both records. The Edinburgh RAAF station had relatively complete data for the period 1990 to 1994, and for this reason this period was selected for the MUSIC modelling.

The five years of six-minute rainfall data used for the MUSIC modelling had annual totals varying from 239 mm to 653 mm, with an annual average of 410 mm. For comparison, the average annual rainfall found using daily rainfall data at the same station between 1973 and 2020 is approximately 425 mm. While the annual average rainfall for the modelling period is slightly lower than the long term average, the record contains high rainfall years and low rainfall years. It is therefore considered suitable for understanding the patterns of pollutant generation, relative impacts of development and the effectiveness of mitigation options within the study area.

The model uses monthly average evapotranspiration data for Gawler, extracted from the BoM's gridded data set for potential areal evapotranspiration. The annual average evapotranspiration is 1,130 mm.

2.3 Catchment data

The definition of catchment areas and characteristics (% impervious area) was based on the catchments in the TUFLOW and DRAINS models used for hydrological and hydraulic analysis. These catchments were group together based on location to form larger lumped catchments.

The effective impervious area for each lumped catchment was calculated using the proportional average of the directly connected impervious areas. The catchment zoning/surface type was based on a review of the land use layers. For the ACHRD study area, many catchments were identified as residential, with several pockets of industrial land use types. For the GEP study area, 'industrial' surface types were selected for each catchment within the model. The associated pollutant load parameters are consistent with the recommendations in Myers et al. (2015) for lumped catchment modelling for South Australian stormwater management plans.

The adopted water quality parameters for the land use types within the MUSIC models for the ACHRD and GEP SMPs are summarised in Table 2.2.

Table 2.2 Water quality parameters for lumped catchment modelling

Land use	Flow	TSS $\log_{10}$ values		TP $\log_{10}$ values		TN $\log_{10}$ values	
		Mean	SD	Mean	SD	Mean	SD
Urban residential	Baseflow	1	0.34	-0.97	0.31	0.2	0.2
	Stormflow	2.18	0.39	-0.47	0.32	0.26	0.23
Commercial	Baseflow	0.78	0.39	-0.6	0.5	0.32	0.3
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34
Industrial	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.2
	Stormflow	1.92	0.44	-0.59	0.36	0.25	0.32
Rural residential	Baseflow	0.53	0.24	-1.54	0.38	-0.52	0.39
	Stormflow	2.26	0.51	-0.56	0.28	0.32	0.30
Agriculture	Baseflow	1	0.13	-1.155	0.13	-0.155	0.13
	Stormflow	2.477	0.31	-0.495	0.3	0.29	0.26

The rainfall-runoff parameters adopted in the model are summarised below.

Impervious areas:

- Rainfall threshold 1 mm/day

Pervious areas:

- Soil storage capacity 40 mm
- Initial storage 30% of capacity
- Field capacity 30 mm

2.4 Drainage links

The drainage links within the MUSIC model were defined based on a review of the stormwater network and outflow points of the DRAINS catchments. No routing was applied. This is considered conservative, consistent with the recommendation of Myers et al. (2015) which states "routing is not required in South Australian MUSIC modelling undertaken for compliance with water quality targets to ensure results are conservative".

2.5 Climate change modelling in MUSIC

Review of the climate projections for the SSWFE region shows a significant variation in seasonal changes to rainfall, with the greatest reductions expected in winter and spring. As such, for the purpose of water balance modelling (i.e. water harvesting), the 2050 and 2090 seasonal average annual rainfall and evapotranspiration scaling factors shown in Table 2.3 have been applied to the historic rainfall data.

Table 2.3 Climate change factors applied to meteorological data in MUSIC

	2050	2090
Rainfall		
Summer	-3%	-3%
Autumn	+2%	+2%
Winter	-9%	-19%
Spring	-14%	-19%
Annual evapotranspiration	+5.1%	+10.2%

2.6 Model configuration

The configuration of the MUSIC models used for the ACHRD and GEP catchments are shown in Figure 2.1 and Figure 2.2, respectively.

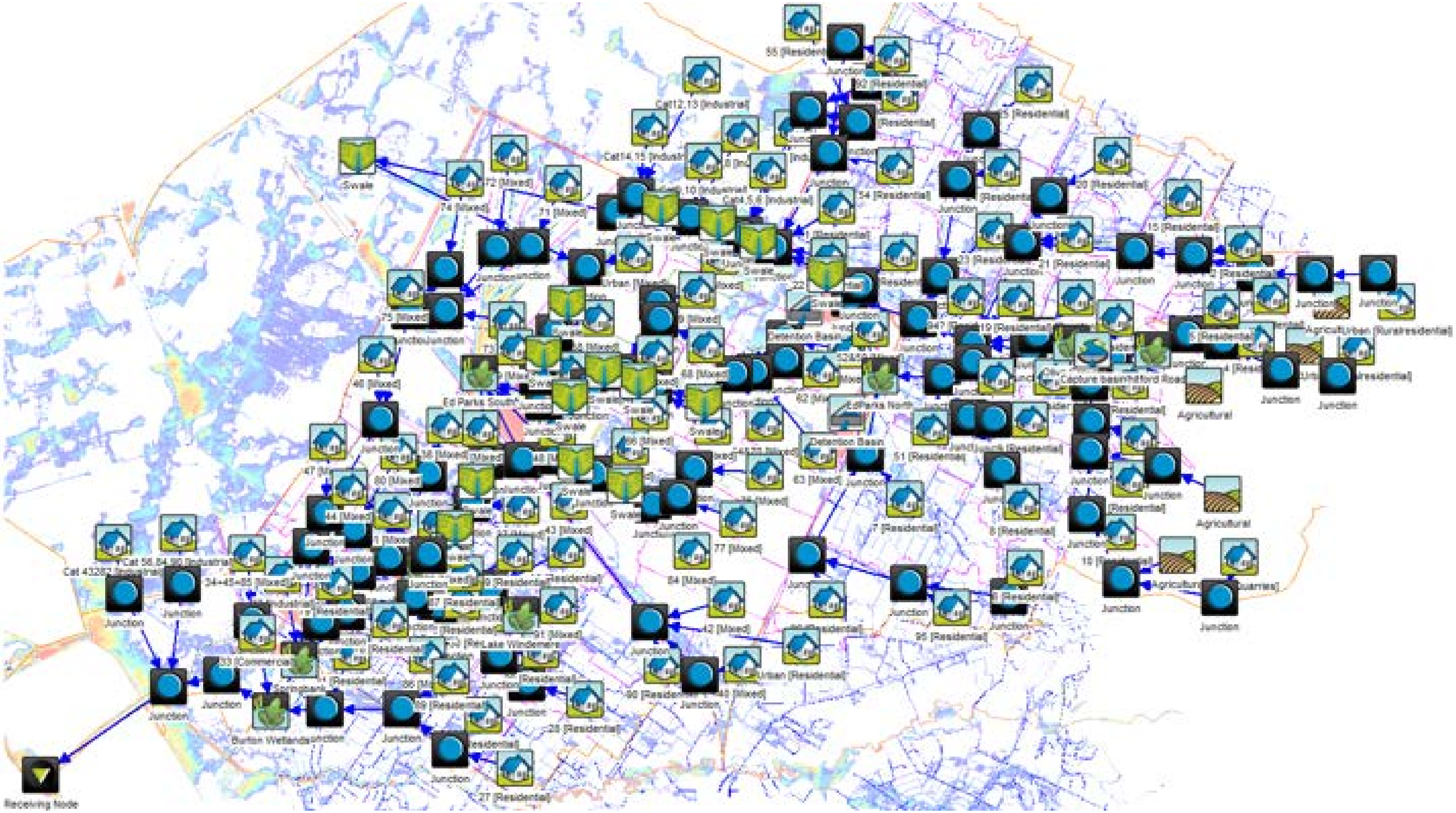


Figure 2.1 ACHRD catchment MUSIC model configuration

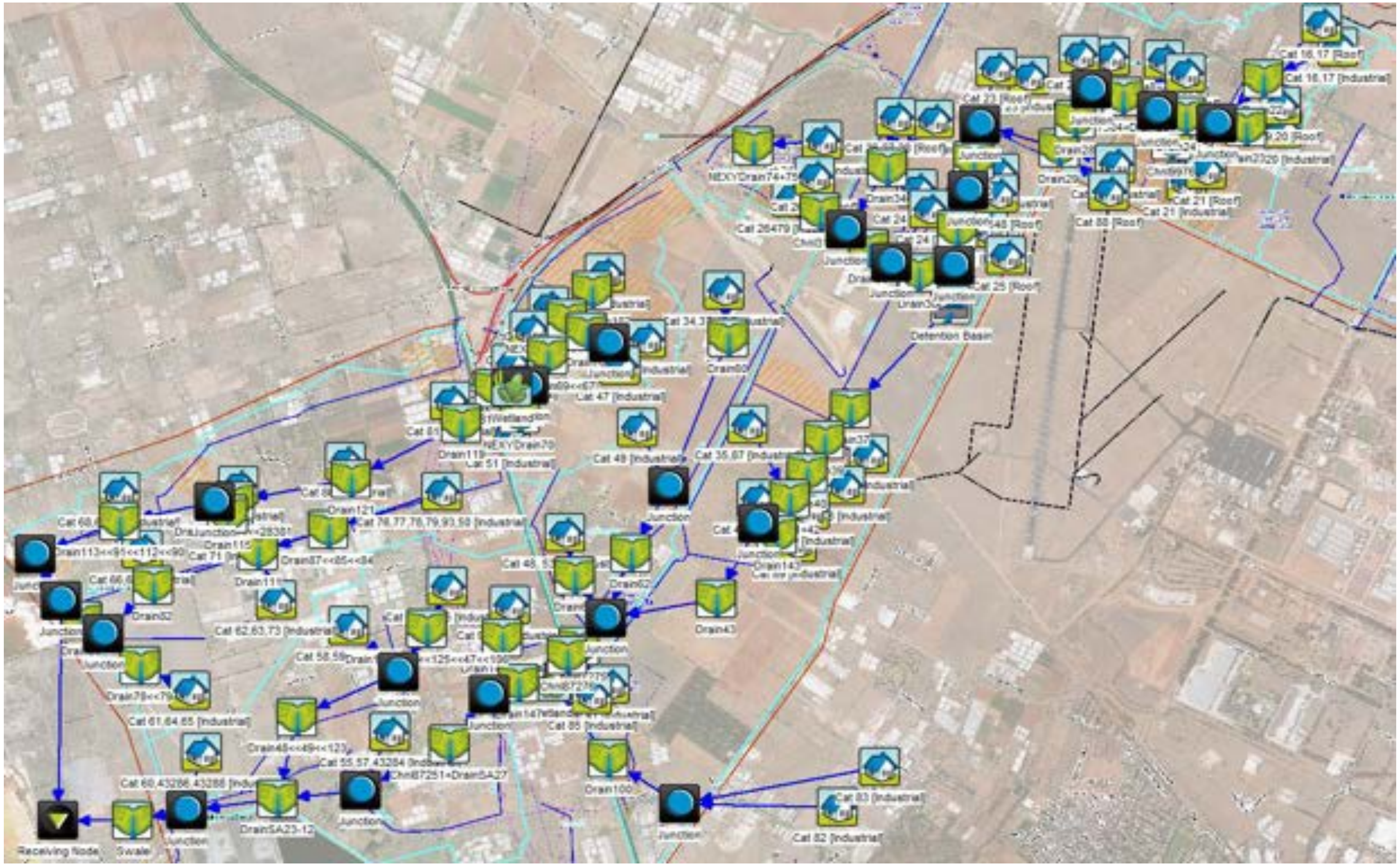


Figure 2.2 GEP catchment MUSIC model configuration

3 References

Myers, B, Cook S, Pezzaniti, D, Kemp, D, Neland, P 2015, *Implementing Water Sensitive Urban Design in Stormwater Management Plans*, Goyder Institute for Water Research Technical Report Series No. 16/7, Adelaide, South Australia.

Appendix G – Safety in design

SF71: WHS HAZARD RISK REGISTER

PROJECT OR DESIGN ELEMENT:	Client:	Project Number:
Adams Creek and Helps Road Drain Catchment Stormwater Management Plan	City of Playford and City of Salisbury	20170712

This Workshop was attended by the representatives listed below.

Brief Description Of Design Element:	Brief Description of any specific Safety Focus or Requirements:
Stormwater elements described in SMP (ref. 20170712R001)	Construction and maintenance

Workshop Organiser or Chair

Responsible Officer:	Project Role:	Organisation:
Tim Kerby	Project Leader	Tonkin

RISK ASSESSMENT

Activity or Task	Hazards or Environmental Impacts	Perceived Risk: Consequence	Perceived Risk: Likelihood	Perceived Risk: Risk Rating	Control Measures (Eliminate, Substitute, Isolate/Engineering Controls, Administrative Controls, PPE)	Residual Risk: Consequence	Residual Risk: Likelihood	Residual Risk: Risk Rating	Person responsible for Controls	Status
Construction	Damage to existing services causing injury to workers	4	3	12	DBYD and service locating to be carried out as part of the design Locate drain alignment away from services Minimise number of service crossings Contractor to do their own service locating Contractor to comply with service authority requirements and not to use mechanical excavation in vicinity of services Mark approximate location of services on drawings	4	2	8	Designer and Contractor	Identified
Design	Deep excavation. Collapse of batters onto construction crew members	5	3	15	Contractor to manage trench excavation through appropriate shoring	5	2	10	Contractor	Action Assigned
Excavation, drainage installation and backfilling	Services - damage to or electrification from overhead power infrastructure in work area	5	3	15	Notes to be added to construction drawings to highlight the general location of overhead powerlines, as part of detailed design	5	2	10	Designer and Contractor	Action Assigned
Construction	Location - disgruntled stakeholders due to construction, restricted access and noise	3	3	9	Contractor/Council to provide adequate stakeholder notification/consultation prior to construction commencing. Works to be undertaken in discrete stages. Contractor to submit a detailed traffic control proposal to the superintendent.	2	2	4	Contractor and Council	Action Assigned
Construction	Contaminated groundwater / soil encountered on site	4	3	12	Investigations to be undertaken as part of detailed design	4	2	8	Council	Action Assigned
Construction	Shallow groundwater encountered on site	4	3	12	Responsibility for adequate shoring and dewatering during construction to be left with contractor. Design inverts to be kept relatively shallow.	4	2	8	Designer and Contractor	Action Assigned
Construction / Ongoing	Potential for pipe or culvert to crack during installation or ongoing life	3	3	9	Ensure adequate cover and bedding is specified Checks to be undertaken to ensure backfilling and pipe class consistent between design and drawings	3	2	6	Designer and Contractor	Action Assigned
Construction	Unknown service encountered during construction causing high relocation costs	4	4	16	DBYD to be undertaken by contractor prior to construction. Approximate location and depth of known services to be marked on drawings as part of further design development. Service locating to be undertaken if risk assessed as too high during detailed design.	4	3	12	Designer and Contractor	Action Assigned
Traffic Management	Working in close proximity to road. Workers hit by a vehicle.	5	3	15	Contractor to submit a detailed traffic control proposal to the superintendent	5	2	10	Contractor and Council	Action Assigned
Operation	Permanent water posing a drowning risk	5	3	15	Basins to be constructed with relatively flat batters. Potential for signage/fencing to restrict access.	5	2	10	Contractor and Council	Action Assigned
Operation	Drowning risk due to deep flows in channels and basins	5	3	15	Channels to have appropriate signage/fencing	5	2	10	Contractor and Council	Action Assigned
Operation	Increased risk of bird strike due to permanent water near RAAF base	4	2	8	Limit ponding time to 48 hours after rain ceases, or use netting over basins within close proximity to RAAF base	4	1	4	Desginer	Action Assigned
Construction	Creation of dust and sediment	3	4	12	Contractor to implement SEDMP during construction Time construction works to coincide with drier parts of the year. Work sequence to be undertaken from downstream to upstream.	3	3	9	Contractor	Action Assigned

SF71: WHS HAZARD RISK REGISTER

Activity or Task	Hazards or Environmental Impacts	Perceived Risk: Consequence	Perceived Risk: Likelihood	Perceived Risk: Risk Rating	Control Measures (Eliminate, Substitute, Engineering Controls, Administrative Controls, PPE)	Residual Risk: Consequence	Residual Risk: Likelihood	Residual Risk: Risk Rating	Person responsible for Controls	Status
Construction	Construction works within close proximity to railway line / moving trains causing injury/death to workers	5	3	15	Contractor to organise rail closure periods and ensure qualified train spotters on site	1	1	1	Contractor	Action Assigned
Construction and maintenance	Injury to workers in remote areas on private property (e.g. snake bite, falls)	4	3	12	Contractor to develop appropriate communication plan / work in teams	4	2	8	Contractor	Action Assigned

Workshop Attendees

Name of Attendee	Name of Employer	Project Role	Relevant Qualifications	Date	Time	Signature to acknowledge
Tim Kerby	Tonkin	Project Leader	Qualified Engineer, MIEAust, CPEng	16/10/2019	11:30 AM	
Michael McEvoy	Tonkin	Civil Engineer	Qualified Engineer	16/10/2019	11:30 AM	

RISK ASSESSMENT GUIDE

SAFETY AND ENVIRONMENTAL HAZARD IDENTIFICATION/RISK ASSESSMENT

LIKELIHOOD

5	**Event will occur**	The event is a common occurrence on all projects
4	**Event almost certain to occur**	The event will probably / is likely to occur at least once during most projects
3	**Event may occur**	The event is possible to / might occur during some projects
2	**Event not likely to occur**	The event is unlikely to occur (though it could occur during similar work activities)
1	**Event rarely occurs**	The event could occur, but it is rare / only in exceptional circumstances

PROJECT (Level 1) RISK RATINGS

1-4	Low	*Broadly acceptable - managed by routine procedures*
5-8	Medium	*Tolerable - managed with general controls*
9-15	High	*Undesirable - managed with specific controls*
16-25	Extreme	*Intolerable - design to be changed or do not start activity*

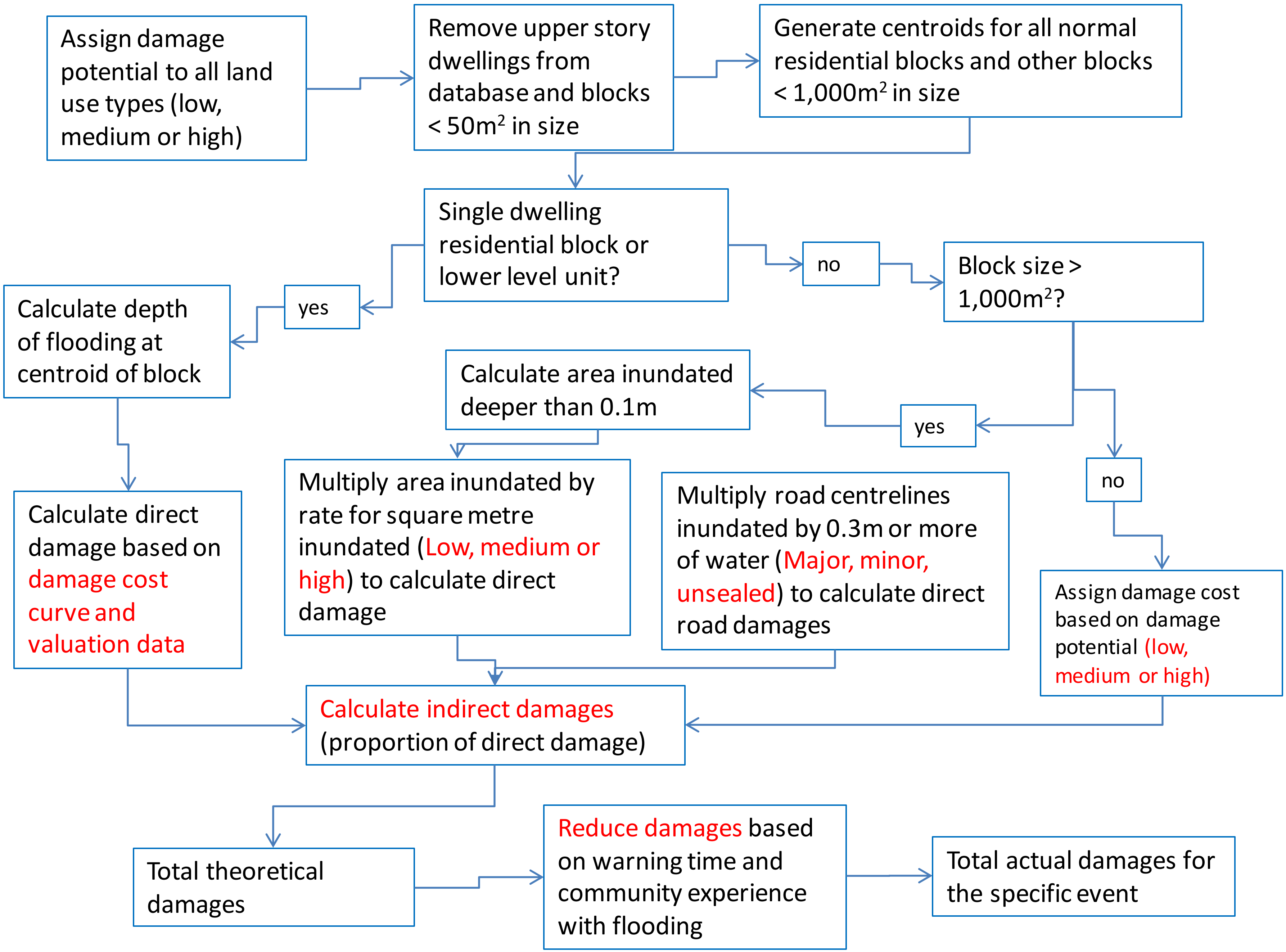
	DESCRIPTOR	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
5	Event will occur	5 MEDIUM	10 HIGH	15 HIGH	20 EXTREME	25 EXTREME
4	Event almost certain to occur	4 LOW	8 MEDIUM	12 HIGH	16 EXTREME	20 EXTREME
3	Event may occur	3 LOW	6 MEDIUM	9 HIGH	12 HIGH	15 HIGH
2	Event not likely to occur	2 LOW	4 LOW	6 MEDIUM	8 MEDIUM	10 HIGH
1	Event rarely occurs	1 LOW	2 LOW	3 LOW	4 LOW	5 MEDIUM

Lowest Level of Control ← → **Highest Level of Control**

PPE — Administration — Isolation/Engineering — Substitution — Elimination

Level	Descriptor	CONSEQUENCE / SEVERITY / IMPACT
5	Catastrophic	*Loss of human life, complete design failure, loss of security and safety or extensive financial or social loss*
4	Major	*Major and permanent injury, hospitalisation, partial design failure, major system damage or major financial or social loss*
3	Moderate	*Moderate injury or illness, medical treatment required, degradation of design or moderate financial or social loss*
2	Minor	*Minor injury or illness, First Aid required, minor impact on design performance or operator inconvenience*
1	Insignificant	*No injury, inconvenience caused by event, virtually no impact*

Appendix H – Flood damages flowchart


Assign damage potential to all land use types (low, medium or high)
Remove upper story dwellings from database and blocks < 50m² in size
Generate centroids for all normal residential blocks and other blocks < 1,000m² in size
Single dwelling residential block or lower level unit?
yes
no
Block size > 1,000m²?
Calculate depth of flooding at centroid of block
Calculate area inundated deeper than 0.1m
yes
no
Calculate direct damage based on damage cost curve and valuation data
Multiply area inundated by rate for square metre inundated (Low, medium or high) to calculate direct damage
Multiply road centrelines inundated by 0.3m or more of water (Major, minor, unsealed) to calculate direct road damages
Assign damage cost based on damage potential (low, medium or high)
Calculate indirect damages (proportion of direct damage)
Total theoretical damages
Reduce damages based on warning time and community experience with flooding
Total actual damages for the specific event

ID	DESCRIPTION	CATEGORY	ID	DESCRIPTION	CATEGORY
99999	EXCLUDE	E	2145	FRUIT AND VEG.	H
100	EXCLUDE	E	2146	BREAD, CAKES AND PASTRY	H
0	EXCLUDE	E	2147	HEALTH FOOD AND DRINKS	H
1100	HOUSE	R	2148	FISH	H
1101	HOUSE & GRANNY FLAT	R	2149	WINE SHOP	H
1110	HOME INDUSTRY WHERE OWNER RESIDES IN PROPERTY	R	2151	CHICKEN	H
1111	HOUSE & OFFICE	R	2152	SELF-SERVE ICE DEPOT	H
1112	HOUSE & SURGERY	R	2155	PERFUMERY	H
1113	HOUSE WITH MANUFACTURING & SERVICE INDUSTRY	R	2157	TOYS	H
1114	HOUSE & HOLIDAY CABIN	R	2158	CRAFT AND POTTERY	H
1115	HOUSE & FLAT	R	2160	SPECIALTY SHOPS	H
1117	HOUSE WITH SINGLE BED & BREAKFAST	R	2161	CHEMIST	H
1118	HOUSE WITH UNESTABLISHED GROUNDS/GARDENS	R	2162	NEWSAGENT, BOOK SHOP ETC.	H
1119	UNFINISHED HOUSE	R	2163	MUSIC, RECORDS, VIDEO	H
1200	MULTIPLE UNIT	R	2164	JEWELLERY	H
1220	MAISONETTE	R	2165	SPORTING GOODS	H
1230	ROW HOUSE	R	2166	FLORIST AND PLANT SHOPS	H
1300	HOME UNIT	R	2167	GIFT SHOP AND TOBACCONIST	H
1310	GROUND FLOOR HOME UNIT ONLY	R	2168	SECOND-HAND AND ANTIQUES	H
1315	DETACHED SINGLE STOREY HOME UNIT	R	2169	PET SHOPS	H
1319	BASEMENT HOME UNIT	R	2170	SUPERMARKETS	H
1320	GROUND FLOOR HOME UNIT IN A MULTI-STOREY BLOCK	R	2180	MOTOR VEHICLES AND ACCESSORIES	H
1321	FIRST FLOOR HOME UNIT	E	2181	SERVICE STATION	H
1322	SECOND FLOOR HOME UNIT	E	2182	MOTOR VEHICLE SALES	H
1323	THIRD FLOOR HOME UNIT	E	2183	SECOND-HAND MOTOR VEHICLE SALES	H
1324	FOURTH FLOOR HOME UNIT	E	2184	SPARE PARTS AND ACCESSORIES	H
1325	FIFTH FLOOR HOME UNIT	E	2185	TYRES AND TUBES	H
1326	SIXTH FLOOR HOME UNIT	E	2186	CARAVAN SALES	H
1327	SEVENTH FLOOR HOME UNIT	E	2187	BOAT AND MARINE SALES	H
1328	EIGHTH FLOOR HOME UNIT	E	2188	BICYCLE SALES AND REPAIRS	H
1329	NINTH FLOOR OR ABOVE HOME UNIT	E	2189	MOTORCYCLE SALES AND SERVICE	H
1330	TOWNHOUSE - DEFINED AS HOME UNIT WITH BOTH GROUND AND FIRST FLOOR AREAS	R	2190	SHOP AND DWELLING	H
1335	TOWNHOUSE - HOME UNIT OVER TWO LEVELS IN WHICH THE LOWER LEVEL IS ABOVE GROUND LEVEL	R	2199	VACANT SHOP	M
1400	FLATS	R	2200	FINANCE, ASSURANCE & REAL ESTATE SERVICES	H
1410	SINGLE STOREY FLATS - PURPOSE BUILT	R	2210	BANKS	H
1411	SINGLE STOREY FLATS - HOUSE CONVERTED TO FLATS	R	2220	HIRE PURCHASE	H
1412	SINGLE STOREY FLATS - PAIR OF MAISONETTES	R	2230	MONEY LENDING, PAWNBROKING	H
1413	SINGLE STOREY FLATS - BUILT FOR STRATA TITLING	R	2240	STOCKBROKING, SHAREBROKING	H
1420	TWO STOREY AND HIGHER FLATS - PURPOSE BUILT	R	2250	TRUSTEE COMPANIES	H
1421	TWO STOREY AND HIGHER FLATS - TWO STOREY HOUSE CONVERTED TO FLATS	R	2260	ASSURANCE AND INSURANCE	H
1423	TWO STOREY AND HIGHER FLATS - BUILT FOR STRATA TITLING	R	2271	BUILDING SOCIETIES	H
1430	TOWN HOUSE STYLE FLATS	R	2272	CREDIT UNIONS	H
1432	TOWN HOUSE STYLE FLATS - PAIR OF TWO STOREY MAISONETTES	R	2275	FRIENDLY SOCIETIES	H
1433	TOWN HOUSE STYLE FLATS - BUILT FOR STRATA TITLING	R	2280	REAL ESTATE AGENCIES	H
1500	PRIVATE HOTELS AND BOARDING HOUSES AND BOARDING HOUSES	H	2290	AUCTIONEERS, VALUERS AND OTHER SERVICES	H
1600	HOSTELS	H	2300	PERSONAL SERVICES	H
1700	INSTITUTIONAL RESIDENTIAL	H	2310	FOOD AND DRINK	H
1710	NURSES RESIDENTIAL QUARTERS ACCOMMODATION	H	2311	RESTAURANT - UNLICENSED	H
1720	COLLEGE AND UNIVERSITY RESIDENTIAL ACCOMMODATION	H	2312	RESTAURANT - LICENSED	H
1730	OTHER RESIDENTIAL HALL OR DORMITORY	H	2313	CAFE	H
1740	ORPHANS' ACCOMMODATION	H	2314	PIZZA BAR- UNLICENSED	H
1750	RELIGIOUS QUARTERS - MONASTERIES ETC.	H	2315	PIZZA BAR - LICENSED	H
1760	RETIRED AND AGED ACCOMMODATION	R	2316	HAMBURGERS	H
1765	INDEPENDENT LIVING UNIT	R	2319	CATERERS	H
1770	OLD FOLKS' HOMES	H	2320	BEAUTY SALONS, LADIES HAIRDRESSING	H
1780	INSTITUTIONAL RESIDENTIAL ACCOMMODATION N.E.C.	H	2330	MEN'S HAIRDRESSING AND TOBACCONIST	H
1800	HOTEL AND MOTEL	H	2340	LAUNDERING, DRY CLEANING AND DYEING SERVICE	H
1810	HOTEL ACCOMMODATION	H	2350	CLOTHING REPAIRS, ALTERATIONS AND CLEANING PICK-UP SERVICE	H
1820	MOTEL	H	2360	SHOE REPAIRS	H
1825	SERVICED APARTMENTS (INC. STRATA-TITLED HOTEL/MOTEL UNITS)	H	2370	FUNERAL AND CREMATORIAL SERVICES	H
1831	HOTEL/MOTEL COMMUNITY	H	2380	PHOTOGRAPHIC SERVICES, INCLUDING COMMERCIAL	H
1832	HOTEL/MOTEL OTHER	H	2390	LIBRARY AND BOOK-LENDING SERVICES	H
1833	SHORT TERM ACCOMMODATION - SINGLE UNIT	R	2400	PERSONAL SERVICES	H
1834	SHORT TERM ACCOMMODATION - MULTIPLE UNITS	H	2410	DANCING SCHOOLS	H
1912	RURAL RESIDENTIAL HOUSE (HOUSE WITHOUT PRIMARY PRODUCTION)	L	2420	MOTOR DRIVING SCHOOLS	H
1920	SHACK	R	2430	TRAVEL AND TOURIST BUREAU	H
1921	SHACK (WHICH IS THE PRINCIPAL PLACE OF RESIDENCE OF THE OWNER)	R	2440	TAB AND BETTING SERVICES	H
1980	RURAL LIVING (PROPERTY WITH A HOUSE AND WHICH FORMS PART OF A LARGER SIGNIFICANT PRIMARY PRODUCTION HOLDING BUT NOT NECESSARILY IN THE SAME OWNERSHIP)	R	2450	LOTTERY SALES	H
1981	AGRICULTURE	L	2460	GYMNASIUMS, SAUNAS ETC.	H
1982	LIVESTOCK	L	2470	ENGRAVER, KEYCUTTING, LOCKSMITH	H
1983	HORTICULTURE	L	2490	PERSONAL SERVICES N.E.C.	H
1984	FORESTRY	L	2500	OFFICE (BUILDINGS)	H
1985	POULTRY	M	2510	ADVERTISING SERVICES	H
1986	MIXED FARMING	L	2520	TYPEWRITING, COPYING AND SECRETARIAL SERVICES	H
1987	MARKET GARDENING	L	2525	OFFICE EQUIPMENT SUPPLIES, COMPUTERS ETC.	H
1988	RESEARCH CENTRE	H	2530	BUSINESS MANAGEMENT AND CONSULTANT SERVICES	H
1989	NURSERY	M	2540	EMPLOYMENT AGENCIES	H
1990	RURAL LIVING	L	2550	INDUSTRIAL AND TRADE ASSOCIATIONS, PROFESSIONAL ORGANISATIONS, TRADE UNIONS	H
1991	HOUSE AND AGRICULTURE (NON-VIABLE)	L	2560	RESEARCH, DEVELOPMENT AND TESTING SERVICES	H
1992	HOUSE AND LIVESTOCK (NON-VIABLE)	L	2570	MAPPING AND AERIAL SURVEY SERVICES	H
1993	HOUSE AND HORTICULTURE (NON-VIABLE)	L	2580	WINDOW AND OFFICE CLEANING SERVICES	H
1994	HOUSE AND FORESTRY (NON-VIABLE)	L	2590	DISINFECTING AND EXTERMINATING SERVICES	H
1995	HOUSE AND POULTRY (NON-VIABLE)	L	2591	PICTURE FRAMER	H
1996	HOUSE AND MIXED FARMING (NON-VIABLE)	L	2595	SWIMMING POOL CONTRACTOR (INCLUDING POOL DISPLAYS)	H
1997	HOUSE AND MARKET GARDEN (NON-VIABLE)	L	2596	GARAGE, CARPORT, VERANDAH DISPLAY AND SALES	H
1999	HOUSE AND PLANT NURSERY (NON-VIABLE)	L	2600	OFFICE/WAREHOUSE	H
2000	WHOLESALE TRADE	H	2605	SHOWROOM	H
2010	SOFTGOODS DEALING	H	2610	EQUIPMENT RENTAL AND LEASING SERVICES	H
2011	WHOLESALE TRADE - SOFTGOODS - DISTRIBUTOR/AGENCY	H	2615	MATERIALS HANDLING EQUIPMENT SALES & SERVICING	H
2012	WHOLESALE TRADE - SOFTGOODS - WAREHOUSE	H	2620	CAR AND TRUCK RENTAL SERVICES	H
2020	WHOLESALE TRADE - FOOD AND DRINK	H	2630	BREAKDOWN AND TOWING SERVICES	H
2021	WHOLESALE TRADE - FOOD AND DRINK - DISTRIBUTOR/AGENCY	H	2640	REFRIGERATED STORAGE, BOND STORAGE AND WAREHOUSING	H
2022	WHOLESALE TRADE - FOOD AND DRINK - WAREHOUSE	H	2645	GENERAL AUCTION ROOMS	H
2030	WHOLESALE TRADE - TIMBER AND OTHER BUILDING MATERIALS	H	2650	FARM PRODUCTS, WAREHOUSING STORAGE AND SILOS (EXCL. STOCKYARDS)	H
2031	WHOLESALE TRADE - TIMBER AND OTHER BUILDING MATERIALS - DISTRIBUTOR/AGENCY	H	2651	SILO - CONCRETE CELLS	H
2032	WHOLESALE TRADE - TIMBER AND OTHER BUILDING MATERIALS - WAREHOUSE	H	2652	SILO - STEEL CELLS	H
2040	WHOLESALE TRADE - PETROLEUM PRODUCTS	H	2653	SILO - HORIZONTAL BINS	H
2041	WHOLESALE TRADE PETROLEUM PRODUCTS - DISTRIBUTOR/AGENCY	H	2654	SILO - TEMPORARY STORAGE	H
2042	WHOLESALE TRADE PETROLEUM PRODUCTS - WAREHOUSE	H	2660	STOCKYARD SERVICES	H
2050	WHOLESALE TRADE - FUEL (OTHER THAN PETROLEUM PRODUCTS)	H	2661	STOCKYARD SERVICES - HORSES	H
2051	WHOLESALE TRADE - WOOD	H	2662	STOCKYARD SERVICES - STABLES	H
2052	WHOLESALE TRADE - COAL	H	2665	STOCK AGENT'S OFFICE	H
2053	WHOLESALE TRADE - BRIQUETTES	H	2669	SADDLERY, RIDING OUTFITTERS	H
2054	WHOLESALE TRADE - GAS	H	2670	MOTION PICTURE DISTRIBUTION AND SERVICE	H
2060	WHOLESALE TRADE - MOTOR VEHICLES AND ACCESS. DISTRIBUTION	H	2680	DETECTIVE AND PROTECTIVE SERVICES	H
2070	WHOLESALE TRADE - DRUGS AND MEDICINES	H	2690	BUSINESS SERVICES N.E.C.	H
2080	WHOLESALE TRADE - WOOL, SKIN AND PRODUCE (OTHER THAN DAIRY DEALING AND STOCK AND STATION AGENCIES)	H	2699	VACANT OFFICE	M
2081	WHOLESALE TRADE - WOOL, SKIN AND PRODUCE - DISTRIBUTOR/AGENCY WITH NO PRIMARY PRODUCTION CARRIED OUT ON THE LAND	H	2700	PROFESSIONAL SERVICES	H
2082	WHOLESALE TRADE - WOOL, SKIN AND PRODUCE - WITH PRIMARY PRODUCTION BEING CARRIED OUT ON THE LAND	H	2710	ENGINEERING	H
2083	WHOLESALE TRADE - WOOL, SKIN AND PRODUCE - WAREHOUSE - WITH NO PRIMARY PRODUCTION CARRIED OUT ON THE LAND	H	2720	SURVEYING	H
2084	WHOLESALE TRADE - WOOL, SKIN AND PRODUCE - WAREHOUSE - WITH PRIMARY PRODUCTION BEING CARRIED OUT ON THE LAND	H	2730	ACCOUNTING, AUDITING AND BOOKKEEPING	H
2090	WHOLESALE TRADE N.E.C.	H	2735	COMPUTER CONSULTANTS, PROGRAMMERS & SOFTWARE SERVICES	H
2100	RETAIL TRADE, SHOPS, SHOPPING CENTRE	H	2740	ARCHITECTURE (INC. LANDSCAPE)	H
2110	DEPARTMENT AND GENERAL STORES	H	2750	PLANNING AND TRANSPORT	H
2120	DRAPERY, CLOTHING AND FOOTWEAR	H	2760	LEGAL SERVICES	H
2121	CLOTHING	H	2770	PHYSICIANS AND SURGEONS	H
2124	DRAPERY SOFTGOODS, MANCHESTER, SOFT FURNISHINGS, HABERDASHERY ETC.	H	2775	VETERINARY SURGEONS	H
2125	FOOTWEAR	H	2778	ACUPUNCTURIST	H
2126	SEWING CENTRE	H	2780	DENTISTS	H
2129	CLOTHING, DRAPERY ETC. N.E.C.	H	2785	PHYSIOTHERAPIST	H
2130	HOUSEHOLD GOODS	H	2786	CHIROPRACTOR	H
2131	BASIC BUILDING MATERIALS, BUILDERS' HARDWARE AND SUPPLIERS (INC. TOOLS OF TRADE)	H	2787	CHIROPODIST	H
2132	ELECTRICAL STORES	H	2790	PROFESSIONAL SERVICES N.E.C.	H

ID	DESCRIPTION	CATEGORY	ID	DESCRIPTION	CATEGORY
2133	DOMESTIC HARDWARE	H	2800	CONSTRUCTION SERVICES	H
2134	GARDENING EQUIPMENT	H	2810	BUILDERS GENERAL	H
2135	DOMESTIC REFRIGERATION	H	2820	CIVIL ENGINEERING CONTRACTORS	H
2136	COMMERCIAL REFRIGERATION	H	2830	PLUMBING, HEATING AND AIR-CONDITIONING SERVICES	H
2137	FURNITURE, FURNISHINGS AND FLOOR COVERINGS	H	2840	PAINTING, PAPER HANGING AND DECORATING SERVICES	H
2138	HOUSEHOLD GOODS N.E.C.	H	2850	ELECTRICAL SERVICES	H
2139	ELECTRICAL GOODS N.E.C.	H	2860	MASONRY STONE WORK, TILE SETTING AND PLASTERING AND CONCRETE SERVICES	H
2140	FOOD AND DRINK	H	2890	CONSTRUCTION SERVICES N.E.C.	H
2141	DELICATESSEN	H	2900	WORKSHOP	H
2142	GROCER	H	2910	MOTOR VEHICLE REPAIR SERVICES	H
2143	LICENSED GROCER	H	2920	CAR WASH SERVICES	H
2144	BUTCHER	H	2930	ELECTRICAL REPAIR SERVICES (EXCEPT RADIO AND T.V.)	H
2940	RADIO AND T.V. REPAIRS	H	6650	AIR TRANSPORTATION N.E.C.	H
2950	WATCH, CLOCK AND JEWELLERY REPAIR SERVICES	H	6651	AIR NAVIGATION BEACON	H
2960	LAWNMOWER REPAIRS	H	6660	WHARVES (INCLUDING STORAGE)	M
2970	UPHOLSTERER	H	6661	SLIPWAYS	L
2990	REPAIR SERVICES N.E.C.	H	6662	BOAT RAMP	L
3100	FOOD, BEVERAGES, TOBACCO	H	6670	LIGHTHOUSE	M
3110	FOOD MANUFACTURING	H	6680	MARINA	M
3111	SLAUGHTERING, PREPARATION, PRESERVING OF MEAT, ABATTOIRS	H	6681	MARINA	M
3112	DAIRY PRODUCTS	H	6690	MARINE TRANSPORT N.E.C.	M
3113	CANNING AND PRESERVING OF FRUITS AND VEG.	H	6700	TELECOMMUNICATIONS	H
3114	PROCESSING OF FISH AND OTHER SEAFOOD	H	6710	TELEPHONE EXCHANGE OPERATION	H
3115	VEG. AND ANIMAL OILS AND FATS	H	6720	TELEGRAPH OPERATION	H
3116	GRAIN MILL PRODUCTS	H	6730	RADIO BROADCASTING	H
3117	BAKERY	H	6740	RADIO TRANSMITTING	H
3118	SUGAR FACTORIES AND REFINERIES	H	6750	T.V. BROADCASTING	H
3119	COCOA CHOCOLATE & CONFECTIONERY	H	6760	T.V. TRANSMITTING	H
3121	FOOD PRODUCTS N.E.C.	H	6790	TELECOMMUNICATIONS N.E.C.	H
3122	PREPARED ANIMAL FEEDS	H	6800	POSTAL SERVICES	H
3123	ICE MANUFACTURE/COLD STORE	H	6810	POST OFFICE	H
3124	CITRUS PACKING SHED	H	6820	SORTING AND MAIL EXCHANGE OPERATION	H
3130	BEVERAGE INDUSTRIES	H	6830	POST OFFICE GARAGING, EQUIPMENT AND MAINTENANCE	H
3131	DISTILLERY (SPIRITS)	H	6840	POSTAL SERVICES N.E.C.	H
3132	BEVERIDGE	H	6900	OTHER PUBLIC UTILITIES N.E.C.	H
3133	BREWERY (ALES)	H	6970	CEMETERIES	M
3134	SOFT DRINKS	H	6980	PUBLIC CONVENIENCES	M
3139	WINERY (WINES)	H	6990	PUBLIC UTILITIES N.E.C.	M
3140	TOBACCO MANUFACTURING	H	7100	OUTDOOR ARENAS SPORTS OVAL	L
3200	TEXTILES, CLOTHING, LEATHER INDUSTRIES	H	7105	OUTDOOR ARENA	L
3210	TEXTILES	H	7110	ATHLETICS	L
3211	SPINNING, WEAVING AND FINISHING TEXTILES	H	7120	BASEBALL	L
3212	TEXTILE GOODS EXCEPT CLOTHING	H	7130	CRICKET	L
3213	KNITTING MILLS	H	7140	FOOTBALL	L
3214	CARPETS AND RUGS	H	7141	AUSTRALIAN RULES	L
3215	CORDAGE, ROPE AND TWINE	H	7142	SOCCER	L
3219	OTHER TEXTILE MANUFACTURING N.E.C.	H	7143	RUGBY	L
3220	CLOTHING (EXCEPT FOOTWEAR)	H	7150	HOCKEY	L
3230	LEATHER, LEATHER AND FUR PRODUCTS	H	7160	LACROSSE	L
3231	TANNERIES AND LEATHER FINISHING	H	7170	POLO	L
3232	FUR DRESSING AND DYEING INDUSTRIES	H	7210	ARCHERY	L
3233	LEATHER PRODUCTS AND LEATHER SUBSTITUTES	H	7220	BASKETBALL	L
3240	MANUFACTURE OF FOOTWEAR	H	7230	LAWN BOWLS	L
3300	WOOD AND WOOD PRODUCTS	H	7240	CROQUET	L
3310	MANUFACTURING OF WOOD AND WOOD AND CORK PRODUCTS, EXCEPT FURNITURE	H	7250	TENNIS	L
3311	SAWMILLS, PLANING AND OTHER WOOD MILLS	H	7260	SPORTS GROUNDS N.E.C.	L
3312	WOODEN AND CANE CONTAINERS AND SMALL CANEWARE	H	7300	GOLF COURSE	L
3319	WOOD AND CORK PRODUCTS N.E.C.	H	7310	GOLF - PITCH AND PUTT	L
3320	FURNITURE AND FIXTURES (EXCEPT PRIMARILY METAL)	H	7320	GOLF - PUTT PUTT	M
3410	PAPER AND PAPER PRODUCTS	H	7330	GOLF - DRIVING RANGE	M
3411	PULP, PAPER AND PAPERBOARD	H	7400	RACING TRACKS	L
3412	CONTAINERS AND BOXES OF PAPER AND PAPERBOARD	H	7410	RACING TRACK - CAR	L
3419	PULP, PAPER AND PAPERBOARD PRODUCTS N.E.C.	H	7420	RACING TRACK - BICYCLE	L
3420	PRINTING, PUBLISHING AND ALLIED INDUSTRIES	H	7430	RACING TRACK - DOG	L
3500	CHEMICALS, PETROLEUM, COAL, RUBBER AND PLASTIC PRODUCTS	H	7440	RACING TRACK - GO-KART	L
3510	INDUSTRIAL CHEMICALS INCLUDING FERTILISERS	H	7450	RACING TRACK - HORSE (RACING)	L
3511	BASIC INDUSTRIAL CHEMICALS	H	7460	RACING TRACK - HORSE (TROTTING)	L
3512	FERTILISERS AND PESTICIDES	H	7470	RACING TRACK - MOTOR CYCLE	L
3513	SYNTHETIC RESINS, PLASTIC MATERIALS, MAN-MADE FIBRES (EXCEPT GLASS)	H	7490	RACING TRACK N.E.C.	L
3520	OTHER CHEMICAL PRODUCTS	H	7500	EXTENSIVE AREAS	L
3521	PAINTS, VARNISHES, LACQUERS	H	7510	CAMPING AND/OR CARAVANING	L
3522	DRUGS AND MEDICINES	H	7520	TOURIST LODGE MOTEL - CABIN ACCOMMODATION	H
3523	SOAP AND CLEANING PREPARATIONS, PERFUMES, COSMETICS AND OTHER TOILET PREPARATIONS	H	7530	PARKS AND GARDENS INCLUDING PICNICKING	L
3529	CHEMICAL PRODUCTS N.E.C.	H	7550	RIDING	L
3530	PETROLEUM REFINERIES	H	7551	HORSE-RIDING SCHOOL	M
3531	OIL PIPELINE RIGHT OF WAY AND PRESSURE CONTROL	H	7552	EQUESTRIAN CENTRES	M
3540	PETROLEUM AND COAL PRODUCTS	H	7560	SHOOTING	L
3550	RUBBER PRODUCTS	H	7580	AIRCRAFT	H
3551	TYRE AND TUBE INDUSTRIES	H	7581	GLIDING	H
3559	RUBBER PRODUCTS N.E.C.	H	7582	POWER AIRCRAFT	H
3560	PLASTIC PRODUCTS N.E.C.	H	7583	MODEL AIRCRAFT	H
3600	NON METALLIC MINERAL PRODUCTS, EXCEPT PETROLEUM & COAL PROD.	H	7584	PARACHUTING	L
3610	POTTERY, CHINA AND EARTHENWARE	H	7590	AMUSEMENT CENTRE	H
3620	GLASS AND GLASS PRODUCTS	H	7600	STADIUMS - INDOOR	H
3690	OTHER NON-METALLIC MINERAL PRODUCTS	H	7610	BADMINTON	H
3691	STRUCTURAL CLAY PRODUCTS	H	7620	BOWLING ALLEY	H
3692	CEMENT, LIME AND GYPSUM PRODUCTS	H	7630	BASKETBALL - INDOOR	H
3699	NON-METALLIC MINERAL PRODUCTS N.E.C.	H	7640	CHESS	H
3700	BASIC METAL INDUSTRIES	H	7650	DARTS	H
3710	IRON AND STEEL BASIC INDUSTRIES	H	7660	SKATING - INDOOR	H
3720	NON-FERROUS METAL BASIC INDUSTRIES	H	7661	ROLLER SKATING - INDOOR	H
3800	FABRICATED METAL PRODUCTS, MACHINERY & EQUIPMENT	H	7662	ICE SKATING	H
3810	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT	H	7670	SQUASH	H
3811	CUTLERY, HAND TOOLS, GENERAL HARDWARE	H	7680	TABLE TENNIS	H
3812	METAL FURNITURE AND FIXTURES	H	7685	TENNIS - INDOOR	H
3813	STRUCTURAL METAL PRODUCTS	H	7690	INDOOR RECREATION AREAS N.E.C.	H
3819	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT N.E.C.	H	7700	WATER AREAS	L
3820	MANUFACTURE OF MACHINERY, EXCEPT ELECTRICAL	H	7710	CANOEING	L
3821	ENGINES AND TURBINES	H	7720	FISHING	L
3822	AGRICULTURAL MACHINERY AND EQUIPMENT	H	7730	ROWING	L
3823	METAL & WOOD WORKING MACHINERY	H	7740	SAILING	L
3824	SPECIAL INDUSTRIAL MACHINERY AND EQUIPMENT EXCEPT METAL AND WOOD - WORKING MACHINERY	H	7750	WATER SKIING	L
3825	OFFICE COMPUTING AND ACCOUNTING MACHINERY	H	7760	SURFING	L
3829	MACHINERY AND EQUIPMENT EXCEPT ELECTRICAL N.E.C.	H	7770	SWIMMING	L
3830	MANUFACTURE OF ELECTRICAL MACHINERY, APPARATUS, APPLIANCES AND SUPPLIES	H	7771	S.L.S.A. CLUBROOMS	M
3831	ELECTRICAL INDUSTRIAL MACHINERY AND APPARATUS	H	7780	MODEL SHIPS	M
3832	RADIO, TV AND COMMUNICATION EQUIPMENT AND APPARATUS	H	7790	WATER AREAS N.E.C.	M
3833	ELECTRICAL APPLIANCES AND HOUSEWARES	H	7791	BOAT SHED	M
3839	ELECTRICAL APPARATUS AND SUPPLIES N.E.C.	H	7900	RECREATION N.E.C.	L
3840	MANUFACTURE OF TRANSPORT EQUIPMENT	H	8100	METALS	H
3841	SHIP BUILDING AND REPAIRING	H	8110	BASE METALS	H
3842	RAILROAD EQUIPMENT MANUFACTURE	H	8111	BASE METALS - MINES	H
3843	MOTOR VEHICLE MANUFACTURE	H	8112	BASE METALS - OPEN WORKINGS	H
3845	MOTORCYCLE AND BICYCLE MANUFACTURE	H	8113	BASE METALS - WELLS	H
3846	AIRCRAFT MANUFACTURE	H	8114	BASE METALS - ABANDONED WORKINGS	L
6280	SEWAGE PRESSURE CONTROL	H	8119	BASE METALS - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER	H
6290	WATER UTILITY OPERATION, IRRIGATION OR SEWAGE DISPOSAL N.E.C.	H	8120	PRECIOUS METALS	H
6300	SOLID WASTE DISPOSAL	H	8121	PRECIOUS METALS - MINES	H
6310	REFUSE INCINERATION	H	8122	PRECIOUS METALS - OPEN WORKINGS	H
6320	CENTRAL GARBAGE GRINDING	H	8123	PRECIOUS METALS - WELLS	H
6330	COMPOSTING	H	8124	PRECIOUS METALS - ABANDONED WORKINGS	L
6340	SANITARY LAND FILLING	H	8129	PRECIOUS METALS - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER	H
6350	REFUSE DISPOSAL	H	8160	ALUMINIUM-BAUXITE	H
6360	INDUSTRIAL WASTE DISPOSAL	H	8161	ALUMINIUM-BAUXITE - MINES	H
6370	ACTIVE SLAG DUMPING AND MINERAL WASTE DISPOSAL	H	8162	ALUMINIUM-BAUXITE - OPEN WORKINGS	H
6390	SOLID WASTE DISPOSAL N.E.C.	H	8163	ALUMINIUM-BAUXITE - WELLS	H
6400	RAILWAYS (INCL. RAPID RAIL TRANSIT AND STREET CAR TRANSPORT)	M	8164	ALUMINIUM-BAUXITE - ABANDONED WORKINGS	L
6410	RAILWAY LINE	M	8169	ALUMINIUM-BAUXITE - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	H
6420	RAILWAY SWITCHING AND MARSHALLING	M	8180	MINOR ELEMENTS	H
6430	RAILWAY TERMINAL FACILITIES (PASSENGER)	M	8181	MINOR ELEMENTS - MINES	H

ID	DESCRIPTION	CATEGORY	ID	DESCRIPTION	CATEGORY
6440	RAILWAY TERMINAL FACILITIES (FREIGHT)	M	8182	MINOR ELEMENTS - OPEN WORKINGS	H
6450	RAILWAY EQUIPMENT AND MAINTENANCE	M	8183	MINOR ELEMENTS - WELLS	H
6460	STREETCAR RIGHT OF WAY	L	8184	MINOR ELEMENTS - ABANDONED WORKINGS	L
6470	STREETCAR EQUIPMENT AND MAINTENANCE	L	8189	MINOR ELEMENTS - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER	H
6480	STREETCAR TERMINAL	L	8190	METALS N.E.C.	H
6490	RAILWAY, RAPID RAIL TRANSIT AND STREETCAR TRANSPORTATION OPERATION N.E.C.	M	8191	METALS N.E.C. - MINES	H
6500	MOTOR VEHICLE TRANSPORTATION	M	8192	METALS N.E.C. - OPEN WORKINGS	H
6510	BUS PASSENGER TERMINAL (WHERE NOT LOCATED WITHIN PUBLIC RIGHT OF WAY)	H	8193	METALS N.E.C. - WELLS	H
6520	BUS GARAGING AND EQUIPMENT MAINTENANCE	H	8194	METALS N.E.C. - ABANDONED WORKINGS	L
6530	CAR PARKING	L	8199	METALS N.E.C. - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER	H
6531	CAR PARKING STATION	H	8200	NON-METALS	H
6532	CAR PARKING LOT	H	8210	INDUSTRIAL AND CHEMICAL	H
6540	TRUCK FREIGHT TERMINAL	M	8211	INDUSTRIAL AND CHEMICAL - MINES	H
6550	TRUCK FREIGHT GARAGING AND EQUIPMENT MAINTENANCE	H	8212	INDUSTRIAL AND CHEMICAL - OPEN WORKINGS	H
6560	REMOVAL, HAULAGE, CARTING AND CARRYING	H	8213	INDUSTRIAL AND CHEMICAL - WELLS	H
6561	WEIGHBRIDGE	H	8214	INDUSTRIAL AND CHEMICAL - ABANDONED WORKINGS	L
6570	PARCELS DELIVERY	H	8219	INDUSTRIAL AND CHEMICAL - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	H
6580	TAXICAB	H	8220	SALTS	H
6590	MOTOR VEHICLE TRANSPORTATION N.E.C.	H	8221	SALTS - MINES	H
6600	AIR AND MARINE TRANSPORTATION, CARGO STORAGE	H	8222	SALTS - OPEN WORKINGS	H
6610	AIRPORT	H	8223	SALTS - WELLS	H
6620	HELICOPTER OPERATION (WHERE SEPARATE FROM 6610)	H	8224	SALTS - ABANDONED WORKINGS	L
6630	HOVERCRAFT OPERATION	H	8229	SALTS - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND	H
8230	DIMENSION STONE	H	5300	SOCIAL WELFARE	H
8231	DIMENSION STONE - MINES	H	5310	SOCIAL SERVICE AND WELFARE PROVISION	H
8232	DIMENSION STONE - OPEN WORKINGS	H	5320	YMCA AND YWCA FACILITIES	H
8233	DIMENSION STONE - WELLS	H	5330	CHARITABLE ORGANISATIONS	H
8234	DIMENSION STONE - ABANDONED WORKINGS	L	5340	MISSIONS FOR ABORIGINES	M
8239	DIMENSION STONE - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	H	5390	SOCIAL WELFARE N.E.C.	H
8240	CRUSHED STONE	L	5400	ARMED SERVICES	H
8241	CRUSHED STONE - MINES	L	5410	AIR FORCE	H
8242	CRUSHED STONE - OPEN WORKINGS	M	5420	ARMY	M
8243	CRUSHED STONE - WELLS	L	5430	NAVY	M
8244	CRUSHED STONE - ABANDONED WORKINGS	L	5440	ARMED SERVICES COMMUNICATIONS FUNCTIONS	H
8249	CRUSHED STONE - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	M	5490	ARMED SERVICES N.E.C.	M
8250	SAND AND GRAVEL	L	5500	CULTURAL ACTIVITIES & NATURE EXHIBITIONS	M
8251	SAND AND GRAVEL - MINES	L	5510	LIBRARY AND READING	H
8252	SAND AND GRAVEL - OPEN WORKINGS	M	5511	INSTITUTE LIBRARY	M
8253	SAND AND GRAVEL - WELLS	M	5520	MUSEUM	H
8254	SAND AND GRAVEL - ABANDONED WORKINGS	L	5530	ART GALLERY	H
8259	SAND AND GRAVEL - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	M	5540	PLANETARIUM	H
8260	CLAY	L	5550	AQUARIUM	H
8261	CLAY - MINES	M	5560	BOTANICAL GARDEN AND ARBORETUM	M
3849	TRANSPORT EQUIPMENT MANUFACTURE N.E.C.	H	5570	ZOOLOGICAL	M
3850	MANUFACTURE OF PROFESSIONAL AND SCIENTIFIC EQUIPMENT AND MEASURING AND CONTROLLING INSTRUMENTS AND PHOTOGRAPHIC AND OPTICAL GOODS	H	5580	SHOWGROUNDS	H
3851	PROFESSIONAL AND SCIENTIFIC EQUIPMENT AND MEASURING AND CONTROLLING INSTRUMENTS	H	5590	CULTURAL ACTIVITIES AND NATURE EXHIBITIONS N.E.C.	H
3852	PHOTOGRAPHIC AND OPTICAL GOODS	H	5600	PLACES OF ASSEMBLY	H
3853	WATCHES AND CLOCKS	H	5610	CHURCHES, SEMINARIES	H
3900	OTHER MANUFACTURING INDUSTRIES	H	5620	PUBLIC HALLS	H
3901	JEWELLERY AND RELATED ARTICLES	H	5630	CONFERENCE CENTRES	H
3902	MUSICAL INSTRUMENTS	H	5631	CONFERENCE CENTRES - WITH ACCOMMODATION	H
3903	SPORTING AND ATHLETIC GOODS	H	5632	CONFERENCE CENTRES - WITHOUT ACCOMMODATION	M
3904	DENTAL LABORATORY	H	5640	PROFESSIONAL SOCIETIES	H
3909	MANUFACTURING INDUSTRIES N.E.C.	H	5650	LODGES	H
4100	VACANT LAND-URBAN	L	5661	GIRL GUIDES	H
4101	VACANT LAND WITH MINOR IMPROVEMENTS (URBAN)	L	5662	BOY SCOUTS	H
4110	VACANT ALLOTMENT CONSERVATION OR RECREATION	L	5670	YOUTH CENTRES	M
4111	SHACK SITE (NOT IN CONFORMITY WITH REQUIREMENTS UNDER THE PLANNING ACT)	R	5680	PRIVATE CLUBS (NON-RESIDENTIAL)	H
4150	VACANT LAND - RURAL RESIDENTIAL (NO PRIMARY PRODUCTION)	L	5681	PRIVATE CLUBS (NON-RESIDENTIAL) - UNLICENSED	H
4151	VACANT LAND WITH MINOR IMPROVEMENTS (RURAL LIVING)	L	5690	PLACES OF ASSEMBLY N.E.C.	H
4190	HERITAGE AREA (INCLUDES RUINS)	L	5700	AMUSEMENTS & ENTERTAINMENTS	H
4200	WOODED AREA	L	5710	AMUSEMENT PARKS & CENTRES	M
4210	WOODED AREA CONSERVATION	L	5720	BILLIARDS	H
4300	WATER AREA	L	5730	SOCIAL/ENTERTAINMENT CLUB	H
4310	LAND COVERED WITH WATER-SALT	L	5731	SOCIAL/ENTERTAINMENT CLUB - UNLICENSED	H
4320	LAND COVERED WITH WATER-FRESH	L	5740	NIGHTCLUBS AND DISCOTHEQUES	H
4330	SWAMP OR LAND SUBJECT TO FLOODING	L	5741	NIGHTCLUBS AND DISCOTHEQUES - UNLICENSED	H
4340	WATER RESERVE	L	5750	CINEMAS	H
4400	STEEP OR ROCKY LAND	L	5751	PICTURE THEATRES	H
4410	STEEP OR ROCKY LAND - SANDHILLS, CONSERVATION	L	5752	DRIVE-IN THEATRES	M
4420	STONE RESERVE	L	5760	DANCING	H
4500	RESERVE	L	5770	CONCERT, THEATRICAL, DRAMA, BALLET	H
4510	UNDEVELOPED RESERVE	L	5790	AMUSEMENTS AND ENTERTAINMENTS N.E.C.	H
4520	DEVELOPED RESERVE	L	5800	MEDICAL & HEALTH	H
4530	MEDIAN STRIPS, PLANTATIONS, ROAD RESERVES, STANDPIPES AND UNDEFINED LAND WHICH CANNOT BE SOLD	L	5810	HOSPITAL	H
4600	AGISTMENT	L	5811	PRIVATE HOSPITAL	H
4700	CAR PARK	L	5812	COMMUNITY HOSPITAL	H
4900	LAND USED FOR SOME FORM OF PRIMARY PRODUCTION BUT NOT A VIABLE UNIT	L	5820	MENTAL HOSPITAL	H
4910	AGRICULTURE (NON-VIABLE)	L	5830	SANATORIA, NURSING HOME, CONVALESCENT AND REST HOME AND HEALTH CENTRES	H
4911	CEREALS (NON-VIABLE)	L	5850	AMBULANCE	H
4912	SMALL SEEDS (NON-VIABLE)	L	5860	MBHA CLINICS	H
4913	FODDER CROPS (NON-VIABLE)	L	5880	QUARANTINE STATION	M
4914	CEREALS AND FODDER (NON-VIABLE)	L	5890	MEDICAL AND HEALTH SERVICES INC. VETERINARY N.E.C.	H
4915	CEREALS AND SHEEP (NON-VIABLE)	L	5900	OTHER PUBLIC SERVICES	H
4916	CEREALS AND CATTLE (NON-VIABLE)	L	5910	POLICE	H
4917	CEREALS AND PIGS (NON-VIABLE)	L	5920	REFORMATORY	H
4918	OILSEED (NON-VIABLE)	L	5930	GAOL	H
4919	AGRICULTURE N.E.C. (NON-VIABLE)	L	5940	FIRE	H
4920	LIVESTOCK (NON-VIABLE)	L	5941	FIRE STATION OR DEPOT	H
4921	SHEEP - WOOL (NON-VIABLE)	L	5951	SEA RESCUE SQUADRON	H
4922	SHEEP - MUTTON (NON-VIABLE)	L	5952	COAST GUARD	H
4923	CATTLE - DAIRY (NON-VIABLE)	L	5990	PUBLIC SERVICES N.E.C.	H
4924	CATTLE - BEEF (NON-VIABLE)	L	6100	GAS, ELECTRICITY	M
4925	SHEEP AND CATTLE (NON-VIABLE)	L	6110	GAS PIPELINE RIGHT OF WAY (EXCLUSIVE USE OF LAND)	M
4926	PIGS (NON-VIABLE)	L	6120	GAS PRODUCTION	H
4927	HORSES (NON-VIABLE)	L	6130	NATURAL OR MANUFACTURED GAS STORAGE AND DISTRIBUTION	M
4928	GOATS (NON-VIABLE)	L	6140	GAS PRESSURE CONTROL	H
4929	LIVESTOCK N.E.C. (NON-VIABLE)	L	6150	ELECTRICITY TRANSMISSION RIGHT OF WAY	M
4930	VINES (NON-VIABLE)	L	6160	ELECTRICITY POWER STATION	H
4931	CITRUS (NON-VIABLE)	L	6170	ELECTRICITY SUB-STATION	H
4932	STONE FRUITS (NON-VIABLE)	L	6190	ELECTRICITY AND GAS UTILITY OPERATIONS N.E.C.	H
4933	POME FRUITS (NON-VIABLE)	L	6200	WATER, SEWAGE DISPOSAL	H
4934	ALMONDS (NON-VIABLE)	L	6210	WATER PIPELINE RIGHT OF WAY (EXCLUSIVE USE OF LAND)	M
4935	STONE AND POME (NON-VIABLE)	L	6220	WATER TREATMENT (PURIFICATION)	M
4936	VINE AND OTHERS (NON-VIABLE)	L	6230	WATER STORAGE	M
4937	CITRUS AND OTHERS (NON-VIABLE)	L	6240	IRRIGATION DISTRIBUTION	M
4938	STONE AND OTHERS (NON-VIABLE)	L	6250	WATER PRESSURE CONTROL	H
4939	HORTICULTURE N.E.C. (NON-VIABLE)	L	6260	SEWAGE TREATMENT	H
4940	FORESTRY (NON-VIABLE)	L	6270	SEWAGE SLUDGE DRYING	H
4941	SOFTWOOD (NON-VIABLE)	L	8262	CLAY - OPEN WORKINGS	M
4942	HARDWOOD (NON-VIABLE)	L	8263	CLAY - WELLS	M
4943	FORESTRY NURSERY (NON-VIABLE)	L	8264	CLAY - ABANDONED WORKINGS	L
4949	FORESTRY N.E.C. (NON-VIABLE)	L	8269	CLAY - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND	M
4950	POULTRY (NON-VIABLE)	L	8270	PRECIOUS STONES	H
4951	POULTRY - BROILER (NON-VIABLE)	L	8271	PRECIOUS STONES - MINES	H
4952	POULTRY - EGGS (NON-VIABLE)	L	8272	PRECIOUS STONES - OPEN WORKINGS	H
4953	POULTRY - HATCHERY (NON-VIABLE)	L	8273	PRECIOUS STONES - WELLS	H
4959	POULTRY N.E.C. (NON-VIABLE)	L	8274	PRECIOUS STONES - ABANDONED WORKINGS	L
4960	MIXED FARMING (NON-VIABLE)	L	8279	PRECIOUS STONES - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER	H
4961	VINES AND STOCK (NON-VIABLE)	L	8290	NON-METALS N.E.C.	H
4962	DAIRYING AND POTATOES (NON-VIABLE)	L	8291	NON-METALS N.E.C. - MINES	H
4963	DAIRYING AND PIGS (NON-VIABLE)	L	8292	NON-METALS N.E.C. - OPEN WORKINGS	H
4964	STOCK AND POULTRY (NON-VIABLE)	L	8293	NON-METALS N.E.C. - WELLS	H
4965	CEREALS, STOCK, HORTICULTURE (NON-VIABLE)	L	8294	NON-METALS N.E.C. - ABANDONED WORKINGS	L
4966	MARKET GARDENING AND ORCHARD (NON-VIABLE)	L	8299	NON-METALS N.E.C. - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	H

ID	DESCRIPTION	CATEGORY	ID	DESCRIPTION	CATEGORY
4969	MIXED FARMING N.E.C. (NON-VIABLE)	L	8300	NATURAL FUELS	H
4970	MARKET GARDENING (NON-VIABLE)	L	8310	OIL	H
4971	VEGETABLES (NON-VIABLE)	L	8311	OIL - MINES	H
4972	FLOWERS (NON-VIABLE)	L	8312	OIL - OPEN WORKINGS	H
4973	GLASSHOUSE (NON-VIABLE)	L	8313	OIL - WELLS	H
4974	BERRY FRUITS (NON-VIABLE)	L	8314	OIL - ABANDONED WORKINGS	L
4975	POTATOES (NON-VIABLE)	L	8319	OIL - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND	H
4976	PEAS (NON-VIABLE)	L	8320	GAS	H
4977	TOMATOES (NON-VIABLE)	L	8321	GAS - MINES	H
4978	ONIONS (NON-VIABLE)	L	8322	GAS - OPEN WORKINGS	H
4979	MARKET GARDENING N.E.C. (NON-VIABLE)	L	8323	GAS - WELLS	H
5100	GOVERNMENTAL	H	8324	GAS - ABANDONED WORKINGS	L
5110	EXECUTIVE, LEGISLATIVE AND JUDICIAL FUNCTIONS (EXCL. COURTS)	H	8329	GAS - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND	H
5120	COURTS	H	8340	SULPHUR	H
5130	LOCAL GOVERNMENT	H	8341	SULPHUR - MINES	H
5140	CONSULAR AGENCY, INFORMATION AND LEGATION SERVICES	H	8342	SULPHUR - OPEN WORKINGS	H
5180	CONSULAR AGENCY, INFORMATION AND LEGATION SERVICES	H	8343	SULPHUR - WELLS	H
5190	OTHER GOVERNMENT SERVICES N.E.C.	H	8344	SULPHUR - ABANDONED WORKINGS	L
5200	EDUCATIONAL	H	8349	SULPHUR - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED	H
5210	KINDERGARTEN AND CHILD MINDING SERVICES	H	8350	COAL	H
5211	PRIVATE KINDERGARTEN AND CHILD MINDING SERVICES	H	8351	COAL - MINES	H
5220	PRIMARY SCHOOL	M	8352	COAL - OPEN WORKINGS	H
5221	PRIVATE PRIMARY SCHOOL	M	8353	COAL - WELLS	H
5222	AREA SCHOOL	M	8354	COAL - ABANDONED WORKINGS	L
5230	SECONDARY SCHOOL	M	8359	COAL - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND	H
5231	PRIVATE SECONDARY SCHOOL	M	8390	NATURAL FUELS N.E.C.	H
5240	TERTIARY COLLEGE	M	8391	NATURAL FUELS N.E.C. - MINES	H
5241	UNIVERSITY	H	8392	NATURAL FUELS N.E.C. - OPEN WORKINGS	H
5242	TECHNICAL COLLEGE	M	8393	NATURAL FUELS N.E.C. - WELLS	H
5243	TEACHER'S COLLEGE	H	8394	NATURAL FUELS N.E.C. - ABANDONED WORKINGS	L
5250	AGRICULTURAL COLLEGE	M	8399	NATURAL FUELS N.E.C. - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LANDOWNED AND USED BY THE SAME OWNER	H
5260	TRADES COLLEGE	M	8400	MINING AND QUARRYING N.E.C.	H
5270	ADULT EDUCATION	M	8401	MINING AND QUARRYING N.E.C. - MINES	H
5280	OTHER PROFESSIONAL SCHOOLS AND PRIVATE TEACHING	M	8402	MINING AND QUARRYING N.E.C. - OPEN WORKINGS	H
5290	EDUCATIONAL N.E.C.	M	8403	MINING AND QUARRYING N.E.C. - WELLS	H
8404	MINING AND QUARRYING N.E.C. - ABANDONED WORKINGS	L	9620	DAIRYING AND POTATOES	L
8409	MINING AND QUARRYING N.E.C. - SECONDARY INDUSTRY IS PRIMARY PRODUCTION AND IS VIABLE IN ITSELF OR WITH OTHER LAND OWNED AND USED BY THE SAME OWNER	H	9621	DAIRYING AND POTATOES - IRRIGATED	L
9100	AGRICULTURE	L	9624	DAIRYING AND POTATOES - STOCK WATERING	L
9110	CEREALS	L	9630	DAIRYING AND PIGS	L
9111	CEREALS - IRRIGATED	L	9631	DAIRYING AND PIGS - IRRIGATED	L
9114	CEREALS - STOCK WATERING	L	9634	DAIRYING AND PIGS - STOCK WATERING	L
9120	SMALL SEEDS	L	9640	STOCK AND POULTRY	L
9121	SMALL SEEDS - IRRIGATED	L	9641	STOCK AND POULTRY - IRRIGATED	L
9124	SMALL SEEDS - STOCK WATERING	L	9644	STOCK AND POULTRY - STOCK WATERING	L
9130	FODDER CROPS	L	9650	CEREALS, STOCK, HORTICULTURE	L
9131	FODDER CROPS - IRRIGATED	L	9651	CEREALS, STOCK, HORTICULTURE - IRRIGATED	L
9134	FODDER CROPS - STOCK WATERING	L	9654	CEREALS, STOCK, HORTICULTURE - STOCK WATERING	L
9140	CEREALS AND FODDER	L	9660	MARKET GARDENING AND ORCHARD	L
9141	CEREALS AND FODDER - IRRIGATED	L	9661	MARKET GARDENING AND ORCHARD - IRRIGATED	L
9144	CEREALS AND FODDER - STOCK WATERING	L	9664	MARKET GARDENING AND ORCHARD - STOCK WATERING	L
9150	CEREALS AND SHEEP	L	9690	MIXED FARMING N.E.C.	L
9151	CEREALS AND SHEEP - IRRIGATED	L	9691	MIXED FARMING N.E.C. - IRRIGATED	L
9154	CEREALS AND SHEEP - STOCK WATERING	L	9694	MIXED FARMING N.E.C. - STOCK WATERING	L
9160	CEREALS AND CATTLE	L	9700	MARKET GARDENING	L
9161	CEREALS AND CATTLE - IRRIGATED	L	9710	VEGETABLES	L
9164	CEREALS AND CATTLE - STOCK WATERING	L	9711	VEGETABLES - IRRIGATED	L
9170	CEREALS AND PIGS	L	9714	VEGETABLES - STOCK WATERING	L
9171	CEREALS AND PIGS - IRRIGATED	L	9720	FLOWERS	L
9174	CEREALS AND PIGS - STOCK WATERING	L	9721	FLOWERS - IRRIGATED	L
9180	OILSEED	L	9724	FLOWERS - STOCK WATERING	L
9181	OILSEED - IRRIGATED	L	9730	GLASSHOUSE	L
9184	OILSEED - STOCK WATERING	L	9731	GLASSHOUSE - IRRIGATED	L
9190	AGRICULTURE N.E.C.	L	9734	GLASSHOUSE - STOCK WATERING	L
9191	AGRICULTURE N.E.C. - IRRIGATED	L	9740	BERRY FRUITS	L
9194	AGRICULTURE N.E.C. - STOCK WATERING	L	9741	BERRY FRUITS - IRRIGATED	L
9200	LIVESTOCK	L	9744	BERRY FRUITS - STOCK WATERING	L
9210	SHEEP-WOOL	L	9750	POTATOES	L
9211	SHEEP-WOOL - IRRIGATED PASTURE	L	9751	POTATOES - IRRIGATED	L
9212	SHEEP-WOOL - STUD	L	9754	POTATOES - STOCK WATERING	L
9213	SHEEP-WOOL - STOCK PADDOCKS	L	9760	PEAS	L
9214	SHEEP-WOOL - STOCK WATERING	L	9761	PEAS - IRRIGATED	L
9220	SHEEP-MUTTON	L	9764	PEAS - STOCK WATERING	L
9221	SHEEP-MUTTON - IRRIGATED PASTURE	L	9770	TOMATOES	L
9222	SHEEP-MUTTON - STUD	L	9771	TOMATOES - IRRIGATED	L
9223	SHEEP-MUTTON - STOCK PADDOCKS	L	9774	TOMATOES - STOCK WATERING	L
9224	SHEEP-MUTTON - STOCK WATERING	L	9780	ONIONS	L
9230	CATTLE-DAIRY	L	9781	ONIONS - IRRIGATED	L
9231	CATTLE-DAIRY - IRRIGATED PASTURE	L	9784	ONIONS - STOCK WATERING	L
9232	CATTLE-DAIRY - STUD	L	9790	MARKET GARDENING N.E.C.	L
9233	CATTLE-DAIRY - STOCK PADDOCKS	L	9791	MARKET GARDENING N.E.C. - IRRIGATED	L
9234	CATTLE-DAIRY - STOCK WATERING	L	9794	MARKET GARDENING N.E.C. - STOCK WATERING	L
9240	CATTLE-BEEF	L	9800	RESEARCH HOLDING	L
9241	CATTLE-BEEF - IRRIGATED PASTURE	L	9900	MISCELLANEOUS PRIMARY PRODUCTION	L
9242	CATTLE-BEEF - STUD	L	9910	BEEKEEPING	L
9243	CATTLE-BEEF - STOCK PADDOCKS	L	9920	BREEDING ANIMALS AND BIRDS	L
9244	CATTLE-BEEF - STOCK WATERING	L	9930	NURSERY (PLANTS)	M
9250	SHEEP AND CATTLE	L	9940	FISHING	M
9251	SHEEP AND CATTLE - IRRIGATED PASTURE	L	9941	OYSTERS	M
9252	SHEEP AND CATTLE - STUD	L	9942	PRAWNS	M
9253	SHEEP AND CATTLE - STOCK PADDOCKS	L	9950	MUSHROOMS	L
9254	SHEEP AND CATTLE - STOCK WATERING	L	9990	PRIMARY PRODUCTION N.E.C.	L
9260	PIGS	L	9994	PRIMARY PRODUCTION N.E.C. - STOCK WATERING	L
9261	PIGS - IRRIGATED PASTURE	L			
9262	PIGS - STUD	L			
9263	PIGS - STOCK PADDOCKS	L			
9264	PIGS - STOCK WATERING	L			
9270	HORSES	L			
9271	HORSES - IRRIGATED PASTURE	L			
9272	HORSES - STUD	L			
9273	HORSES - STOCK PADDOCKS	L			
9274	HORSES - STOCK WATERING	L			
9279	HORSES AND RIDING SCHOOL	L			
9280	GOATS	L			
9281	GOATS - IRRIGATED PASTURE	L			
9282	GOATS - STUD	L			
9283	GOATS - STOCK PADDOCKS	L			
9284	GOATS - STOCK WATERING	L			
9290	LIVESTOCK N.E.C.	L			
9291	LIVESTOCK N.E.C. - IRRIGATED PASTURE	L			
9292	LIVESTOCK N.E.C. - STUD	L			
9293	LIVESTOCK N.E.C. - STOCK PADDOCKS	L			
9294	LIVESTOCK N.E.C. - STOCK WATERING	L			
9300	VINES	L			
9301	VINES - IRRIGATED	L			
9302	VINES - NURSERY	L			
9304	VINES - STOCK WATERING	L			
9310	CITRUS	L			
9311	CITRUS - IRRIGATED	L			
9312	CITRUS - NURSERY	L			
9314	CITRUS - STOCK WATERING	L			
9320	STONE FRUITS	L			
9321	STONE FRUITS - IRRIGATED	L			
9322	STONE FRUITS - NURSERY	L			
9324	STONE FRUITS - STOCK WATERING	L			
9330	POME FRUITS	L			
9331	POME FRUITS - IRRIGATED	L			
9332	POME FRUITS - NURSERY	L			
9334	POME FRUITS - STOCK WATERING	L			
9340	ALMONDS	L			
9341	ALMONDS - IRRIGATED	L			

ID	DESCRIPTION	CATEGORY	ID	DESCRIPTION	CATEGORY
9342	ALMONDS - NURSERY	L			
9344	ALMONDS - STOCK WATERING	L			
9350	STONE AND POME FRUITS	L			
9351	STONE AND POME FRUITS - IRRIGATED	L			
9352	STONE AND POME FRUITS - NURSERY	L			
9354	STONE AND POME FRUITS - STOCK WATERING	L			
9360	VINES AND OTHERS	L			
9361	VINES AND OTHERS - IRRIGATED	L			
9362	VINES AND OTHERS - NURSERY	L			
9364	VINES AND OTHERS - STOCK WATERING	L			
9370	CITRUS AND OTHERS	L			
9371	CITRUS AND OTHERS - IRRIGATED	L			
9372	CITRUS AND OTHERS - NURSERY	L			
9374	CITRUS AND OTHERS - STOCK WATERING	L			
9380	STONE FRUITS AND OTHERS	L			
9381	STONE FRUITS AND OTHERS - IRRIGATED	L			
9382	STONE FRUITS AND OTHERS - NURSERY	L			
9384	STONE FRUITS AND OTHERS - STOCK WATERING	L			
9390	HORTICULTURE N.E.C.	L			
9391	HORTICULTURE N.E.C. - IRRIGATED	L			
9392	HORTICULTURE N.E.C. - NURSERY	L			
9394	HORTICULTURE N.E.C. - STOCK WATERING	L			
9400	FORESTRY	L			
9410	SOFTWOOD	L			
9411	SOFTWOOD - GOVERNMENT	L			
9412	SOFTWOOD - PRIVATE	L			
9414	SOFTWOOD - STOCK WATERING	L			
9420	HARDWOOD	L			
9421	HARDWOOD - GOVERNMENT	L			
9422	HARDWOOD - PRIVATE	L			
9424	HARDWOOD - STOCK WATERING	L			
9430	FORESTRY NURSERY	L			
9431	FORESTRY NURSERY - GOVERNMENT	L			
9432	FORESTRY NURSERY - PRIVATE	L			
9434	FORESTRY NURSERY - STOCK WATERING	L			
9490	FORESTRY N.E.C.	L			
9491	FORESTRY N.E.C. - GOVERNMENT	L			
9492	FORESTRY N.E.C. - PRIVATE	L			
9494	FORESTRY N.E.C. - STOCK WATERING	L			
9500	POULTRY	M			
9510	POULTRY - BROILER	M			
9520	POULTRY - EGGS	M			
9530	POULTRY - HATCHERY	M			
9590	POULTRY N.E.C.	M			
9600	MIXED FARMING	L			
9610	VINES AND STOCK	L			
9611	VINES AND STOCK - IRRIGATED	L			
9614	VINES AND STOCK - STOCK WATERING	L			

Appendix I – URPS workshop

WORKSHOP NOTES

Project	Stormwater Management Plans – Adams Creek and Helps Road Drain catchment Greater Edinburgh Parks and St Kilda catchment
Date	25 October 2017
Location	Tonkin Consulting, 66 Rundle Street, Kent Town SA
Project Reference	2017-0231

Attendees

Braden Austin	City of Playford	Martin Fidge	DPTI
Paul Johnson	City of Playford	Ruth Ward	EPA
Andrew Smith	City of Playford	Colin Martin	Martin Real Estate
Peter Jansen	City of Salisbury	Yun Lian	Martin Real Estate
Bruce Naumann	City of Salisbury	Simon Tonkin	Masterplan
Harry Pitrans	City of Salisbury	Gerry Davies	PIRSA
Jason Tamas	City of Salisbury	Jason Rollison	Renewal SA
Dameon Roy	City of Salisbury	Harry Roberts	SA Water
Murray Townsend	Coast Protection Board	Claudio Cordillo	SCT
Greg Ahrens	Department of Defence	Tim Kerby	Tonkin Consulting (Consultant Team PM)
Alex Frolow	Department of Defence	Samantha West	Tonkin Consulting
Damian Moroney	DEWNR - Natural Resources AMLR	Zoe Hambour	URPS (Facilitator)
Rachel Murchland	DEWNR	Angela Hazebroek	URPS (Facilitator)
		Anna Pannell	URPS (Facilitator)

1. Objectives of workshop

The objectives of the workshop were to:

> Provide stakeholders and community representatives with information about the project team's approach to the project.

> Discuss desired outcomes for stormwater management in the catchment.

> Identify and document existing and potential development and stormwater issues in the catchments.

> Identify and document options for stormwater management including flood mitigation, water quality improvement and stormwater harvest and reuse.

2. Introduction and Background

Braden Austin (City of Playford) provided an introduction to the stormwater management planning project and its objectives, noting the concurrent development of a stormwater management plan for the Smith Creek catchment to the north.

Tim Kerby (Tonkin Consulting, Consultant Team Project Manager) provided a summary of the previous investigations including flood modelling. Tim gave a brief description of the catchment, identifying key features and areas subject to flooding.

Anna Pannell (URPS) described the engagement activities planned for the project and the objectives of the workshop.

3. Desired outcomes for stormwater management

To assist in developing objectives for the SMPs, attendees were asked:

"What are your desired outcomes for stormwater management?"

The workshop facilitators collated the outcomes and grouped them by theme as shown in the table below. These were used later in the workshop as the basis for a discussion about stormwater management priorities.

THEME	DESIRED OUTCOMES
Funding and costs	• Certainty of costs to land-owners • Understanding of compensation/equalisation mechanisms among landowners • Funding – SMA funds committed next 20 years • Location of infrastructure vs who pays vs who is impacted by reduced land area • Existing and approved development not funding reuse or water quality improvement
Physical infrastructure	• Integrate channels into future road layout, rather than through sites • More trash racks and sediment traps within catchments • All flood retention and detention basins as close to source as possible • Better defined and maintained drainage channels • Detention basin design that creates or enhances shorebird habitat • Ability to manage runoff given landscapes minimal natural fall / gravity • Interaction with evaporation ponds • Reduce existing detention basins • Timing critical – infrastructure needed now (SMP may delay)
WSUD	• Excellent WSUD in developing areas • Retrofit WSUD in existing development in catchments
Harvesting and reuse	• Water quality required for ASR • Alternate water supply source (harvesting) • Potential to make use of water in horticulture • Existing stormwater harvesting schemes, no negative impact on water quality • Increase in stormwater treatment and MAR • Maximise water capture and reuse for food production
Economic development	• Enabler for economic development • Priority of Northern Economic Plan
Runoff	• No discharge or deposition of pollution or waste on to SA Water Bolivar site

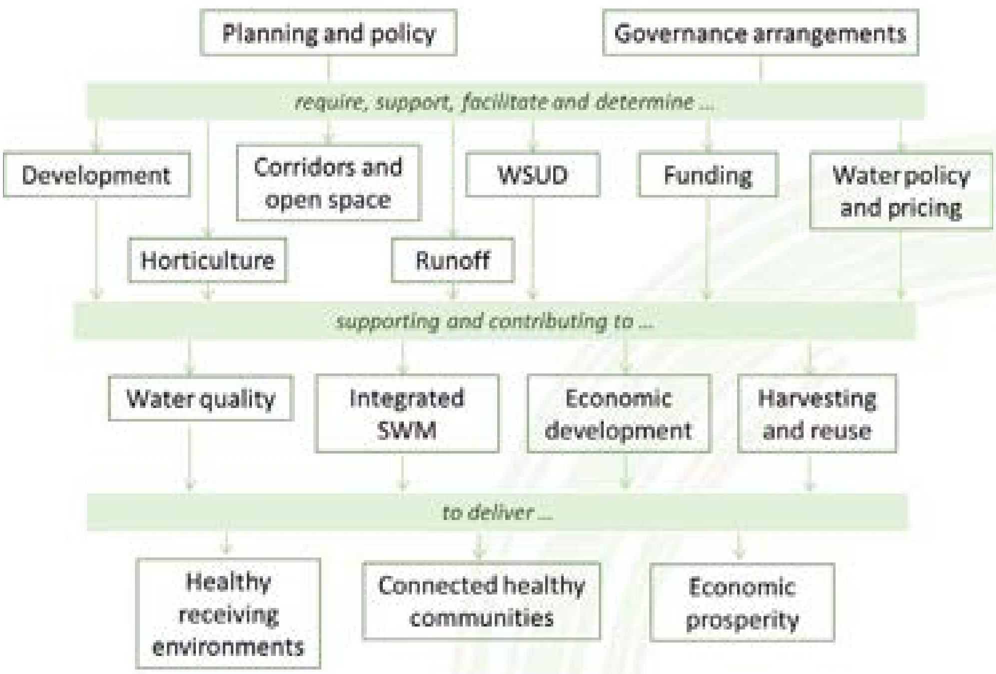
	• NRM Target – 75% reduction in stormwater runoff – achieve while runoff rates increase greatly from 2-5mm per year to 200-400mm per year • Manage stormwater runoff in greenhouse areas
Contamination	• Consideration of legacy contamination • Manage / mitigate contamination pathways • Defence contamination and wider PFAS contamination
Corridors and open space	• Active green space that doubles as drainage corridors • Improved amenity for residents through better multi-objective open space opportunities • Use of stormwater infrastructure for passive and active pursuits, formal and informal spaces and corridors • Linked corridors, green trails and biodiversity links • Consideration, implementation and prioritisation of multiple objectives including reuse, water quality, flow management, green space for recreation, aesthetics and cooling • Airfield management and operations eg wildlife, glare • Bird and wildlife control – airfield operations
Receiving environments	• Reduce sediment outflows to the gulf • Minimise impacts to Gulf waters • Quality discharge is a key consideration, meaning reducing flows as much as possible and achieving multiple objectives • Minimise discharge to Gulf and maximise water quality • SA Water not a receiving site for stormwater • Marine receiving waters
Planning and development	• Safeguards for vacant land for future stormwater infrastructure • Pre-defined corridors for regional drainage scheme • Consider likely increases in urban density • Flexibility to adapt for unintended growth/development • Employment/industry area – all land needs to be drained • Improvements in existing development occur concurrently with multi-objective stormwater management in newly developed areas • Residential land use within area between Waterloo Corner, Heaslip, Port Wakefield and Northern Expressway using stormwater within the development • Confirmation of proposed drainage reserves/easements for future planning • Long term plan that links to Development Assessments to ensure developer/Federal funding sources are channelled appropriately • Clarity of information for translation into development policy
Drainage and flooding	• Flood protection of Defence estate and infrastructure • Stormwater passes through Bolivar without breaking drain boundaries • Short-medium-long term strategy for flood issues currently experienced • Deal with rising water table in some areas, integrate with surface water drainage • Protect horticulture from flooding
Horticulture	• High quality farm land is still important • Manage impacts on food bowl
Integrated SW management	• Integrated water management with SA Water and councils • Integrated stormwater infrastructure as part of a developed community • Connected communities with stormwater being one catalyst for that connection
Governance	• Relationship of SMA with Regional Authority and Planning and Design Code

Following the issues and opportunities identification (see items 4 and 5), attendees were asked to vote on which outcomes they thought were the most important. Each attendee was given three votes to allocate to outcome themes and the votes allocated are shown in the table below. A discussion of the voting scores and themes was facilitated and the links between each of the outcomes were discussed.

OUTCOME THEME	**VOTES**
Planning and development	11
Funding and costs	8
Receiving environments	6
Physical infrastructure	5
Drainage and flooding	5
Economic development	4
Contamination	4
Harvesting and reuse	3
Corridors and open space	3
Integrated SW management	3
WSUD	2
Runoff	2
Governance	2
Horticulture	1

Attendees noted the difficulty in separating some of the themes, and the links between themes, especially that the achievement of some outcomes, for example the improved quality of discharges to receiving environments requires management of runoff through physical infrastructure and WSUD, which are facilitated by supportive planning policy and development.

During the write-up of the workshop notes, the project team developed the following diagram which indicates some of the links and hierarchy discussed at the workshop.



4. Issues for stormwater management

Attendees were asked to consider issues for stormwater management across the two catchments by placing numbered dots on maps of the catchment corresponding to particular issues. Comments relating to each issue were noted.

Map 1 shows the identified issues.

5. Opportunities for stormwater management

Attendees were asked to consider opportunities for stormwater management across the two catchments by placing numbered dots on maps of the catchment corresponding to particular issues. Comments relating to each opportunity were noted.

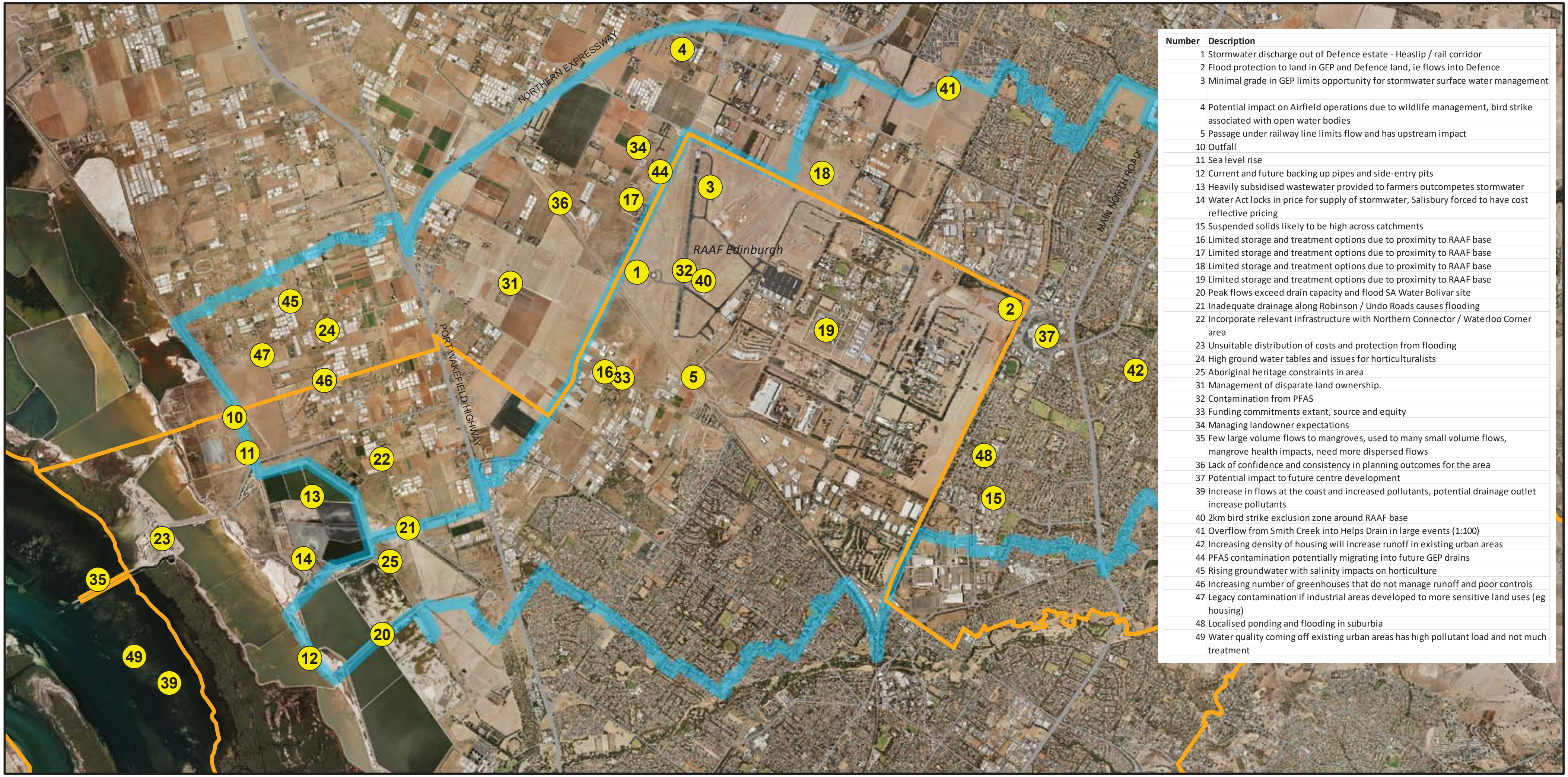
Map 2 shows the identified opportunities.

7. Next steps and further information

The project team described key next steps and invited attendees to provide further feedback.

Comments or issues relating to technical issues should be directed to the Tonkin Project Manager, Tim Kerby (Tonkin), ph 8273 3100 or email Tim.Kerby@tonkin.com.au

Comments or issues relating to engagement activities should be directed to Anna Pannell (URPS), ph 8333 7999 or email anna@urps.com.au.



Number	Description
1	Stormwater discharge out of Defence estate - Heaslip / rail corridor
2	Flood protection to land in GEP and Defence land, ie flows into Defence
3	Minimal grade in GEP limits opportunity for stormwater surface water management
4	Potential impact on Airfield operations due to wildlife management, bird strike associated with open water bodies
5	Passage under railway line limits flow and has upstream impact
10	Outfall
11	Sea level rise
12	Current and future backing up pipes and side-entry pits
13	Heavily subsidised wastewater provided to farmers outcompetes stormwater
14	Water Act locks in price for supply of stormwater, Salisbury forced to have cost reflective pricing
15	Suspended solids likely to be high across catchments
16	Limited storage and treatment options due to proximity to RAAF base
17	Limited storage and treatment options due to proximity to RAAF base
18	Limited storage and treatment options due to proximity to RAAF base
19	Limited storage and treatment options due to proximity to RAAF base
20	Peak flows exceed drain capacity and flood SA Water Bolivar site
21	Inadequate drainage along Robinson / Undo Roads causes flooding
22	Incorporate relevant infrastructure with Northern Connector / Waterloo Corner area
23	Unsuitable distribution of costs and protection from flooding
24	High ground water tables and issues for horticulturalists
25	Aboriginal heritage constraints in area
31	Management of disparate land ownership.
32	Contamination from PFAS
33	Funding commitments extant, source and equity
34	Managing landowner expectations
35	Few large volume flows to mangroves, used to many small volume flows, mangrove health impacts, need more dispersed flows
36	Lack of confidence and consistency in planning outcomes for the area
37	Potential impact to future centre development
39	Increase in flows at the coast and increased pollutants, potential drainage outlet increase pollutants
40	2km bird strike exclusion zone around RAAF base
41	Overflow from Smith Creek into Helps Drain in large events (1:100)
42	Increasing density of housing will increase runoff in existing urban areas
44	PFAS contamination potentially migrating into future GEP drains
45	Rising groundwater with salinity impacts on horticulture
46	Increasing number of greenhouses that do not manage runoff and poor controls
47	Legacy contamination if industrial areas developed to more sensitive land uses (eg housing)
48	Localised ponding and flooding in suburbia
49	Water quality coming off existing urban areas has high pollutant load and not much treatment

Map 1 Issues Identification Stormwater management planning stakeholder workshop

0 500 1,000 2,000 3,000 m

Identified issues (refer table for description)

LGA boundary

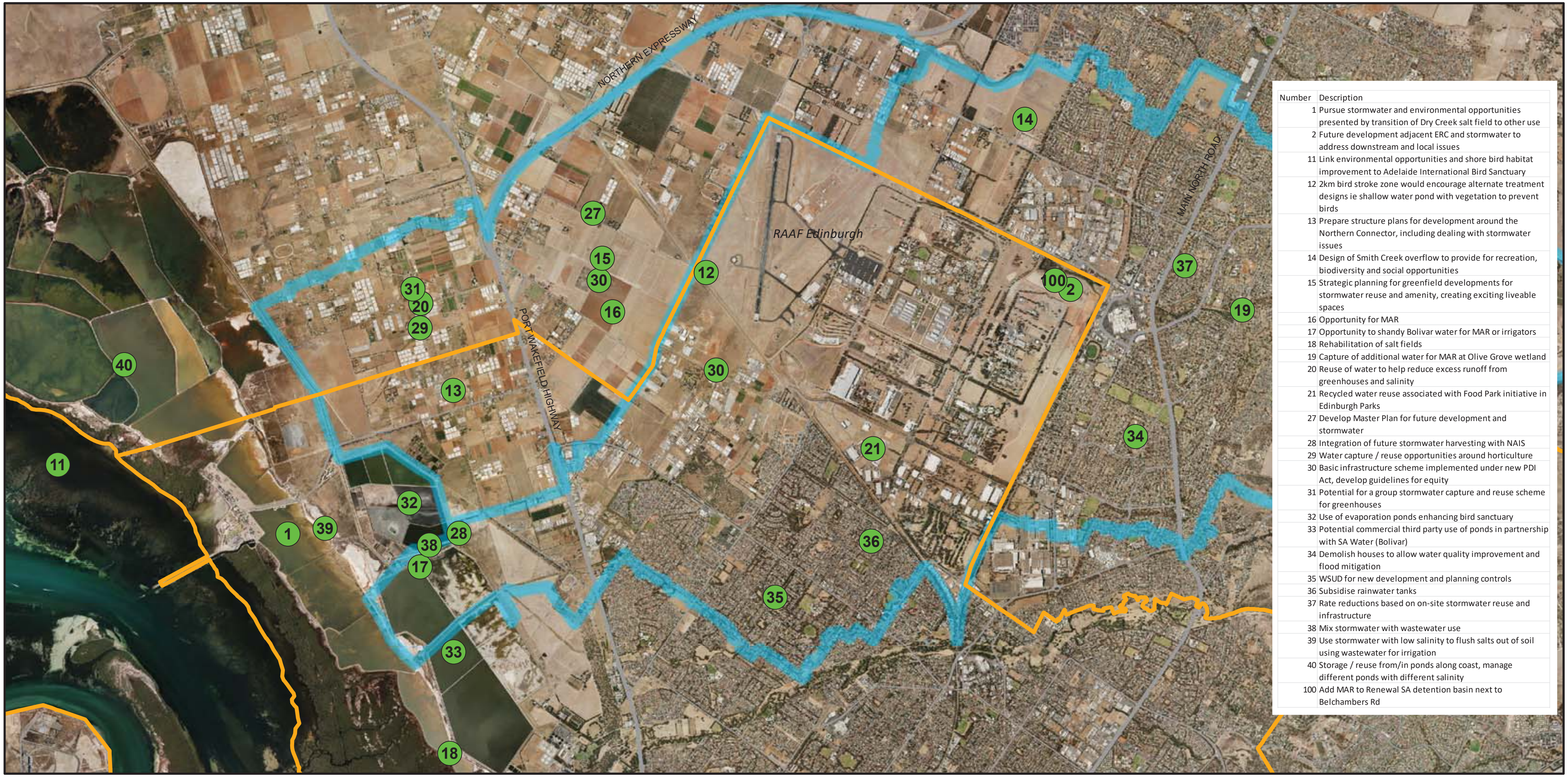
Catchment boundary

Highway, Freeway

Arterial, Subarterial Road

JOB REF.	17ADL-0231
PREPARED BY	AP
DATE	26.10.2017
REVISION	1
DATA SOURCE	DPTI, DEWNR

URPS



Number	Description
1	Pursue stormwater and environmental opportunities presented by transition of Dry Creek salt field to other use
2	Future development adjacent ERC and stormwater to address downstream and local issues
11	Link environmental opportunities and shore bird habitat improvement to Adelaide International Bird Sanctuary
12	2km bird stroke zone would encourage alternate treatment designs ie shallow water pond with vegetation to prevent birds
13	Prepare structure plans for development around the Northern Connector, including dealing with stormwater issues
14	Design of Smith Creek overflow to provide for recreation, biodiversity and social opportunities
15	Strategic planning for greenfield developments for stormwater reuse and amenity, creating exciting liveable spaces
16	Opportunity for MAR
17	Opportunity to shandy Bolivar water for MAR or irrigators
18	Rehabilitation of salt fields
19	Capture of additional water for MAR at Olive Grove wetland
20	Reuse of water to help reduce excess runoff from greenhouses and salinity
21	Recycled water reuse associated with Food Park initiative in Edinburgh Parks
27	Develop Master Plan for future development and stormwater
28	Integration of future stormwater harvesting with NAIS
29	Water capture / reuse opportunities around horticulture
30	Basic infrastructure scheme implemented under new PDI Act, develop guidelines for equity
31	Potential for a group stormwater capture and reuse scheme for greenhouses
32	Use of evaporation ponds enhancing bird sanctuary
33	Potential commercial third party use of ponds in partnership with SA Water (Bolivar)
34	Demolish houses to allow water quality improvement and flood mitigation
35	WSUD for new development and planning controls
36	Subsidise rainwater tanks
37	Rate reductions based on on-site stormwater reuse and infrastructure
38	Mix stormwater with wastewater use
39	Use stormwater with low salinity to flush salts out of soil using wastewater for irrigation
40	Storage / reuse from/in ponds along coast, manage different ponds with different salinity
100	Add MAR to Renewal SA detention basin next to Belchambers Rd

Map 2 Opportunities Identification
Stormwater management planning stakeholder workshop

0 500 1,000 2,000 3,000 m

Identified opportunities (refer table for description)

LGA boundary

Catchment boundary

Highway, Freeway

Arterial, Subarterial Road

JOB REF.	17ADL-0231
PREPARED BY	AP
DATE	26.10.2017
REVISION	1
DATA SOURCE	DPTI, DEWNR

URPS

Appendix J – Multi-criteria analysis

Option	Criteria	Flood Protection of Development		Runoff Quality and Effect on Receiving Waters					Beneficial Use of Stormwater			Social values					Environmental Benefit			Capital, Benefit Cost Ratio and Maintenance Cost				Total Criteria Weighting
	Sub-Criteria	Improved flood protection	Criteria weighting	Reduction in gross pollutants	Reduction in suspended solids	Reduction in nutrients	Reduction in phosphorus	Criteria weighting	Direct Infiltration	Storage and Reuse	Criteria weighting	Improved visual amenity	Improved public safety	Additional useful open space	Disruption during implementation	Criteria weighting	Habitat creation	Increased biodiversity	Criteria weighting	Capital Cost	Economic viability	Recurring / Maintenance Cost	Criteria weighting	Total Weighted Score
	Sub-criteria Weighting	100	**30**	10	40	25	25	**25**	25	75	**10**	20	30	30	20	**5**	50	50	**5**	50	40	10	**25**	**100**
Elizabeth Park windbreaks detention basin	Score (max=4)	3	**22.5**	2	2	2	2	**12.5**	1	3	**6.25**	2	1	1	2	**1.75**	2	2	**2.50**	2	4	3	**18.13**	**63.6**
	Weighted Score	22.5		1.25	5	3.125	3.125		1	5.63		0.50	0.375	0.375	0.50		1.25	1.25		6.25	10.00	1.88		
Dwight Reserve detention basins	Score (max=4)	3	**22.5**	1	1	0	0	**3.125**	1	0	**0.625**	1	1	1	2	**1.50**	1	1	**1.25**	2	4	2	**17.50**	**46.5**
	Weighted Score	22.5		0.625	2.5	0	0		1	0.00		0.25	0.375	0.375	0.50		0.63	0.63		6.25	10.00	1.25		
Elizabeth windbreaks detention basin	Score (max=4)	3	**22.5**	1	1	0	0	**3.125**	1	0	**0.625**	2	1	2	2	**2.125**	1	1	**1.25**	2	3	3	**15.625**	**45.3**
	Weighted Score	22.5		0.625	2.5	0	0		0.625	0		0.5	0.375	0.75	0.5		0.625	0.625		6.25	7.50	1.88		
Raingardens	Score (max=4)	1	**7.5**	0	2	2	2	**11.25**	4	1	**4.375**	4	1	0	2	**1.88**	2	2	**2.5**	3	2	3	**16.250**	**43.8**
	Weighted Score	7.5		0	5	3.125	3.125		2.5	1.875		1	0.375	0	0.50		1.25	1.25		9.375	5	1.88		
WSUD in the backyard	Score (max=4)	1	**7.5**	0	2	2	2	**11.25**	3	2	**5.625**	3	1	0	2	**1.63**	0	0	**0**	3	2	3	**16.250**	**42.3**
	Weighted Score	7.5		0	5	3.125	3.125		1.875	3.75		0.75	0.375	0	0.50		0	0		9.375	5	1.88		
Edinburgh Parks north detention basin	Score (max=4)	1	**7.5**	1	2	2	2	**11.875**	0	4	**7.5**	0	0	0	2	**0.50**	0	0	**0**	2	3	1	**14.38**	**41.8**
	Weighted Score	7.5		0.625	5	3.125	3.125		0	7.5		0	0	0	0.50		0	0		6.25	7.5	0.63		
Asset inspection program	Score (max=4)	3	**22.5**	0	0	0	0	**0**	0	0	**0**	0	3	0	3	**1.88**	0	0	**0**	3	2	3	**16.250**	**40.6**
	Weighted Score	22.5		0	0	0	0		0	0		0	1.125	0	0.75		0	0		9.375	5	1.88		
Promotion Drive flood detention dam	Score (max=4)	2	**15**	1	1	1	1	**6.25**	1	0	**0.625**	1	1	0	3	**1.375**	1	1	**1.25**	2	3	3	**15.625**	**40.1**
	Weighted Score	15		0.625	2.5	1.5625	1.5625		0.63	0.00		0.25	0.375	0	0.75		0.625	0.625		6.25	7.50	1.9		
Education and awareness	Score (max=4)	1	**7.5**	1	1	1	1	**6.25**	0	1	**1.875**	1	1	0	4	**1.625**	1	1	**1.25**	3	4	3	**21.25**	**39.8**
	Weighted Score	7.5		0.625	2.5	1.5625	1.5625		0	1.875		0.25	0.375	0	1.00		0.625	0.625		9.375	10	1.88		
Kaurna Park water harvesting upgrade	Score (max=4)	1	**7.5**	1	2	2	2	**11.875**	0	4	**7.5**	0	0	0	2	**0.50**	0	0	**0**	1	3	1	**11.25**	**38.6**
	Weighted Score	7.5		0.625	5	3.125	3.125		0	7.5		0	0	0	0.50		0	0		3.125	7.5	0.63		
Infiltration systems	Score (max=4)	1	**7.5**	0	1	1	1	**5.625**	4	1	**4.375**	0	1	0	3	**1.13**	0	0	**0**	4	2	3	**19.375**	**38.0**
	Weighted Score	7.5		0	2.5	1.5625	1.5625		2.5	1.875		0	0.375	0	0.75		0	0		12.5	5	1.88		
Revegetation of watercourses	Score (max=4)	1	**7.5**	0	1	1	1	**5.625**	1	0	**0.625**	3	1	0	4	**2.13**	3	3	**3.75**	3	2	3	**16.250**	**35.9**
	Weighted Score	7.5		0	2.5	1.5625	1.5625		0.625	0		0.75	0.375	0	1.00		1.875	1.875		9.375	5	1.88		
Hogarth Road detention basins	Score (max=4)	2	**15**	1	1	0	0	**3.125**	1	0	**0.625**	2	2	1	3	**2.38**	1	1	**1.25**	2	2	3	**13.125**	**35.5**
	Weighted Score	15		0.625	2.5	0	0		0.625	0		0.5	0.75	0.375	0.75		0.625	0.625		6.25	5	1.88		
Grenadier Road drain upgrade	Score (max=4)	1	**7.5**	0	0	0	0	**0**	0	0	**0**	0	1	0	3	**1.125**	0	0	**0**	4	4	4	**25.00**	**33.6**
	Weighted Score	7.5		0	0	0	0		0.00	0.00		0	0.375	0	0.75		0	0		12.50	10.00	2.5		
Channel maintenance	Score (max=4)	1	**7.5**	4	0	0	0	**2.5**	0	0	**0**	4	1	0	4	**2.38**	0	0	**0**	4	2	3	**19.375**	**31.8**
	Weighted Score	7.5		2.5	0	0	0		0	0		1	0.375	0	1.00		0	0		12.5	5	1.88		
Adams Creek outlet pipe upgrade	Score (max=4)	2	**15**	0	0	0	0	**0**	0	0	**0**	0	2	0	1	**1.00**	0	0	**0**	1	3	4	**13.13**	**29.1**
	Weighted Score	15		0	0	0	0		0	0		0	0.75	0	0.25		0	0		3.125	7.5	2.50		
Gawler Railway line cross culverts	Score (max=4)	2	**15**	0	0	0	0	**0**	0	0	**0**	0	2	0	1	**1.00**	0	0	**0**	1	2	4	**10.63**	**26.6**
	Weighted Score	15		0	0	0	0		0	0		0	0.75	0	0.25		0	0		3.125	5	2.50		
RAAF flow diversion drain	Score (max=4)	1	**7.5**	0	0	0	0	**0**	1	4	**8.125**	1	1	0	2	**1.13**	1	1	**1.25**	0	3	1	**8.125**	**26.1**
	Weighted Score	7.5		0	0	0	0		0.625	7.5		0.25	0.375	0	0.50		0.625	0.625		0	7.5	0.63		
Flood warning system	Score (max=4)	1	**7.5**	0	0	0	0	**0**	0	0	**0**	0	2	0	4	**1.75**	0	0	**0**	2	2	2	**12.50**	**21.8**
	Weighted Score	7.5		0	0	0	0		0	0		0	0.75	0	1.00		0	0		6.25	5	1.25		
Salisbury pipe upgrades	Score (max=4)	2	**15**	0	0	0	0	**0**	0	0	**0**	0	2	0	0	**0.75**	0	0	**0**	0	1	4	**5.00**	**20.8**
	Weighted Score	15		0	0	0	0		0	0		0	0.75	0	0.00		0	0		0	2.5	2.50		
Outfall channel upgrades	Score (max=4)	2	**15**	0	0	0	0	**0**	0	0	**0**	0	2	0	3	**1.50**	0	0	**0**	0	0	1	**0.625**	**17.1**
	Weighted Score	15		0	0	0	0		0	0		0	0.75	0	0.75		0	0		0	0	0.63		

Appendix K – Cost estimates

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 25-07-19
Revision: A
Summary of works: Promotion Drive flood detention dam
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 41,912.85
	Sub-Total					**$ 41,912.85**
2.0	**Construction costs**					
2.1	Basin fill material	Embankment fill	m^3	10,600	$ 32.50	$ 344,500.00
2.2	Land acquisition		m^2	2,200	$ 12.00	$ 26,400.00
2.3	Tree removal		item	10	$ 250.00	$ 2,500.00
2.4	300 mm diameter outlet pipe		m	60	$ 217.00	$ 13,020.00
2.5	Headwall		item	2	$ 2,700.00	$ 5,400.00
2.6	Topsoil strip and respread		m^2	2,100	$ 3.50	$ 7,350.00
	Sub-Total					**$ 399,170.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 19,958.50
	Sub-Total					**$ 19,958.50**

Sub-total		**$ 461,041.35**
Contingency	20%	$ 92,208.27
Grand Total		**$ 553,249.62**

Note:

Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 25-07-19
Revision: A
Summary of works: Grenadier Road drain upgrades
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 1,458.00
	Sub-Total					**$ 1,458.00**
2.0	**Construction costs**					
2.1	Topsoil strip and respread		m^2	1,800	$ 3.50	$ 6,300.00
2.2	Embankment fill		m^3	180	$ 32.50	$ 5,850.00
	Sub-Total					**$ 12,150.00**
3.0	**Other costs**					
3.1	Design cost	20% of construction cost	item			$ 2,430.00
	Sub-Total					**$ 2,430.00**

Sub-total		**$ 16,038.00**
Contingency	20%	$ 3,207.60
Grand Total		**$ 19,245.60**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project:	**Adams Creek and Helps Road Drain SMP**
Job No:	20170712
Date:	25-07-19
Revision:	A
Summary of works:	Elizabeth windbreaks detention basin
Estimated:	MM
Review:	TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 37,895.55
	Sub-Total					**$ 37,895.55**
2.0	**Construction costs**					
2.1	Basin	Embankment cut to fill	m^3	1,200	$ 7.20	$ 8,640.00
2.2	Basin	Embankment cut to spoil	m^3	11,260	$ 22.00	$ 247,720.00
2.3	Tree removal		item	70	$ 250.00	$ 17,500.00
2.4	600 mm diameter outlet pipe		m	45	$ 438.00	$ 19,710.00
2.5	Headwall and connection to existing		item	2	$ 3,395.00	$ 6,790.00
2.6	Topsoil strip and respread		m^2	17,300	$ 3.50	$ 60,550.00
	Sub-Total					**$ 360,910.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 18,045.50
	Sub-Total					**$ 18,045.50**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	17,300	$ 0.23	$ 3,979.00
	Sub-Total					**$ 3,979.00**

Sub-total		**$ 416,851.05**
Contingency	20%	$ 83,370.21
Grand Total		**$ 500,221.26**

Note:

Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 07-05-20
Revision: B
Summary of works: Elizabeth Park windbreaks detention basin
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 64,921.18
	Sub-Total					**$ 64,921.18**
2.0	**Construction costs**					
2.1	Basin	Embankment cut to fill	m^3	1,700	$ 7.20	$ 12,240.00
2.2	Basin	Embankment cut to spoil	m^3	18,000	$ 22.00	$ 396,000.00
2.3	Tree removal		item	30	$ 250.00	$ 7,500.00
2.4	1200 mm diameter outlet pipe		m	24	$ 1,700.00	$ 40,800.00
2.5	Headwall and connection to existing		item	2	$ 4,663.00	$ 9,326.00
2.6	Topsoil strip and respread		m^2	14,300	$ 3.50	$ 50,050.00
	Sub-Total					**$ 515,916.00**
3.0	**MAR facility**					
3.1	Pump station		item	1	$ 40,000.00	$ 40,000.00
3.2	Rising main	150 mm diameter pipe	m	535	$ 100.00	$ 53,500.00
3.3	SAPN 3 phase power	Not costed				$ -
3.4	Low flow diversion pipe	Assume 375 mm RCP	m	50	$ 280.00	$ 14,000.00
	Sub-Total					**$ 107,500.00**
4.0	**Other costs**					
4.1	Design cost	5% of construction cost	item			$ 25,795.80
	Sub-Total					**$ 25,795.80**
5.0	**Annual maintenance costs**					
5.1	Basin maintenance	Mow and slash grass	m^2	14,300	$ 0.23	$ 3,289.00
	Sub-Total					**$ 3,289.00**

Sub-total		**$ 714,132.98**
Contingency	20%	$ 142,826.60
Grand Total		**$ 856,959.58**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.
Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project:	**Adams Creek and Helps Road Drain SMP**
Job No:	20170712
Date:	25-07-19
Revision:	A
Summary of works:	Dwight Reserve detention basins
Estimated:	MM
Review:	TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 57,700.65
	Sub-Total					**$ 57,700.65**
2.0	**Construction costs**					
2.1	Basin	Embankment cut to fill	m^3	5,450	$ 7.20	$ 39,240.00
2.2	Basin	Embankment cut to spoil	m^3	12,900	$ 22.00	$ 283,800.00
2.3	Tree removal		item	30	$ 250.00	$ 7,500.00
2.4	1050 mm diameter inlet pipe	Basin 1	m	46	$ 1,302.00	$ 59,892.00
2.5	825 mm diameter oulet pipe	Basin 1	m	39	$ 920.00	$ 35,880.00
2.6	1050 mm diameter inlet pipe	Basin 2	m	15	$ 1,302.00	$ 19,530.00
2.7	375 mm diameter outlet pipe	Basin 2	m	15	$ 280.00	$ 4,200.00
2.8	1050 headwall and connection to existing	Basin 1	item	2	$ 4,663.00	$ 9,326.00
2.9	825 headwall and connection to existing	Basin 1	item	2	$ 4,663.00	$ 9,326.00
2.10	975 headwall and connection to existing	Basin 2	item	2	$ 4,663.00	$ 9,326.00
2.11	375 headwall and connection to existing	Basin 2	item	2	$ 3,180.00	$ 6,360.00
2.12	Inlet pit	Basin 3	item	1	$ 2,500.00	$ 2,500.00
2.13	Topsoil strip and respread		m^2	17,900	$ 3.50	$ 62,650.00
	Sub-Total					**$ 549,530.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 27,476.50
	Sub-Total					**$ 27,476.50**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	17,900	$ 0.23	$ 4,117.00
	Sub-Total					**$ 4,117.00**

Sub-total		**$ 634,707.15**
Contingency	20%	$ 126,941.43
Grand Total		**$ 761,648.58**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project:	**Adams Creek and Helps Road Drain SMP**
Job No:	20170712
Date:	25-07-19
Revision:	A
Summary of works:	Adams Creek outlet pipe upgrade
Estimated:	MM
Review:	TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 161,192.75
	Sub-Total					**$ 161,192.75**
2.0	**Construction costs**					
2.1	1200 mm RCP		m	47	$ 1,700.00	$ 79,900.00
2.2	1350 mm RCP		m	384	$ 2,034.00	$ 781,056.00
2.3	1500 mm RCP		m	261	$ 2,400.00	$ 626,400.00
2.4	Headwall to suit 1200 mm pipe		item	1	$ 2,163.00	$ 2,163.00
2.5	1800 square Junction boxes		ea	5	$ 9,130.00	$ 45,650.00
	Sub-Total					**$ 1,535,169.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 76,758.45
	Sub-Total					**$ 76,758.45**

Sub-total		**$ 1,773,120.20**
Contingency	20%	$ 354,624.04
Grand Total		**$ 2,127,744.23**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 25-07-19
Revision: A
Summary of works: Gawler railway line cross culverts
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 57,434.40
	Sub-Total					**$ 57,434.40**
2.0	**Construction costs**					
2.1	Excavation		m^3	770	$ 44.00	$ 33,880.00
2.2	Culvert 2100 x 750 RCBC		m	141	$ 2,160.00	$ 304,560.00
2.3	Headwall		item	6	$ 3,000.00	$ 18,000.00
2.4	Railway reinstatement		m	30	$ 2,300.00	$ 69,000.00
	Sub-Total					**$ 425,440.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 21,272.00
	Night works allowance	30% of construction cost	item			$ 127,632.00
	Sub-Total					**$ 148,904.00**

Sub-total		**$ 631,778.40**
Contingency	20%	$ 126,355.68
Grand Total		**$ 758,134.08**

Note:

Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 25-07-19
Revision: A
Summary of works: Salisbury pipe upgrades
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 825,238.05
	Sub-Total					**$ 825,238.05**
2.0	**Construction costs**					
2.1	1050 mm RCP		m	1,250	$ 1,302.00	$ 1,627,500.00
2.2	1200 mm RCP		m	1,670	$ 1,700.00	$ 2,839,000.00
2.3	1650 mm RCP		m	1,155	$ 2,650.00	$ 3,060,750.00
2.4	1800 square juncton boxes		each	32	$ 9,130.00	$ 292,160.00
2.5	Lateral drain modifications		each	20	$ 2,000.00	$ 40,000.00
	Sub-Total					**$ 7,859,410.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 392,970.50
	Sub-Total					**$ 392,970.50**

Sub-total		**$ 9,077,618.55**
Contingency	20%	$ 1,815,523.71
Grand Total		**$ 10,893,142.26**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 25-07-19
Revision: A
Summary of works: Hogarth Road detention basins
Estimated: MM
Review: TAK

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 19,489.84
	Sub-Total					**$ 19,489.84**
2.0	**Construction costs**					
2.1	Basin fill material	Basin 1	m^3	1,725	$ 32.50	$ 56,062.50
2.2	Basin fill material	Basin 2	m^3	2,046	$ 32.50	$ 66,495.00
2.3	Tree removal		item	45	$ 250.00	$ 11,250.00
2.4	300 mm RCP	Basin 2	m	130	$ 217.00	$ 28,210.00
2.5	Inlet pit	Basin 1 and Basin 2	item	3	$ 2,500.00	$ 7,500.00
2.6	Topsoil strip and respread		m^2	4,600	$ 3.50	$ 16,100.00
	Sub-Total					**$ 185,617.50**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 9,280.88
	Sub-Total					**$ 9,280.88**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	4,600	$ 0.23	$ 1,058.00
	Sub-Total					**$ 1,058.00**

Sub-total		**$ 214,388.21**
Contingency	20%	$ 42,877.64
Grand Total		**$ 257,265.86**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

tonkin

Project:	**Adams Creek and Helps Road Drain SMP**
Job No:	20170712
Date:	25-07-19
Revision:	A
Summary of works:	Smith Creek overflow basin, 2 m^3/s outlet option
Estimated:	TAK
Review:	MM

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 1,301,624.63
	Sub-Total					**$ 1,301,624.63**
2.0	**Construction costs**					
2.1	Basin excavation	Assumes all cut	m^3	338,000	$ 22.00	$ 7,436,000.00
2.2	Land acquisition	Assumes 1.2 m average storage depth	m^2	280,000	$ 12.00	$ 3,360,000.00
2.3	Topsoil strip and respread		m^2	280,000	$ 3.50	$ 980,000.00
2.4	900 mm diameter outlet pipe		m	900	$ 688.25	$ 619,425.00
2.5	900 headwall		item	1	$ 1,000.00	$ 1,000.00
	Sub-Total					**$ 12,396,425.00**
3.0	**Other costs**					
3.1	Design cost	5% of construction cost	item			$ 619,821.25
	Sub-Total					**$ 619,821.25**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	280,000	$ 0.23	$ 64,400.00
	Sub-Total					**$ 64,400.00**

Sub-total		**$ 14,317,870.88**
Contingency	20%	$ 2,863,574.18
Grand Total		**$ 17,181,445.05**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **Adams Creek and Helps Road Drain SMP**
Job No: 20170712
Date: 15-04-20
Revision: B
Summary of works: Raingardens
Estimated: TAK
Review: MM

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 4,800.00
	Sub-Total					**$ 4,800.00**
2.0	**Construction costs**					
2.1	Streetscape raingarden		m^2	15	$ 3,200.00	$ 48,000.00
	Sub-Total					**$ 48,000.00**
3.0	**Annual maintenance costs**					
3.1	Raingarden maintenance		Item	1	$ 300.00	$ 300.00
	Sub-Total					**$ 300.00**

Sub-total		**$ 52,800.00**
Contingency	20%	$ 10,560.00
Grand Total		**$ 63,360.00**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

Appendix L – What We Heard Report

Draft Stormwater Management Plans 2022/23

Community Engagement What We Heard Report

June 2022

Draft Stormwater Management Plans

What We Heard Report

June 2022

Contents

1. What we asked

Council's draft Stormwater Management Plans (SMPs) are regional level stormwater catchment studies and have been prepared in accordance with Stormwater Management Authority (SMA) Guidelines. Alignment with these guidelines achieves best practice but further ensures future works arising from such plans are eligible for funding from the SMA.

The City of Playford has been working with the City of Salisbury, Town of Gawler, the SMA and Green Adelaide in developing three Regional SMPs, with a first round of community and stakeholder engagement occurring during the development of the draft plans. This included:

- Targeted public and private sector stakeholder workshop in 2017 including Elected Member information sessions.
- Community engagement about key issues, desired outcomes and opportunities for the SMPs in 2018. This engagement consisted of an online and hard copy feedback form, print and social media promotion. Social media reached around 9,000 people but engaged only 0.33% of those. Only five survey responses were received across the three Council areas.

The SMA Planning Guidelines outline that a second round of community engagement is required prior to the SMA approving the SMPs.

The objectives of community engagement for the draft SMPs were to:

- **Inform** the wider community about the draft SMPs and build awareness of their role in guiding future decisions related to stormwater management.
- **Consult** the community on the draft SMPs, seeking views on the objectives of each SMP which have informed the priorities.

The following table identifies what we engaged the community on for the Stormwater Management Plans:

What we need information on and how we will use it	Negotiables	Non-Negotiables
Understanding the level of priority for objectives detailed in the draft Stormwater Management Plans. Community feedback may be used to refine SMPs and will be shared with Council to support decision making when seeking endorsement of SMPs Community objective priorities will be considered when assessing and determining strategy and future planning	Determining which objectives the community feels are most important	The extent or effect of flooding or water quality The stormwater management planning approach Individual measure identified Objectives and levels of service

2. How we asked it (engagement approach)

An overview of the Community Engagement Plan is provided below. These activities were delivered between 7 April and 9 May 2022**.**

Engagement and communication activity included:

Activity	Details
Online Engagement	The Engagement Hub webpage went live on 7 April and formed the central location for all engagement documents including simplified summary document (snapshot) and feedback form.
Feedback Form (online and hard copy)	Updated information on Council's corporate website with links to online engagement listing.
Face to Face Engagement	Three drop-in sessions were held for community members to meet with Council staff, ask questions about the plans and provide feedback in person.
Website Article	Updated information on Council's corporate website with links to online engagement listing.
Social Media	Three dedicated social media posts on City of Playford official social media channels communicating the commencement of community consultation and sharing details of community engagement activities and feedback options.
eNewsletter	An eNewsletter article in Playford eNews to all registered subscribers.
Council Sites	Relevant documents pertaining to the plans and engagement process were displayed at Customer Contact locations and other Council sites.

3. What we heard

Description	Channels	Performance
Aware visitors (number of those who visited Council's online engagement page, saw social media posts or visited the web article online)	Engagement Hub page views Website Article views and average time on page Social Media Reach (three Facebook posts)	562 173 visits with an average of 2:54 minutes spent on page 7,501
Informed visitors (number of those who downloaded a document or visited the FAQs on Engagement Hub)	Document downloads	168
Engaged visitors (number of those who provided feedback in some way – either in the survey, via email or at the community drop-in session	Feedback Forms Attendance at Drop Ins Social Media Engagement (reactions, comments and shares across three Facebook posts) Emails	5 4 613 0

Feedback Forms
Number of responses: 5

Representation from:

Suburb	Count
Angle Vale	3
Elizabeth Downs	1
Virginia	1

Feedback on:

Draft Stormwater Management Plan	Count
Smith Creek Catchment	4
Adams Creek & Helps Road Catchment	1

Feedback Specific to Smith Creek Catchment

Most important

1. Flood management
2. Asset management
3. Water reuse
4. Improve water quality*
4. Protect the Environment*

*Improve water quality and protecting the environment were ranked equally important.

Reason for ranking of importance

"Angle Vale has little to no stormwater management. Do some!"
"We currently have no stormwater scheme, so a start is good."

Feedback Specific to Adams Creek & Helps Road Catchment

Most important

1. Water reuse
2. Protect the environment
3. Improve water quality
4. Asset management
5. Flood management

Reason for ranking of priorities

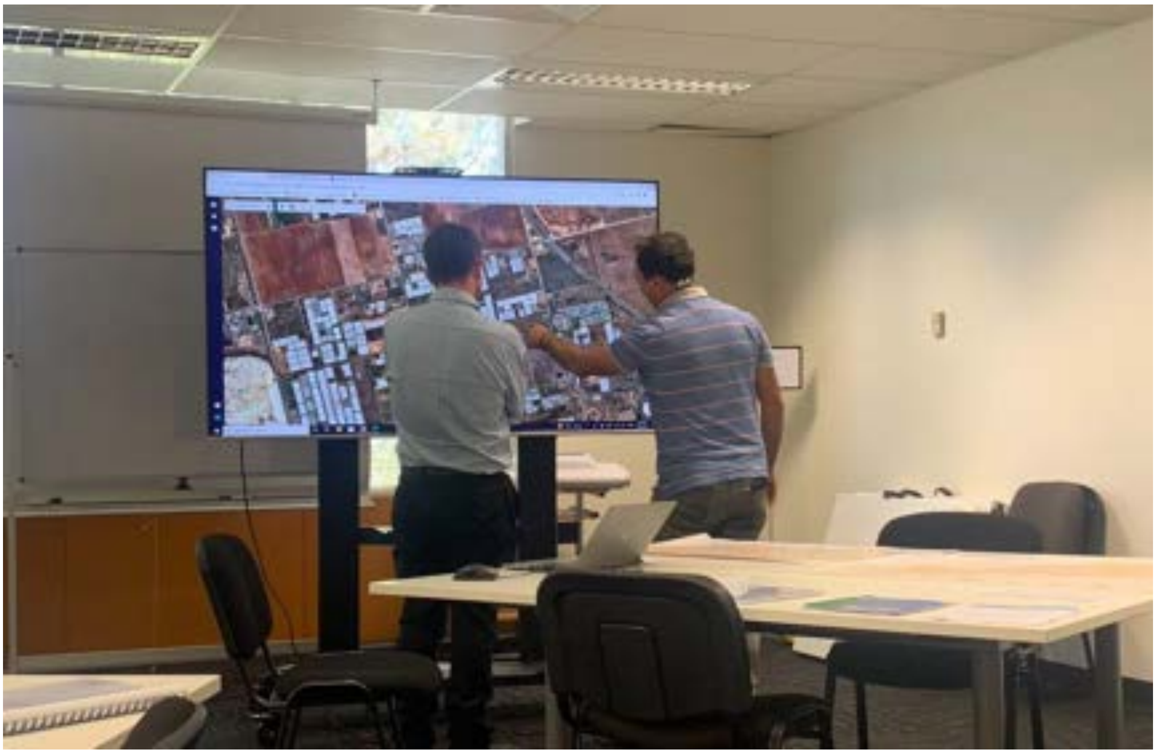
N/A

Community Drop-in Sessions

Session 1: Virginia Horticultural Centre - 19 May 2022
Number of attendees: 1

Concern/Suggestion	Council Response
Discussed the Smith Creek and Greater Edinburgh Park SMPs.	Council's Stormwater Planner outlined the purpose of the Regional SMPs in setting out a stormwater strategy for the council.
Expressed concerns around the impact of Smith Creek widening on properties and whether this was the only opportunity to comment. Expressed appreciation of our time and the work done to prepare the plans.	Council will consult with the community on projects identified within the regional SMPs when they are planned for delivery through future annual business planning processes and through the design phase where appropriate.

The session was also attended by Cr Marsh who discussed the regional plans and how they will form part of Council's strategic document suite.



Session 2: Civic Centre Library – 21 April 2022
Number of attendees: 0

There were no community members attending this session.

This session was attended by Cr Onuzans. Our Stormwater Planner was able to outline the purpose of the regional SMPs and how it addressed stormwater management across the Adams Creek and Helps Road Catchment.

Session 3: Civic Centre Great Hall – 5 May 2022
Number of attendees: 1

Concern/Suggestion	Council Response
Discussed the Smith Creek SMP.	Council staff outlined the diverse levels of stormwater management within the Council area ranging from nuisance flooding to large scale flood management. This discussion leads into the work behind the regional SMPs and next stages of endorsement by the SMA.
Expressed concerns around stormwater issues relevant to Angle Vale.	Comprehensive SMPs have been developed for the growth areas.

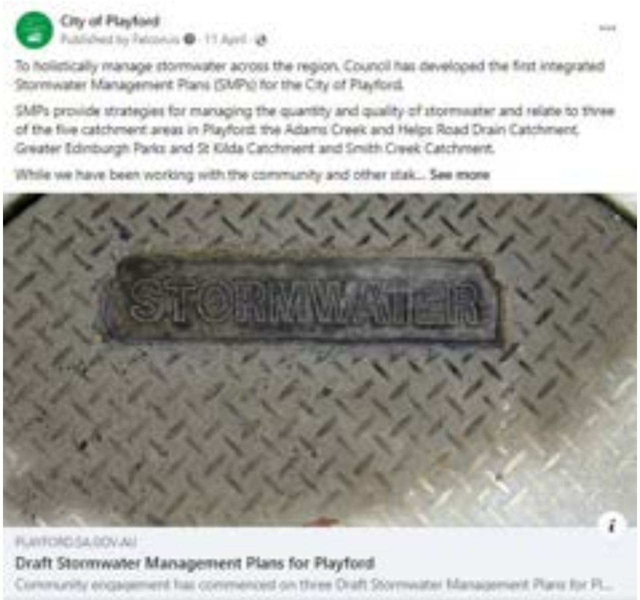
Draft Stormwater Management Plans

What We Heard Report

June 2022

Social Media Summary

Facebook Post One – 11 April, 2022



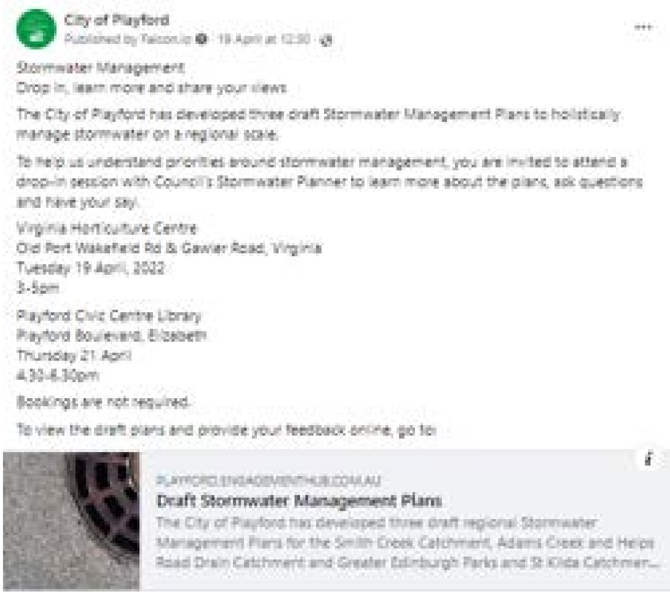
Engagement (Engaged Visitors) - 131
Reactions – 13
Comments –14
Link clicks – 17
Shares – 3

Reach (Aware Visitors) – 1,825

Summary of comments
The comments were mainly questions about specific issues across the city – from requests for a new playground and connecting recycled rainwater.

There was a request for an additional drop-in session which we held in May based on this feedback.

Facebook Post Two – 19 April, 2022



Engagement (Engaged Visitors) - 38
Reactions – 12
Comments – 3
Link clicks – 8
Shares – 8

Reach (Aware Visitors) – 1,666

Summary of comments
The comments were on post shares and therefore not viewable.

Facebook Post Three – 02 May, 2022

Engagement (Engaged Visitors) - 444
Reactions – 78
Comments – 34
Link clicks – 14
Shares – 6

Reach (Aware Visitors) – 4,010

Summary of comments
The majority of comments on this post were on shares and therefore not viewable.

There was a query about a specific drainage problem which was addressed offline.

Summary

Given the complex and targeted nature of the content, the SMP social media posts achieved a pleasing level of reach and engagement. As expected, most comments on posts related to specific issues around Playford and were not specifically related to stormwater management.

There was no feedback provided as to the support or otherwise of the draft SMPs via this channel.

Post number three – featuring an image of Stormwater Planner Shaun Fielding – was the best-performing post. It achieved significant reach and engagement, having 1.4 times more impressions than other posts within 10 days of publishing. This is a reminder that content featuring images native to Facebook and of the real people behind the projects can help achieve greater reach, engagement and awareness.

4. What we will do /our response

The purpose of the community engagement was to inform the community about the regional SMPs that Council had developed for the three major catchment areas in Playford. We also provided the opportunity for the community to tell us what stormwater objectives were important to them in these plans as outlined in the feedback section.

A summary of the community engagement undertaken will be incorporated into the three SMPs. The SMPs will then be submitted to the Elected Members for endorsement to the SMA.

Once the plans are endorsed by the SMA it will enable the council to achieve the following:

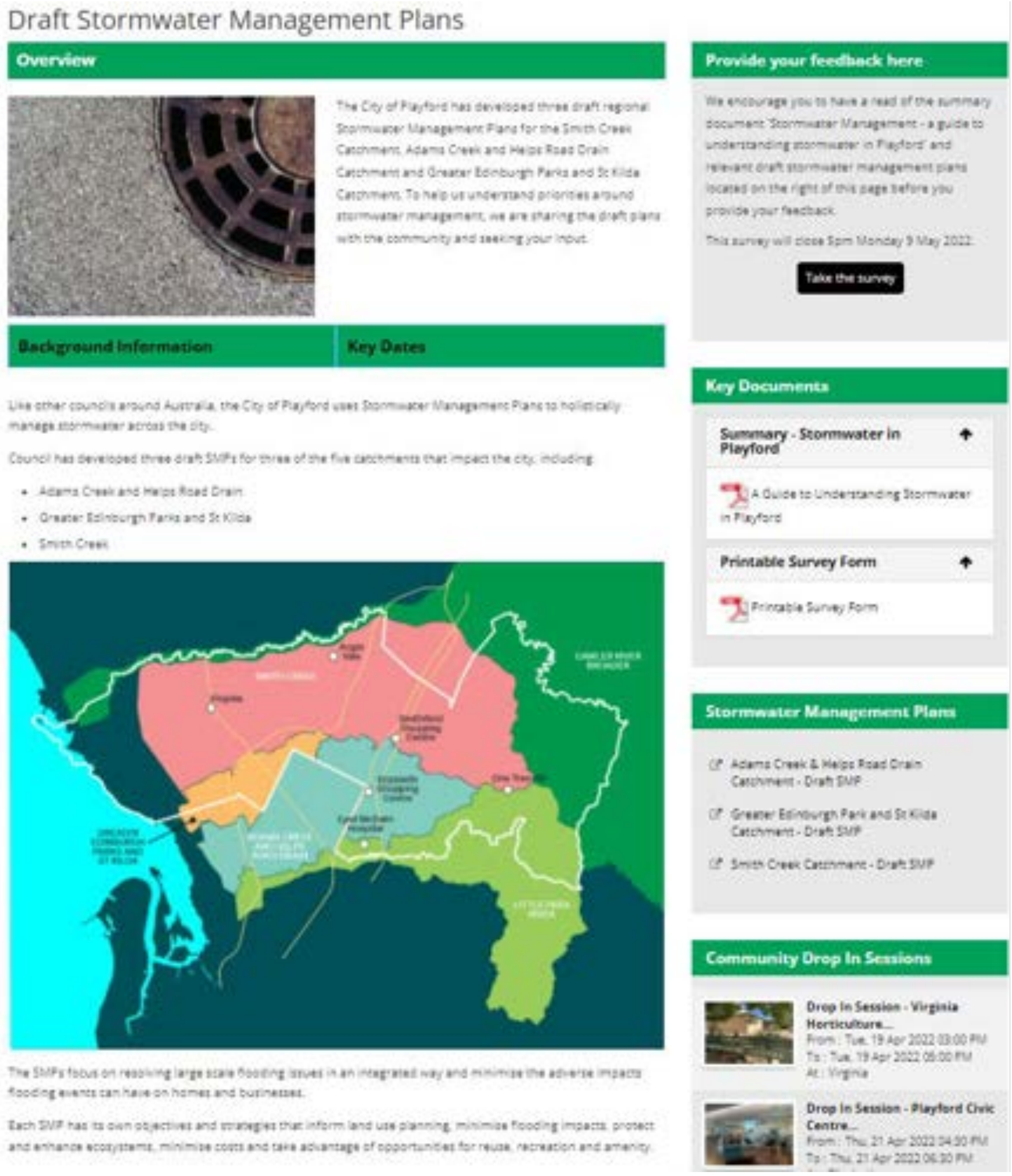
- The SMPs will form part of our long-term strategic document suite that will inform stormwater planning for future years
- Apply for funding of the stormwater projects identified in the SMPs through the SMA (SA Government)
- The council can recover funding from the SMA for the preparation of the SMPs as part of the grant agreement between Council and the SMA.

The feedback provided will also assist Council in determining the priorities of projects identified in the plans. This will enable Council to select stormwater projects that service the community in line with the Playford Community Vision 2043 and Strategic Plan. Council will engage with the relevant stakeholders on a more detailed level on each project.

5. Appendix

5.1 Marketing and communications collateral

Engagement Hub



Draft Stormwater Management Plans

What We Heard Report

June 2022

Feedback Form

CITY OF Playford

Draft Stormwater Management Plan Survey

Consultation close date: Monday 5pm 9 May 2022

The City of Playford has developed three draft regional Stormwater Management Plans for the Smith Creek Catchment, Adams Creek and Helps Road Drain Catchment and Greater Edinburgh Parks and St Kilda Catchment. To help us understand your priorities around stormwater management, we are sharing the draft plans with the Playford community.

What we are seeking feedback on
We have identified 5 objectives we need to address in each draft plan. These are flood management, protecting the environment, water reuse, improving water quality and asset management and are referenced in more detail on the following page.

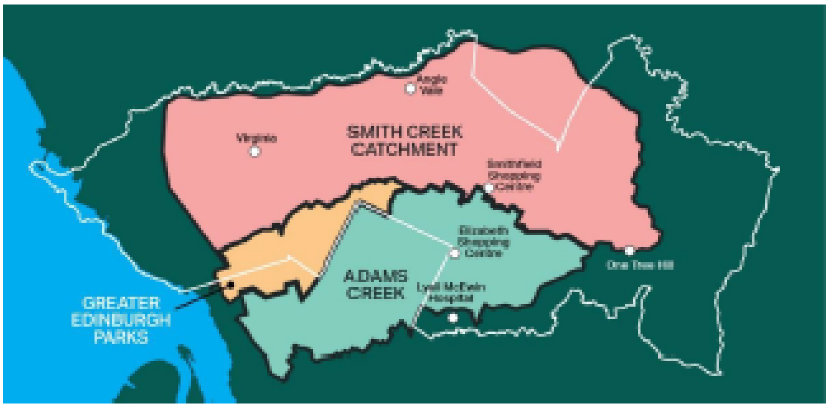
We now need your input to determine what objectives are most important to you. In this survey you will be asked to rank the objectives in order of importance to you and you are welcome to provide any additional comments.

This feedback will inform Council decision making around stormwater management and the prioritisation of stormwater projects in the future.

1. Your suburb: ____

2. Tick the Draft Stormwater Management Plans (SMP) you would like to provide feedback on. A map is below to help you make your selection.

☐	Smith Creek Catchment
☐	Adams Creek and Helps Road Drain Catchment
☐	Greater Edinburgh Parks and St Kilda Catchment



CITY OF Playford

Draft Stormwater Management Plan Survey

Reference - Stormwater Objectives	
Flood management	The protection of buildings and properties from flooding through the construction of detention basins and open channel upgrades.
Improve water quality	Reducing pollution of stormwater from various sources such as roads and farming activities.
Water reuse	The collection of stormwater in our wetlands system that is then treated and reused for irrigating our reserves.
Protect the environment	Improving the health of our creeks and waterways through the removal of rubbish and weeds, revegetating programs and managing erosion.
Asset management	An asset management system for our stormwater network to ensure it is renewed appropriately.

3. Rank the following priorities from 1-5, with 1 being the most important to you. You only need to do this for the plans you would like to provide feedback on.

	Smith Creek Catchment
	Flood management
	Improve water quality
	Water reuse
	Protect the environment
	Asset management

Reason for your ranking (optional)

____
____
____
____
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____
____
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____
____

2

Draft Stormwater Management Plan Survey

Adams Creek and Helps Road Drain Catchment	
☐	Flood management
☐	Improve water quality
☐	Water reuse
☐	Protect the environment
☐	Asset management

Reason for your ranking (optional)

____
____
____
____
____
____
____
____

Greater Edinburgh Parks and St Kilda Catchment	
☐	Flood management
☐	Improve water quality
☐	Water reuse
☐	Protect the environment
☐	Asset management

Reason for your ranking (optional)

____
____
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____
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____
____
____

3

Draft Stormwater Management Plan Survey

4. Do you have additional feedback about the draft Stormwater Management Plans? (Optional)

____
____
____
____
____
____
____
____
____
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____
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Thank you for your time and participation.
Your feedback will be used to refine our plans and help us understand what we need to consider in any future planning around stormwater management in Playford. A summary of our community's feedback and the refined plans will be shared to Council for their consideration and endorsement in June-July 2022 before going to the Stormwater Management Authority and Green Adelaide for final approval. Once approved, final plans will be published and made available on Council's website later this year.

How to submit this form:

- Drop off: Playford Civic Centre or Stretton Centre customer service desks
- Post: Attn: Draft Stormwater Management Plans, 12 Bishopstone Road, Davoren Park SA 5113
- Email: publicconsultation@playford.sa.gov.au

Need more information?
If you need further information or have questions, you are welcome to call us on 8256 0333 and leave your contact details and times of availability. Our Urban Infrastructure Planner, Shaun Fielding, can then reach out for a chat.

Want to be kept up to date on this project? Leave your details below:

Name:	
Phone:	
Email:	

I would like to be kept up to date on other engagements ☐ Yes ☐ No

4