Port Augusta City Council

Port Augusta Stormwater Management Plan

Progress Report

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Our Ref.: 23007-3A

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Document Status

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Appendices

1 Introduction

This Stormwater Management Plan (SMP) for the Local Government Area (LGA) of Port Augusta including Port Augusta, Port Augusta West, Stirling North, Miranda and Shack Road (Commissariat Point and Blanche Harbour), has been prepared for the Port Augusta City Council in accordance with the requirements of the brief. The preparation of the plan has been jointly funded by the Port Augusta City Council (Council) and the Stormwater Management Authority (SMA).

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

This progress report provides background on the LGA in the form of a baseline assessment, describing the current state and condition of the catchment and establishing a baseline against which the effectiveness of stormwater management options can be assessed. This report also summarises the proposed approach to identifying stormwater risk and issues.

2 Baseline Assessment

2.1 Introduction

A baseline assessment of the Local Government Area (LGA) of Port Augusta has been undertaken. This assessment describes the current state of the area and its catchments, establishing a baseline against which the effectiveness of future stormwater management options can be assessed. The following sections describe the elements included in the baseline assessment.

2.2 Administrative Boundaries

A Stormwater Management Plan boundary, forming the study area, has been prepared, and can be seen in Figure 2.1 below. An enlargement of the Port Augusta Study Area is shown in Figure 2.2. The study area was defined based on requirements of the project brief, topography and extent of existing and future development in Port Augusta.

The study area is 116 km^2 in size and spans the Port Augusta township, including Port Augusta West and Stirling North, as well as Shack Road and Miranda. It is located at the top of Spencer Gulf, with Port Augusta on the eastern shore of the gulf and Port Augusta West on the western shore, connected by the Joy Baluch AM Bridge.

The study area is wholly contained within the Port Augusta City Council LGA. The relevant Landscape Board for the study area is the South Australian Arid Lands Landscape Board (SAALLB). The Water Affecting Activity Control Policy (WAACP) locates the study area within Port Augusta and Flinders Ranges Management Zone which is within the Southern and South-Western Flatlands (East) National Resource Management sub cluster.

2.3 Study Area Features

Both Port Augusta and Port Augusta West can be characterised as mostly urban with areas of dense commercial and residential land use. Industrial areas are located mainly on the western side of the gulf, towards Stirling North.

Stirling North represents mainly rural living with larger residential blocks and little commercial and industrial use. There are some areas of new development in Stirling North with denser residential housing. Shack Road and Miranda are both mainly made up of holiday housing and generally used as recreational destinations.

The central township is generally wedged between Spencer Gulf and two large, low-lying lakes, names Bird Lake and Pink Lake. Both lakes are interconnected with an outlet at the southern end to the gulf.

Areas surrounding Port Augusta can be generally characterised as rural in nature with arid scrublands and livestock land usage and minimal development.

2.3.1 Study Area Topography

Topographic features of the study area were defined based on a Digital Elevation Model (DEM) supplied by Council for this SMP. The DEM was generated from Light Detection And Ranging (LiDAR) point data captured in 2022 and cover the main town, Stirling North, Shack Road and Miranda. Details of the LiDAR DEM is outlined below:

- Vertical Accuracy: +/- 0.037m (95% confidence interval)
- Horizontal Accuracy: <= +/- 100mm, 68% confidence interval
- Capture Date: 13 – 14 June 2022
- Point Density: 6pts per m

The DEM data indicates the eastern portion of the study area has a relatively constant and gentle slope from the Flinders Ranges to the gulf, with an average gradient of approximately 0.8%. This area includes Stirling North and portions of Port Augusta east of Bird Lake.

The Port Augusta central township (areas between Bird and Pink Lakes and the gulf) is characterised by moderately variably hilly regions with a number of clear localised trapped low spots focused at the intersection of Seaview Road and Carlton Parade. The town centre is shown to be relatively low-lying with surface levels in some areas below 2 mAHD. A tidal levee exists in the low-lying portions of town, details of which are described in Section 2.5.1.

Port Augusta West is also shown to be moderately hilly with a number of trapped low spots in the vicinity of the Golf Course. Areas near the coast are shown to be low-lying with elevations of less than 2 mAHD, particularly in the vicinity of the western abutment of the Joy Baluch AM Bridge.

The DEM for the main study area is shown in Figure 2.3

2.3.2 Major Catchments

In addition to the Port Augusta urban area catchments, there are also three major creek catchments with overland flows which pass through the study area. Two of the creek catchments are located to the northeast of the urban area, being Mundallio Creek (also referred to a Depot Creek in the project brief) and Saltia Creek, with Sandy Creek to the southwest. Both Mundallio Creek and Sandy Creek flow through mostly rural areas of the study area, while Saltia Creek passes close to Stirling North.

The supplied DEM was supplemented with topographic information of the greater catchment area sourced from Shuttle Radar Topography Mission (SRTM) DEM. This data was obtained from the publicly available 'Elevation Information System' (ELVIS), hosted by Geoscience Australia and available via the Intergovernmental Committee on Surveying and Mapping (ICSM) website (https://elevation.fsdf.org.au/). SRTM is a 1-arc second (30m grid) derived DEM and was used for high level topographic assessment and delineation of major creek catchment systems outlined below.

Sandy Creek Catchment
Sandy Creek approaches Port Augusta West from the southwest, entering the study area near Port Augusta Airport, crossing over Caroona Road and Shack Road before discharging into Spencer Gulf to the south of Port Augusta West. The Sandy Creek catchment is approximately 205km^2 in size and characterised by very steep, mountainous terrain upstream with grades upwards of 3% and flatter terrain downstream flowing into the gulf to the South of Port Augusta West. The catchment is rural in nature with arid scrublands and livestock land usage and minimal development.

Saltia Creek Catchment
Saltia Creek catchment is a large catchment approximately 105km^2 in size located to the east of Port Augusta. It originates in the outskirts of the Southern Flinders Ranges and is characterised by steep with grades upwards of 1.5%, mountains terrain upstream and flatter terrain downstream with grades around 0.5%. The catchment flows by the township of Stirling North with a diversion drain and levee system put in place to protect the township from creek breakouts. Details of the levee Saltia Creek levee system is outlined in Section 2.6.3 There are road crossings at Quorn Road and McConnal Road.

Mundallio Creek Catchment
Mundallio Creek catchment is approximately 44 km^2 in size and characterised by hilly, steep terrain upstream and flatter terrain downstream. The creek has a well-defined channel in the upper reaches with less definition in the lower reaches before discharging into the northern end of Bird Lake.

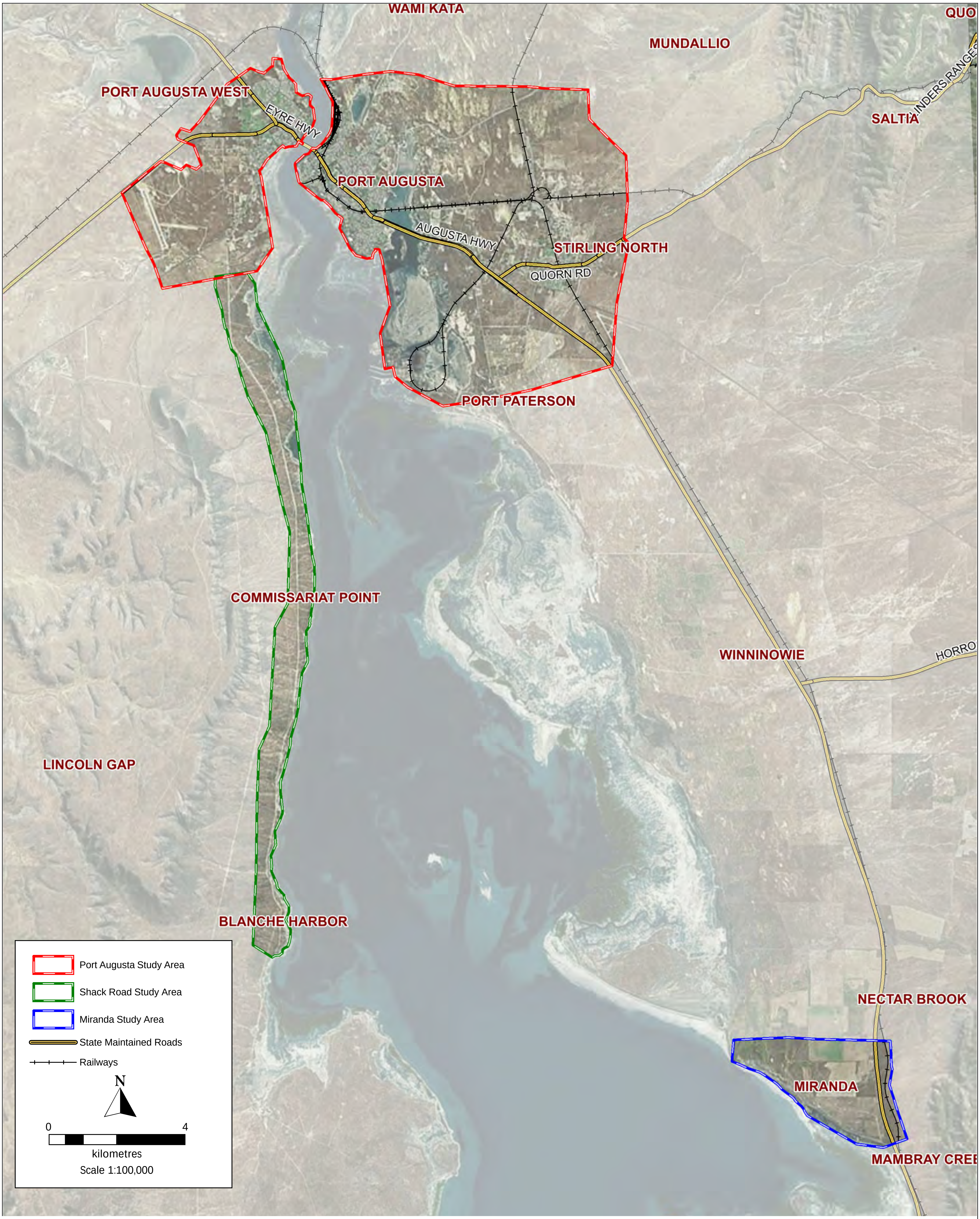
Shack Road Catchments
Shack Road catchment is made up of 46 subcatchments along Shack Road between Commissariat Point and Blanche Harbour. These watercourses originate in the Bluff, a mountain range running parallel to Shack Road. The catchments are characterized by very steep terrain upstream with grades between 4% and 1% in the main channels flattening out towards the coast of Spencer Gulf.

Miranda Rural Catchments
Within the Miranda study area, three rural catchments which extend beyond Princes Highway converge. The study area itself is distinguished by relatively flat and low-lying terrain towards the coastline.

A summary of catchment sizes is presented in **Error! Reference source not found.**, and the catchment extents are shown in Figure 2.4 and Figure 2.5.

Table 2.1 Catchment Size Summary

Catchment	Area (km^2)
Sandy Creek	205
Saltia Creek	105
Mundallio Creek	44
Shack Road Creeks (combined)	67
Miranda	34



Data Sources:
Bing (Aerial Photography)
Data SA (State Maintained Roads and Railways)

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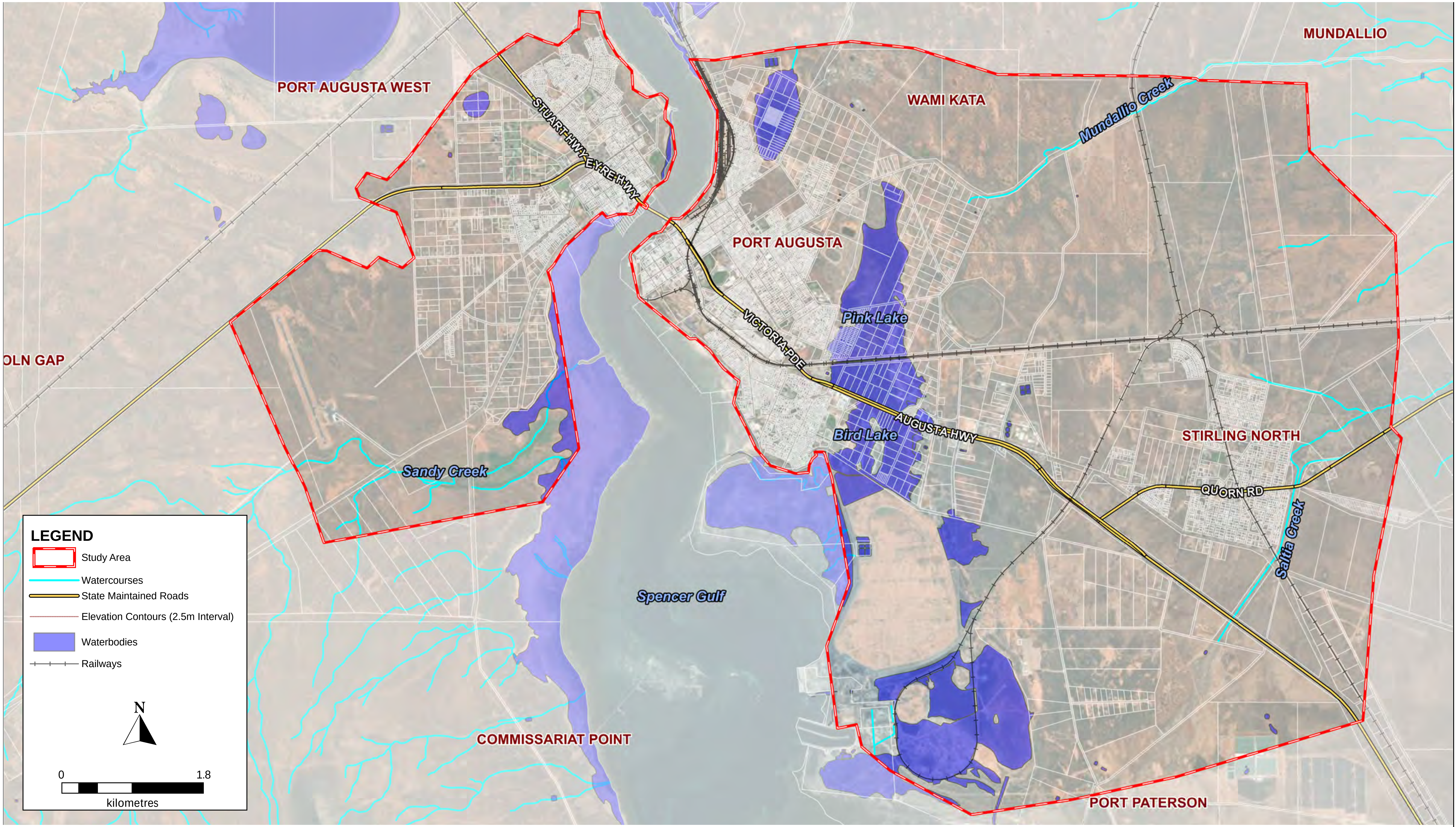
FIGURE 2.1 - STUDY AREA



Data Sources:
Aerometrex (DTM)
Data SA (State Maintained Roads, Watercourses, Waterbodies)

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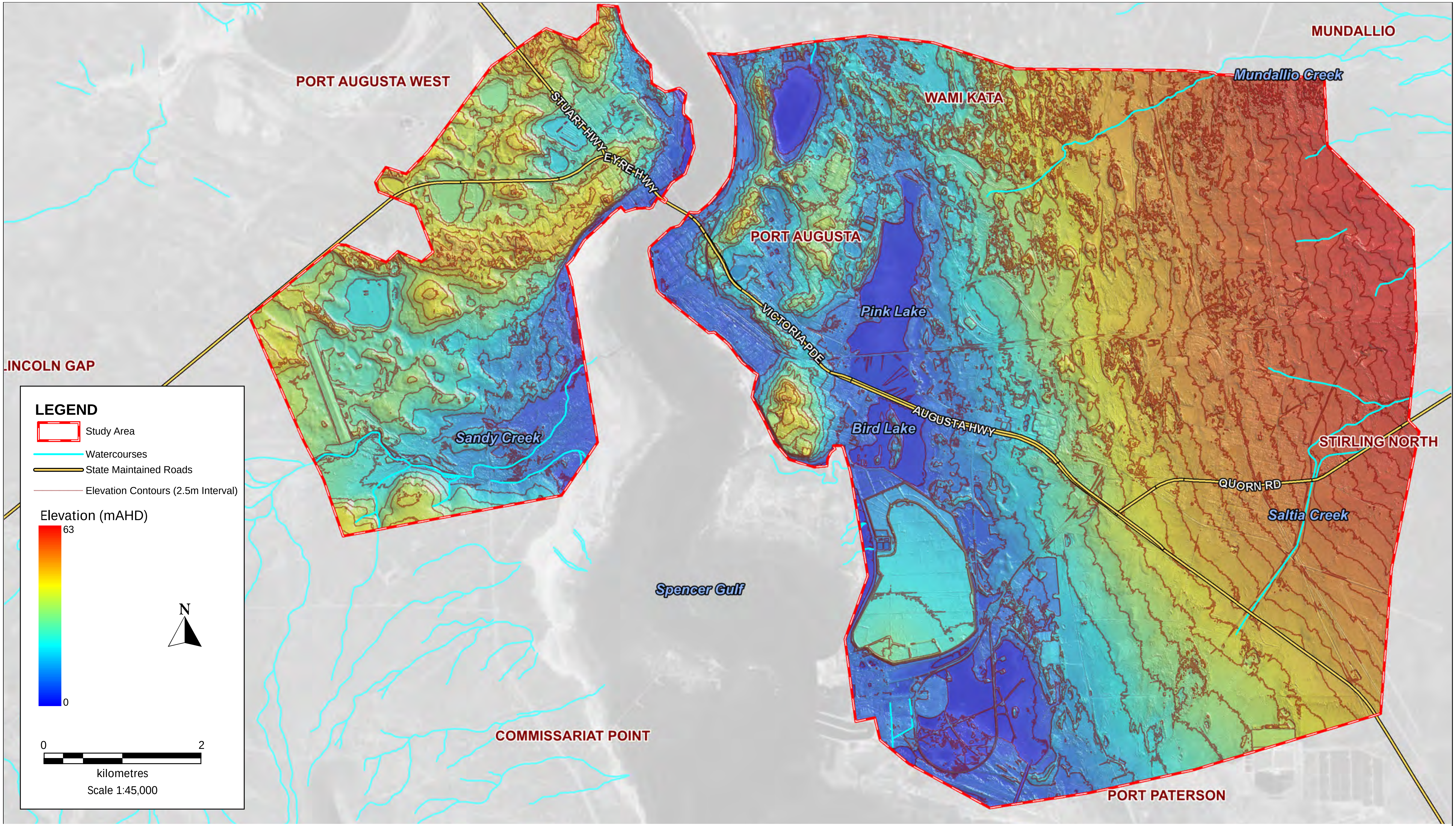
FIGURE 2.2 - STUDY AREA (PORT AUGUSTA)



Data Sources:
Aerometrex (DTM)
Data SA (State Maintained Roads, Watercourses)

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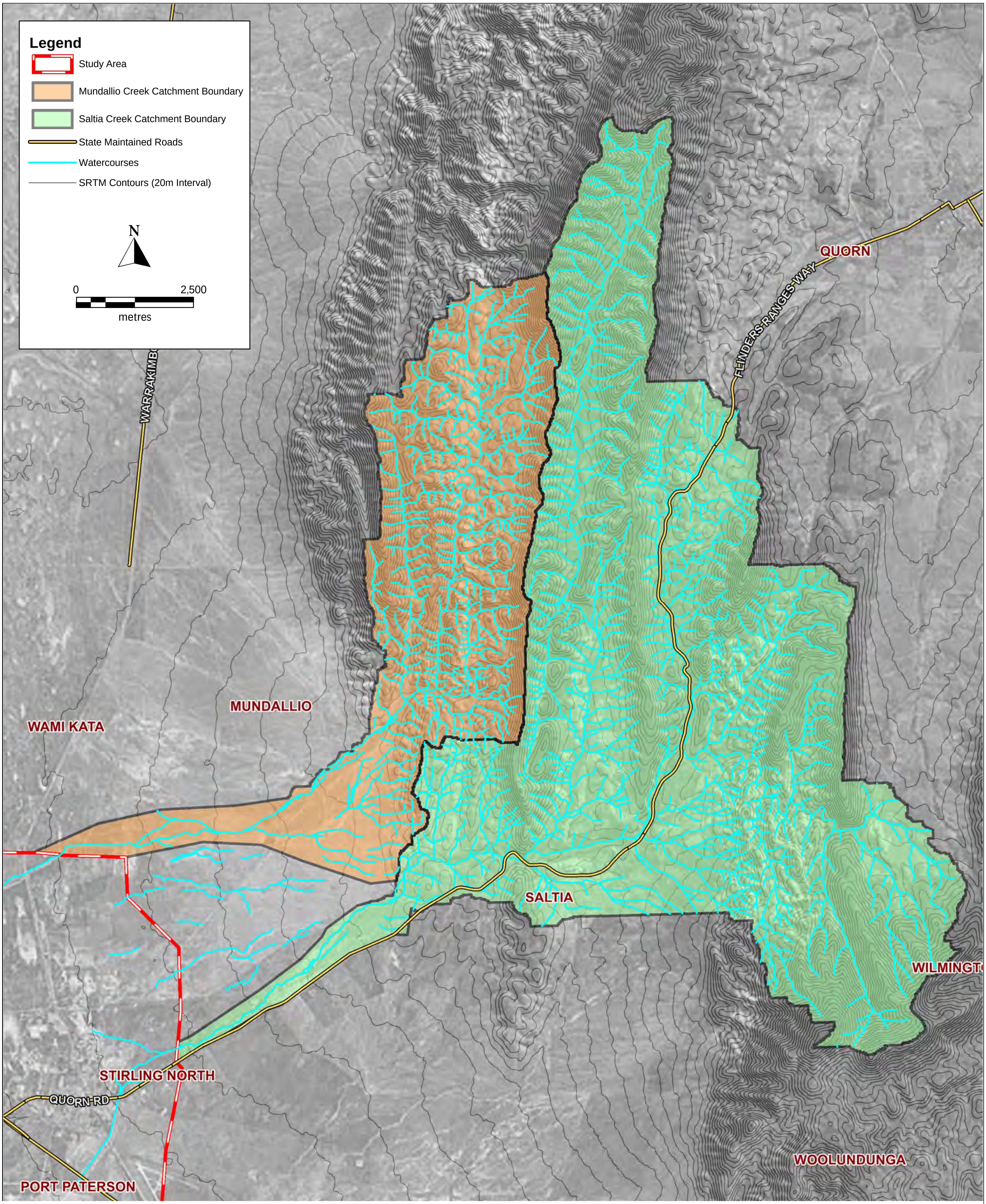
FIGURE 2.3 - PORT AUGUSTA TOPOGRAPHY



Data Sources:
Bing (Aerial Photography)
Data SA (Roads and Railways)

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FIGURE 2.4 - SALTIA CREEK AND MUNDALLIO CREEK MAJOR CATCHMENTS

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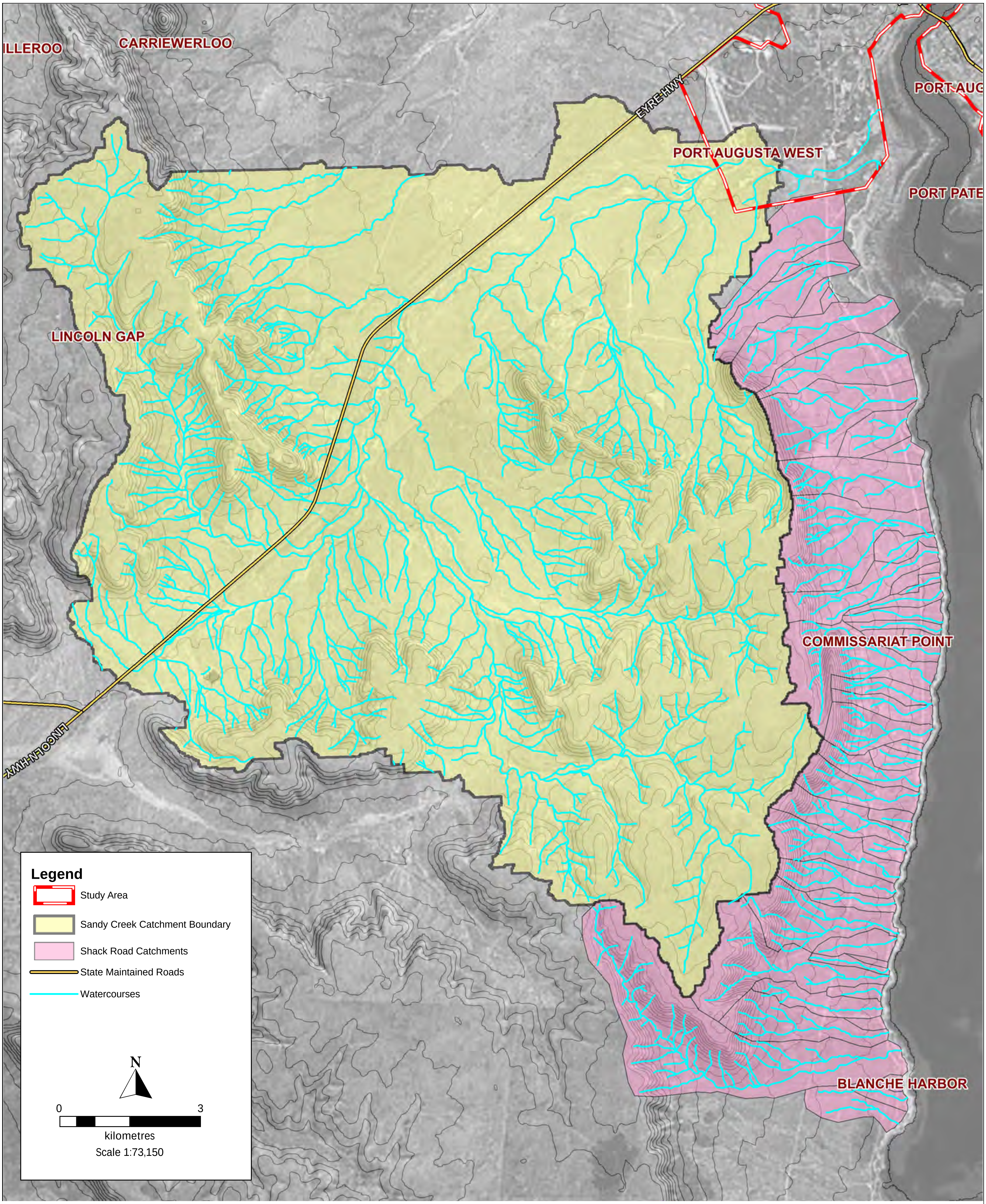

Data Sources:
Bing (Aerial Photography)
Data SA (Roads and Railways)

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FIGURE 2.5 - SANDY CREEK AND SHACK ROAD MAJOR CATCHMENTS

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2.3.3 Land Use

Land use throughout the study area has been sourced from the Valuer General's Generalized Land Use Dataset (2022). This GIS layer is based on actual land use rather than zoning, and within the study area can be broken down as follows:

- 714 ha of Residential, 1063 ha of Rural Residential, 767 ha of Vacant Residential and 27 ha of Nonprivate Residential;
- 133 ha of Agriculture, 59 ha of Horticulture 554 ha of Livestock and 1.2 ha of Food Industry;
- 950 ha of Utility/Industry and 12 ha of Mine/Quarry;
- 122 ha of Commercial and 48 ha of Retail Commercial;
- 92 ha of Public Institution and 46 ha of Education;
- 382 ha of Recreation, 78 ha of Golf and 326 ha of Reserve; and
- 1047 ha of Vacant.

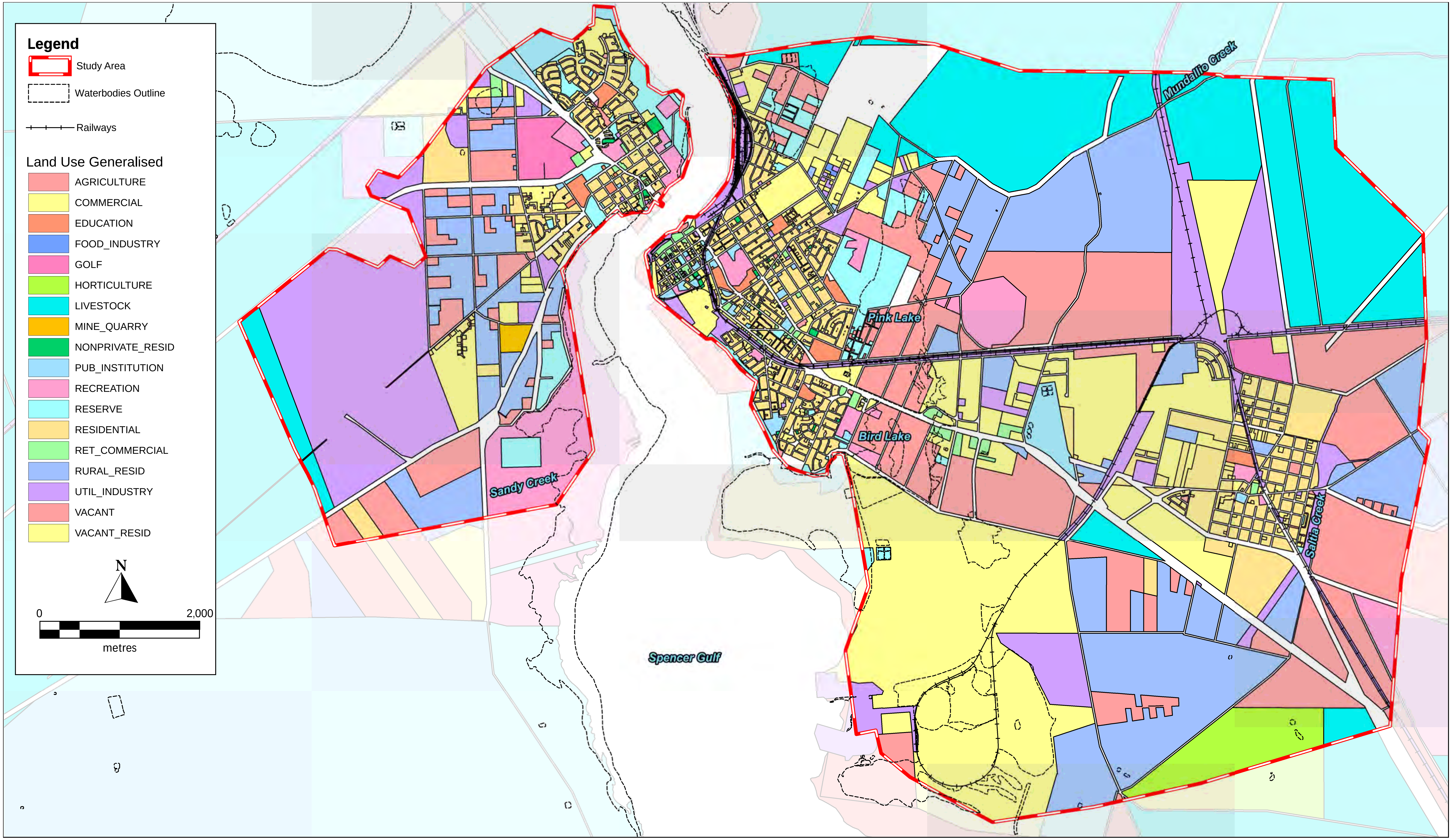
Land use within the main study area can be seen in Figure 2.6.

2.3.4 Geology and Soils

Geological information throughout the study area and upstream catchments has been sourced from the South Australian Resources Information Gateway (SARIG) website developed by the Department for Energy and Mining. This dataset provides stratigraphic information throughout the state and was used to gain an understanding of the geology of the region.

The study area geologically can be separated into four areas: Port Augusta West, Port Augusta, Shack Road, and Miranda. Port Augusta West is mainly situated on quaternary aeolian sediments formed by aeolian sand of inland dune fields. While Port Augusta is dominantly located on the same quaternary aeolian sediments with parts on the southern fringe being built on Saint Kilda formation. Shack Road is located on Pleistocene alluvial/fluvial sediments made up of gravelly and sandy clay. Miranda is positioned on ABC range quartzite. The Sandy Creek catchment is comprised of by dominantly Pleistocene alluvial/fluvial sediments with parts of Eocene-Pleistocene regolith/colluvial unit, the Wilpena group, and Simmens Quartzite member. Both the Saltia Creek and Mundallio Creek catchments are dominated by quaternary aeolian sediments and pleistocene alluvial/fluvial sediments.

We are not aware of any existing literature which investigates the feasibility of aquifer storage and recharge schemes within the Port Augusta study area.



Data Sources:
Bing (Aerial Photo)
Data SA (State Maintained Roads, Land Use)

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FIGURE 2.6 - PORT AUGUSTA LAND USE

2.4 Climate and Hydrology

2.4.1 Rainfall and Temperature Analysis

Daily rainfall data from the Bureau of Meteorology rainfall gauge in Port Augusta at varying locations for 1860 to 2023 was obtained for Port Augusta Post Office (19036), Port Augusta Power Station (19066), Port Augusta Aero (18201), from the Bureau of Meteorology weather station directory online service. The mean annual rainfall in Port Augusta for the Port Augusta Aero station was found to be 223mm.

Statistical analysis of the annual rainfall variation is also provided by the Bureau of Meteorology, which reports variations from the annual mean as summarised in Table 2.2 and Figure 2.7, which show monthly deviations from the annual mean and illustrate monthly trends.

Table 2.2 Rainfall Data for the Port Augusta Region

Statistic [Year of Occurrence]	Annual Rainfall (mm)	% Difference to Mean
1860-1969 Port Augusta Post Office (19036)		
Mean	242.6	-
Lowest [1865]	56.3	-77%
10th percentile	155.1	-36%
Median	236.6	-2%
90th percentile	338.7	40%
Highest [1946]	531.1	119%
1958-1997 Port Augusta Power Station (19066)		
Mean	257.0	-
Lowest [1994]	131.1	-49%
10th percentile	154.3	-40%
Median	242.4	-6%
90th percentile	351.0	37%
Highest [1974]	539.6	110%
2001-2023 Port Augusta Aero (18201)		
Mean	223.2	-
Lowest [2002]	100.4	-55%
10th percentile	120.6	-46%
Median	216	-3%
90th percentile	319.2	43%
Highest [2022]	391.6	75%

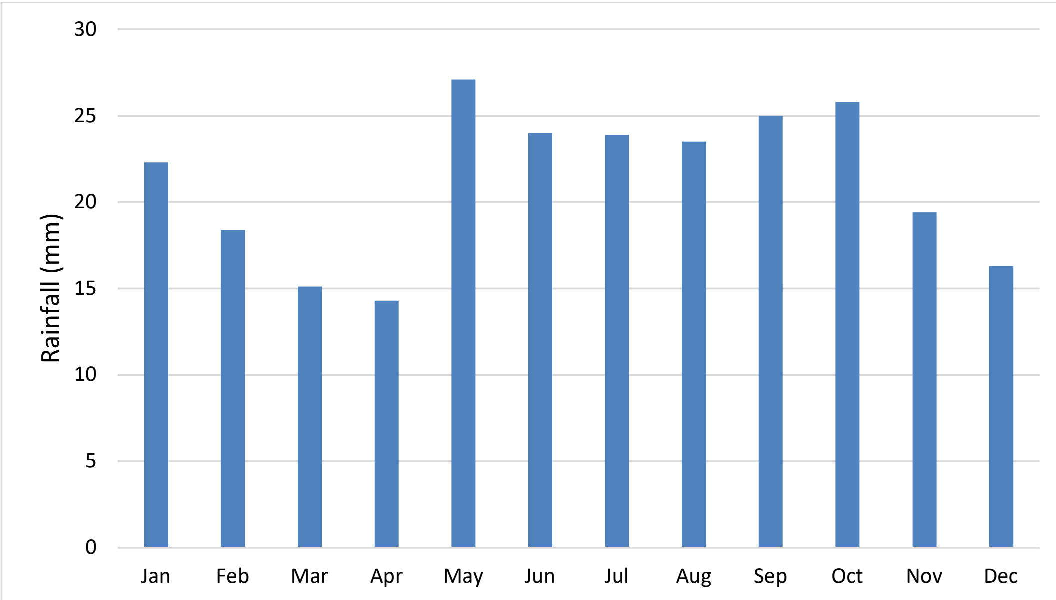


Figure 2.7 Port Augusta Aero (2001-2023) Mean Monthly Rainfall

Historic daily maximum temperature information from 1889 to 2023 at Port Augusta was acquired from the SILO website managed by the State of Queensland (2023). This data was analysed and the average maximum temperature for each month was determined. Daily evaporation data for the same time period was also obtained from the SILO website and analysed to find average monthly evaporation. The two are shown in Figure 2.8 below.

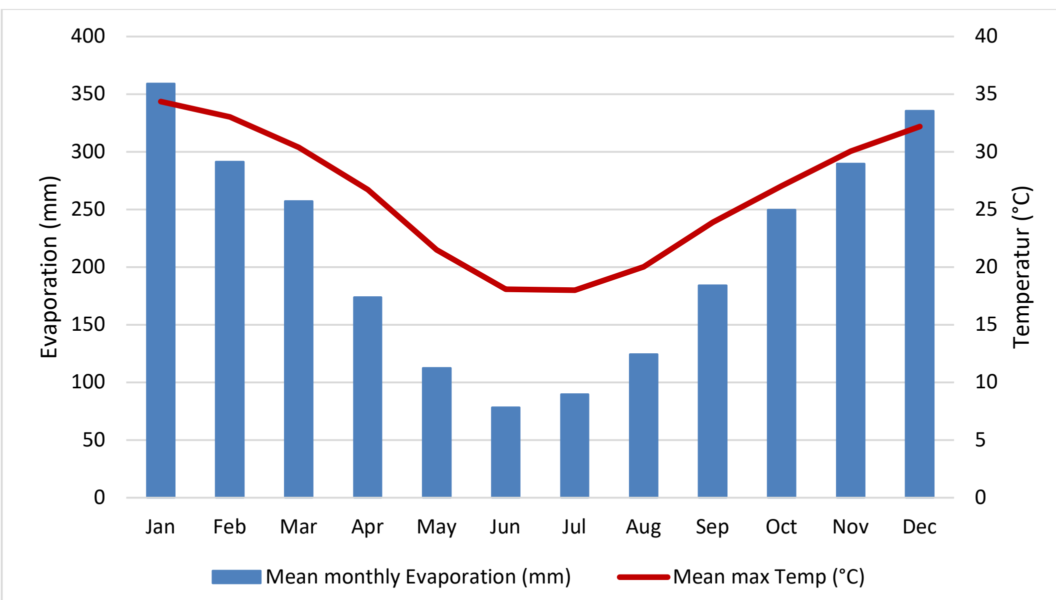


Figure 2.8 Port Augusta Aero (2001-2023) Monthly Evaporation and Temperature

Figure 2.8 above shows that evaporation and maximum temperature are strongly correlated as would be expected.

2.4.2 Design Rainfalls

Design rainfall Intensity-Frequency-Duration (IFD) data has been prepared for the study area utilising the Australian Rainfall and Runoff 2019 (ARR, 2019) online procedure provided by the Bureau of Meteorology. This data is presented in Table 2.3 for the relevant Annual Exceedance Probabilities.

Table 2.3 IFD Design Rainfall Intensities (mm/hr)

Duration	Annual Exceedance Probability (AEP)					
	18%	10%	5%	2%	1%	0.2%
10 min	65.4	81.0	99.6	126.6	148.8	206.4
20 min	45.3	56.4	69.3	88.2	104.1	144.9
45 min	27.2	34.0	41.9	53.3	63.1	88.4
1 hour	22.3	27.9	34.4	43.8	51.8	72.7
1.5 hour	16.7	20.9	25.7	32.7	38.6	54.2
3 hour	10.1	12.5	15.3	19.3	22.7	31.7
6 hour	6.0	7.4	8.9	11.2	13.2	18.2
12 hour	3.5	4.3	5.2	6.6	7.7	10.5

IFD data was also sourced separately for Saltia Creek, Sandy Creek and Mundallio Creek catchments.

2.4.3 Impact of Climate Change

The climate of South Australia is changing. Temperatures have been increasing and rainfall has been declining. There have been longer, hotter and more frequent heatwaves, an increase in dangerous fire weather, an increase in the intensity of heavy rain events and rising sea levels along our coast (DEW, 2022). Within a stormwater management context, potential future changes in rainfall patterns are of particular interest, as these result in changes to levels of flood protection, stormwater drainage performance and the availability of stormwater for harvesting and reuse.

The approach for modelling climate change for this SMP has been developed with reference to the project brief, the methodology outlined in ARR 2019 and *Guide to climate projections for risk assessment and planning in South Australia 2022* (DEW, 2022). In accordance with the project brief, this study will consider a climate planning horizon to the year 2090.

ARR 2019 provides an approach for addressing the risks posed by climate change in projects and decisions that involve estimation of design flood characteristics. It draws on the most recent climate science, particularly the release of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013) as well as climate change projections for Australia (CSIRO and Bureau of Meteorology, 2015).

The procedure relies on the Climate Futures web tool developed by the CSIRO where projected changes from Global Climate Models (GCMs) can be explored for fourteen 20-year periods based on four Representative Concentration Pathways (RCPs) for greenhouse gas and aerosol concentrations that were used to drive the GCMs. The pathways are provided by regional

Natural Resource Management (NRM) clusters (divided into 11 regions nationally), with the Port Augusta study area falling within the Southern and South-Western Flatlands sub-cluster. ARR 2019 recommends the use of RCPs 4.5 and 8.5 (medium and high concentration pathways, respectively) for rainfall intensity impact assessment. ARR 2019 recommends using the projected annual mean surface temperature change to calculate adjustments to the projected rainfall intensity using the following equation:

$$I_p = I_{ARR} \times 1.05^{T_m}$$

Where I_p is the projected rainfall intensity, I_{ARR} is the design rainfall intensity for current climate conditions, 1.05 is the assumed temperature scaling based on the approximately exponential relationship between temperature and humidity, and T_m is the temperature at the midpoint of the selected class interval.

The recommended T_m can be accessed from the ARR Data Hub for specific locations. The following temperature increases, and resultant climate change factors were accessed from the Data Hub for Pot Augusta:

- RCP 4.5 – 2.067°C increase, 10.6% increase to IFD data
- RCP 8.5 – 4.318°C increase, 23.5% increase to IFD data

For selection of an appropriate RCP pathway scenario, *DEW 2022* recommends decision makers consider the lifetime of the assessment being undertaken and the level of risk associated with the decision. For this study, outcomes and drainage strategies will be implemented over both the short term (i.e. within 10 years) and long term (expected life cycle of new infrastructure in the order of 50 – 100 years). *DEW 2022* also states that:

- *Observed temperature changes in Australia have been tracking towards the upper end of the range of temperature change projected in model simulations that include the currently observed conditions of greenhouse gases.*

As such, given observed trends, and the expected life cycle variability of planned outcomes (short to long-term), RCP8.5 (high emissions) was selected as the most appropriate scenario to be adopted for this study.

The Intensity-Frequency-Duration data is shown in Table 2.4 with the 2090 RCP8.5 emissions scenario climate change factor (+23.5%) applied. The modelling of proposed drainage infrastructure will utilise these rainfall intensities.

Table 2.4 IFD Design Rainfall Intensities (mm/hr) with Climate Change Factor (2090)

Duration	Annual Exceedance Probability (AEP) RCP 8.5					
	0.2EY	10%	5%	2%	1%	0.2%
10 min	80.8	100.0	123.0	156.4	183.8	254.9
20 min	55.9	69.7	85.6	108.9	128.6	178.9
45 min	33.6	42.0	51.7	65.8	77.9	109.2
1 hour	27.5	34.4	42.5	54.1	64.0	89.8
1.5 hour	20.6	25.8	31.7	40.4	47.7	66.9
3 hour	12.5	15.4	18.9	23.8	28.0	39.1
6 hour	7.4	9.1	11.0	13.8	16.3	22.5
12 hour	4.3	5.3	6.4	8.1	9.5	13.0

Referring to the *Guide to climate projections for risk assessment and planning in South Australia 2022* (Department for Environment and Water, 2022) for Port Augusta showed that annual rainfall is predicted to decrease. Projections for Port Augusta for RCP scenarios 4.5 and 8.5 are shown in Table 2.5.

Table 2.5 Predicted Changes to Annual Rainfall (2090) (DEW 2022)

RCP Scenario	Projected Annual Rainfall Change (%)
4.5	-17
8.5	-35

Average annual rainfall reduction of 17% and 35% for RCPs 4.5 and 8.5 respectively is predicted. In the context of the stormwater harvest yield and water quality modelling for this SMP, it is proposed to modify the existing rainfall record for the Port Augusta study area (or data from a suitable nearby gauge) based on the 2090 RCP 8.5 scenario. This will result in a 35% reduction to the mean annual rainfall.

The impact of climate change on soil moisture, particularly within the study area, is unclear. However, it is expected that soil moisture will decrease as temperature increases, which is forecasted over the planning horizon for this Stormwater Management Plan.

2.4.4 History of Flooding and Drought in Port Augusta

In its history since settlement, records show Port Augusta and surrounding areas were repeatedly subjected to flooding of varying severity. *Floods in South Australia (1836-2005)* (Bureau of Meteorology, 2006) records particularly severe flood events occurring in 1877, 1884, 1921, 1934, 1989, and 1992. In addition, it documents flooding of varying severity in Port Augusta in 1870, 1879, 1882, 1884, 1886, 1887, 1935, 1937, 1943, 1944, 1946, 1968, 1972, and 1987, 1998, 1999 and 2000.

The most recent flood events occurred in January and September of 2022. The first event occurred on 31st of January 2022 was reported with 51.6 mm of rain fallen between 8 and 9 pm, resulting in widespread flooding of the Augusta Highway/Victoria Parade and Frome Street catchments (see Figure 2.9 below). Analysis of IFD charts indicate a storm of this intensity is roughly equivalent to a 1% AEP event. Further, on the 7th of September 2022, 21 mm of rain was reported to have fallen within 30 minutes, also causing flooding throughout the catchment. Analysis of IFD charts indicate this was likely equivalent to a 10% AEP event.

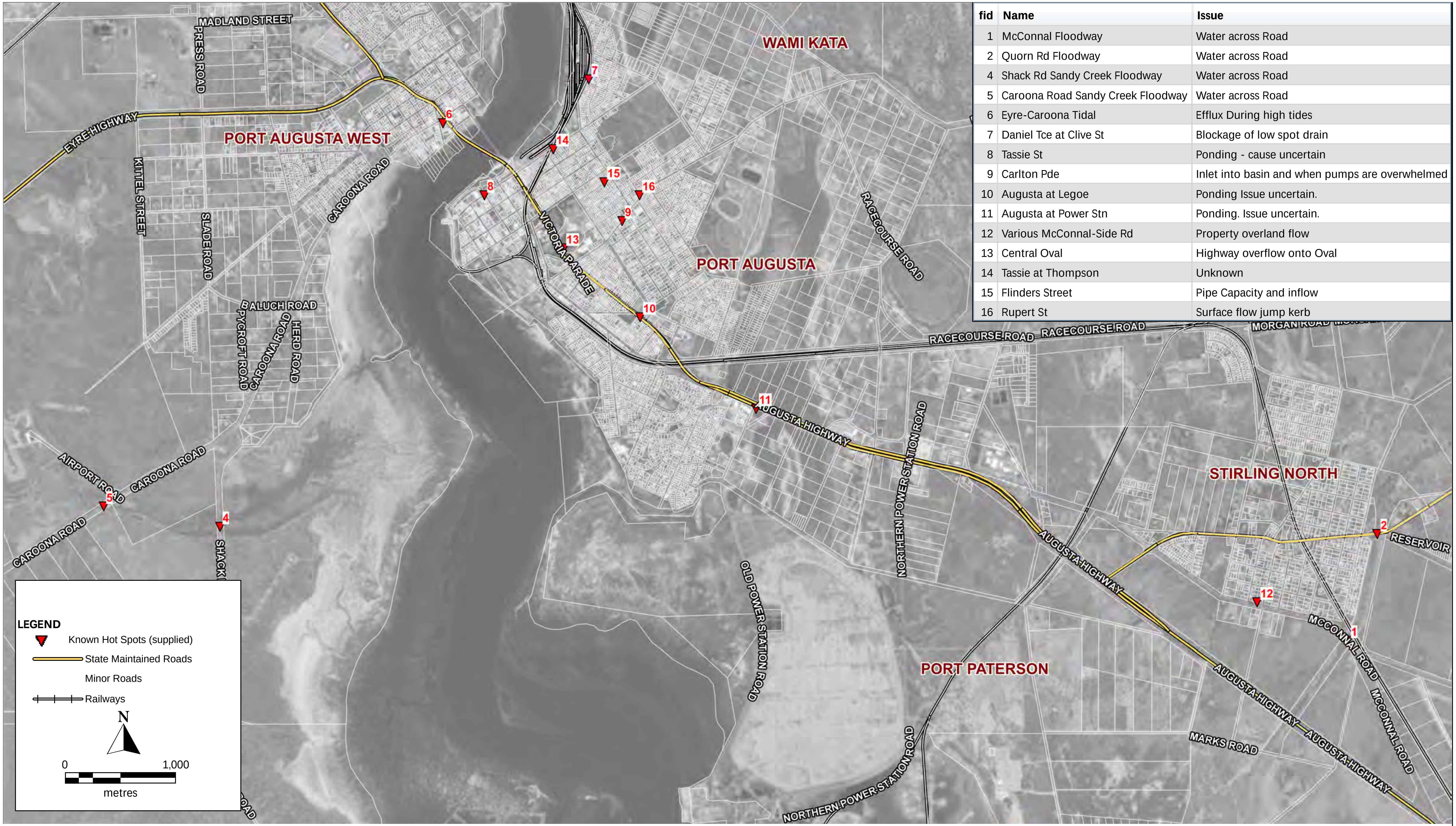
Port Augusta was hit with more than 51mm of water within an hour on Monday night. Picture: Catherine Magay

Figure 2.9 2022 Flooding on Victoria Parade (Source: Cosenza, E [2022], news.com.au)

Council has supplied a GIS-referenced list of flooding related ‘hot-spots’ in Port Augusta. These name Tassie Street, Carlton Parade, and Victoria Parade, as well as Flinders Street and the junction of Caroona Road and Eyre Highway of particular concern. Other identified problem areas are McConnal Road in Stirling North as well as Saltia Creek crossing Quorn Road and McConnal Road and Sandy Creek crossing Caroona Road and Shack Road. Figure 2.10 provides an overview of the flooding hotspots known to Council.

Besides the periods of intense rainfall, Port Augusta has also been impacted by a number of droughts including:

- The great 1860s drought (1864-1866);
- The Federation drought (1895 to 1902);
- The 1914 to 1915 drought;
- The World War II drought (1937 to 1945);
- The 1965 to 1968 drought;
- The 1982 to 1983 drought;
- The Millenium drought (1997 to 2009); and
- The 2017 to 2019 drought.



fid	Name	Issue
1	McConnal Floodway	Water across Road
2	Quorn Rd Floodway	Water across Road
4	Shack Rd Sandy Creek Floodway	Water across Road
5	Caroona Road Sandy Creek Floodway	Water across Road
6	Eyre-Caroona Tidal	Efflux During high tides
7	Daniel Tce at Clive St	Blockage of low spot drain
8	Tassie St	Ponding - cause uncertain
9	Carlton Pde	Inlet into basin and when pumps are overwhelmed
10	Augusta at Legoe	Ponding Issue uncertain.
11	Augusta at Power Stn	Ponding. Issue uncertain.
12	Various McConnal-Side Rd	Property overland flow
13	Central Oval	Highway overflow onto Oval
14	Tassie at Thompson	Unknown
15	Flinders Street	Pipe Capacity and inflow
16	Rupert St	Surface flow jump kerb

Data Sources:
Bing (Aerial Photo)
Data SA (State Maintained Roads, Land Use)

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FIGURE 2.10 - KNOWN HOT SPOTS

2.4.5 Available Hydraulic Data

The Water Data SA website, operated by the Department for Environment and Water (DEW), was accessed to determine the availability of hydrometric data within the study area. While a flow gauge does exist on Saltia Creek (A5080503) no flow data appears to ever have been recorded at this site since its inception in 1983. No other flow gauges were found within any of the other upstream catchments. Similarly, there was no hydrometric data available for the drainage networks within the study area.

2.4.6 Tide and Sea Level Data

Port Augusta is situated at the top of Spencer Gulf and experiences a relatively high tidal range compared to other ports in the gulf. Information on standard tidal relationships was sourced from the Department for Environment (DEW) Water Coast Protection Branch (CPB) and Department for Infrastructure and Transport (DIT) 2020 tide tables.

Tide heights above datum (and converted to AHD) are summarised in the table below for 2020. According to the tide tables the chart datum for Port Augusta to AHD is -2.03m.

Table 2.6 DIT Tide Table Attributes (2020)

Tide attribute	Heights above chart datum	Height to AHD
HAT	3.9	1.87 mAHD
MHHW	3.1	1.07 mAHD
MLHW	1.9	-0.13 mAHD
MSL	1.8	-0.23 mAHD

Storm tide data and Sea Level Rise (SLR) predictions were sourced from DEW CPB (pers. comm. Steve Stefanidis), as follows:

- 1% AEP storm tide: 3.15 mAHD.
- SLR predictions CPB utilises for Port Augusta are:
    - SLR to year 2050: 0.3m
    - SLR to year 2100: 0.5m

Further, it should be noted the CPB recommended Finished Floor Level (FFL) for new development (to year 2050) in Port Augusta is 3.75 mAHD (noting 0.25m freeboard is added to site levels). This consists of:

- 1% AEP tide: 3.15 mAHD
- SLR to year 2050: 0.3 m
- Wave setup: 0.1 m
- Wave runup: 0.20 m

2.4.7 Surface Water and Groundwater Interaction

No studies or information were made available identifying any interaction between surface water and groundwater in Port Augusta. However publicly available drillhole log information from the WaterConnect website suggests the presence of numerous boreholes throughout the study area. Analysis of borehole information indicates variation of Standing Water Level (SWL) depth throughout the study area, with depths of less than 2.0m below surface in the vicinity of the coastline as well as Bird/Pink Lakes and up to 26.0m below surface level further inland in the vicinity of Stirling North. This indicates a connection between areas of low elevation near the sea/lakes with shallow SWL to areas of higher elevation with deeper SWL.

While there are areas with shallow groundwater, these are located in a narrow strip along Spencer Gulf and the lakes (i.e. generally areas with surface levels lower than 3.0 mAHD). Outside these areas SWLs are relatively deep as the ground surface level rises. Groundwater is therefore considered unlikely to meaningfully impact surface water from a stormwater management perspective outside of these low-lying locations.

2.5 Stormwater and Flood Infrastructure

2.5.1 Existing Infrastructure

Port Augusta City Council maintains records of existing stormwater infrastructure, which have been provided for this Stormwater Management Plan. This information is in the form of GIS point and line layers containing the stormwater asset data.

Using the supplied GIS data, together with aerial photography, the DEM and information gained on the site visit, stormwater pit and stormwater pipe layers were created. Figure 2.11 below provides an overview of the location, extent and age of existing stormwater infrastructure within the study area.

There are two coastal protection levees that have been constructed to protect the township from storm surges and tidal movements due to the high tidal range experienced at Port Augusta. The westside foreshore levee bank was built in the 2010 to protect the northern portion of Port Augusta West and the eastern foreshore levee was constructed in the 1990’s. Both levees are constructed to a level of approximately 2.8 mAHD. Stormwater outlets through the levees are equipped with tidal flap gates to prevent backflow and seawater ingress into the study area from high-tide events. The coastal protection levee alignment is shown in Figure 2.11.

A levee system with a length of 5km on both sides of Saltia Creek was constructed to realign the creek to the eastern side of Stirling North and protect the town from outbreaks in high-flow events. The DEM indicates the levee is approximately 2m high. The alignment is shown in Figure 2.11. A summary profile of all existing infrastructure is provided in Table 2.7.

Table 2.7 Existing Stormwater Infrastructure

Asset Class	Description	Quantity
Pipe	150mm dia	142m
	200mm dia	107m
	225mm dia	450m
	300mm dia	9903m
	375mm dia	6513m
	450mm dia	4042m
	525mm dia	2045m
	600mm dia	2190m
	675mm dia	2623m
	750mm dia	585m
	825mm dia	263m
	840mm dia	56m
	900mm dia	584m
	1050mm dia	1186m
	1200mm dia	27m
	2000mm dia	24m
Box Culvert	Size varying	1989 m
Nodes	Single Side Entry Pit	333
	Double Side Entry Pit	230
	Triple Side Entry Pit	20
	Quadruple Side Entry Pit	8
	Grated Inlet Pit	36
	Tidal Gates	40
Stormwater Pumps	Seaview Road Basin	3
	Frome Street Basin	2
	Central Oval	2
	Forster Street	2
	Flinders Place Subdivision	2
	Flinders Terrace	2
	Dunn Place	1
	Sunman Road	1
	Cleary Street	1
	Downey Close Basin	1
	Wharflands Esplanade	1
GPT		6
Detention basins	Seaview Road	1
	Frome Street	1
	Downey Close	1
	Tilling Road	2
	Irons Road	3
	Shirley Street	1
Levees	Coastal	6 km
	Saltia Creek	5 km

2.5.2 Stormwater Asset Age and Condition

Council's GIS stormwater asset database includes an estimate of year of construction. The construction years of the stormwater assets generally vary from 1964 to 2022.

Most existing stormwater assets in central Port Augusta were constructed from late 1970s to early 1980s, with the latest upgrade in the town centre occurring in 2011.

The main stormwater network in Port Augusta West was constructed from 1974 to 1980 with some later additions in the late 1980s.

In Stirling North the original stormwater network was constructed in the 1980s with some later additions in 2004 and 2014.

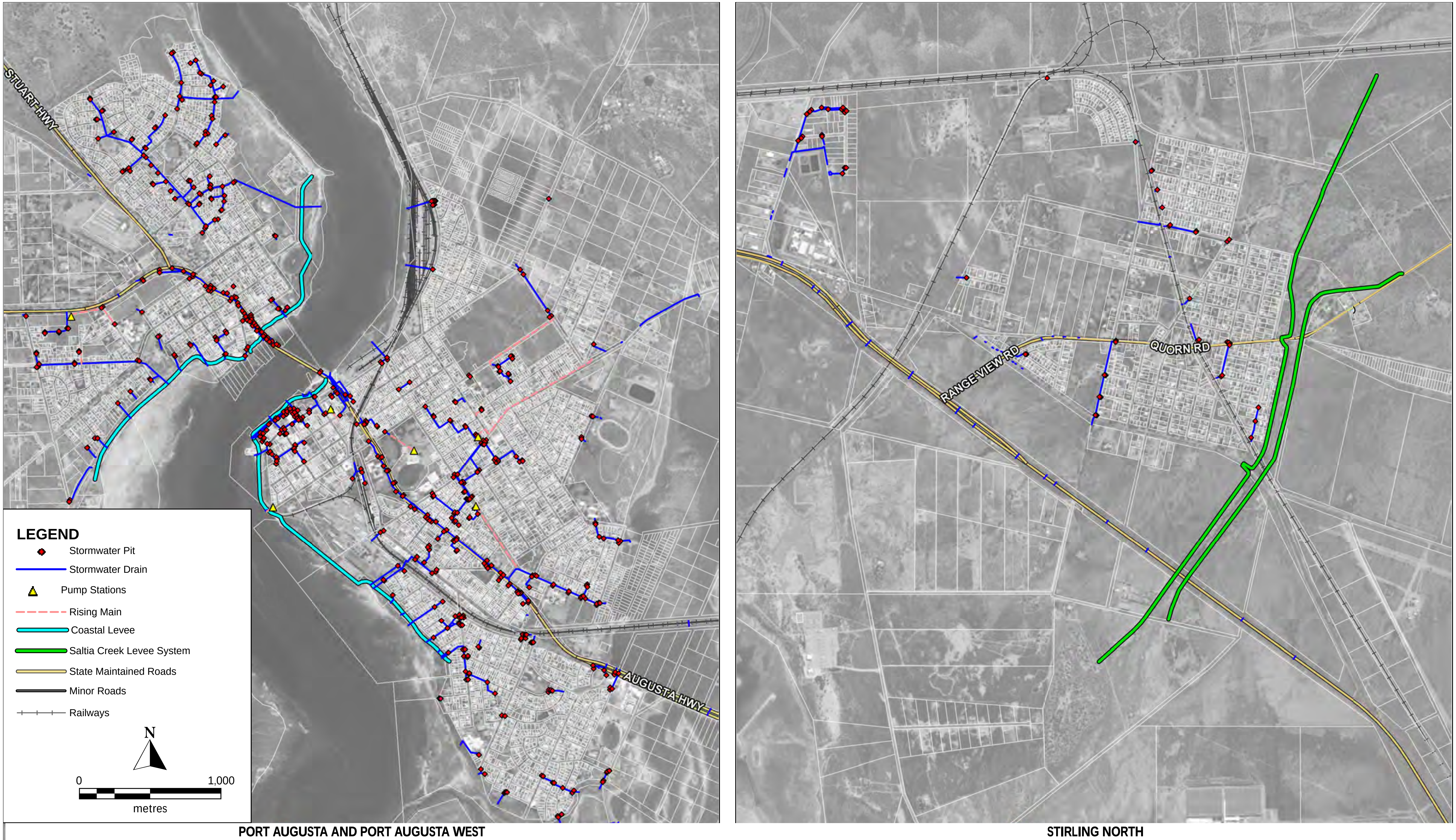
Pockets of newer (post 2014) stormwater are scattered around the study area, generally occurring in areas of new greenfield land development.

2.5.3 Stormwater Asset Management and Planning

Council has developed and relies on a number of asset management plans which provide a guide for the planning and maintenance of Council's stormwater assets. These plans include:

- The Stormwater Asset Management Plan (Port Augusta City Council, 2021).
- Infrastructure Asset Management Plan (Tonkin Consulting, 2016)
- Infrastructure Guidelines SA (IPWEA SA, 2020); and
- Infrastructure Development Guidelines for Land Subdivision & Major Infrastructure Proposals Procedure (Port Augusta City Council, 2022);

Generally key elements of the plans identify the desired level of service, likely future demand, life cycle management and performance monitoring in relation to stormwater (and other Council assets).



Data Sources:
Bing (Aerial Photography)
Data SA (Roads and Railways)

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FIGURE 2.11 - EXISTING STORMWATER INFRASTRUCTURE

2.6 Environmental Values

2.6.1 Water Quality

The primary downstream receiving waterbody is the Upper Spencer Gulf, a protected marine park, and therefore important that appropriate consideration is given to pollutants in runoff leaving the study area. The study area is made up of both urban and rural land uses, each of which have various source factors which can impact the quality of stormwater runoff, such as:

- Industrial and Commercial Activities: Urban areas often host industries and commercial enterprises that discharge various pollutants and sediments into stormwater systems.
- Residential Practices: Household activities such as improper disposal of household chemicals, pet waste, and use of fertilizers/pesticides.
- Agricultural Practices: Farming activities introduce sediments, nutrients (from fertilizers), and chemicals (from pesticides).
- Soil Erosion: Poor land management practices, including land clearing, can result in soil erosion. This eroded soil carries sediments, nutrients, and contaminants.
- Livestock Farming: Animal waste from livestock farms contains pathogens and nutrients that can contaminate water bodies if not managed properly.

For the purposes of this study, water quality from urban areas discharging directly into the watercourses, lakes and marine environments will form the main focus. Typical stormwater pollutants which will be considered in this SMP include:

- Total suspended solids (TSS), commonly clay, gravel, sand and silt, but also including algae and decomposing organic material;
- Total phosphorus (TP), with common sources including sewage, intensive livestock industries, soil, fertilisers and detergents;
- Total nitrogen (TN), with common sources including food processing industries, sewage, intensive livestock industries, soil and fertilisers; and
- Gross pollutants, typically including rubbish, plant debris and coarse sediment.

The presence of total suspended solids in watercourses can result in cloudier water, affecting the oxygen levels within the water and potentially harming animals and plants living within it, as well as humans if the water is consumed. High levels of total phosphorus and total nitrogen often cause blue-green algal blooms, which can produce harmful toxins to humans through contact or consumption. Gross pollutants such as litter can be harmful to receiving waters if not screened, with animals potentially consuming plastics or other rubbish.

2.6.2 Threatened/Sensitive Ecological Communities

2.6.2.1. Upper Spencer Gulf

Coastal areas of Port Augusta form part of the Upper Spencer Gulf Marine Park (USGMP). The marine park covers an area of 1602 square kilometres, extending from the southern end of the Whyalla-Cowleds Landing Aquatic Reserve on the western side of Spencer Gulf to Jarrold Point on the eastern shore, and northwards to the uppermost reaches of Spencer Gulf beyond Port Augusta (DEWNR 2016). *The Nearshore Marine Aquatic Ecosystem Condition Reports* (Environment Protection Authority, 2018) also defines the marine park as part of the Winninowie biounit.

Existing ecological values of the USGMP are summarised in *Baseline and predicted changes for Upper Spencer Gulf Marine Park (DEWNR 2016).* That report summarises and maps the benthic habitats of the USGMP, as presented in Figure 2.12 below.

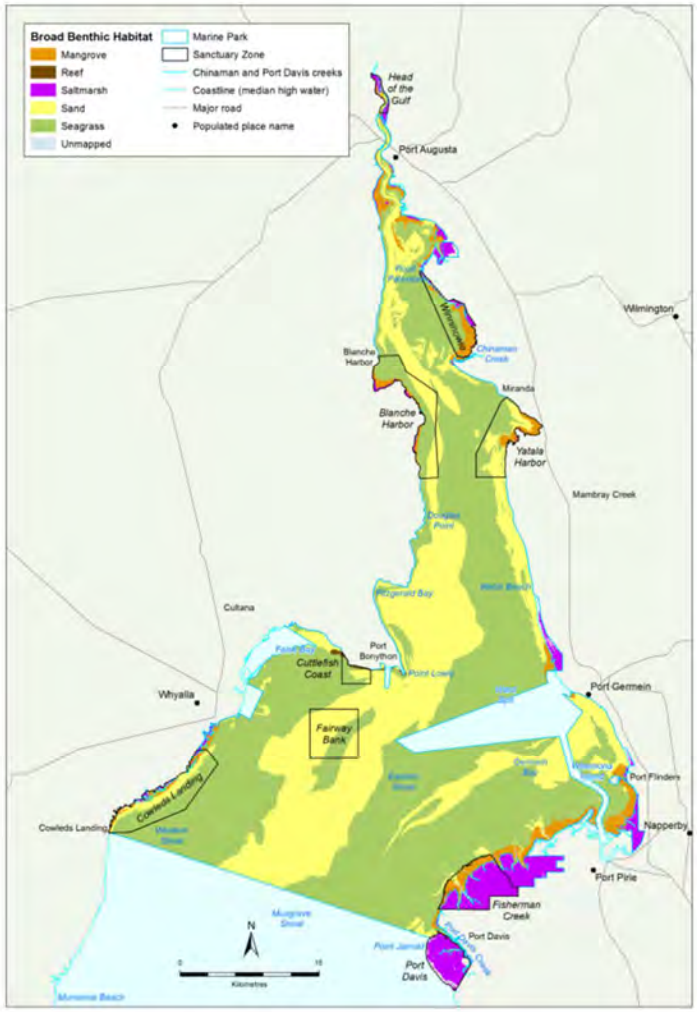


Figure 6. Benthic habitats of the Upper Spencer Gulf Marine Park based on fine and broad scale mapping. Source: DEWNR (2015c, d, e), Miller et al. (2009), Edyvane (1999a, b).

DEWNR Technical report 2016/20 15

Figure 2.12 USGMP Benthic Habitats (DEWNR, 2016)

The figure above indicates the upper gulf is mainly dominated by widespread seagrass meadows and bare sand. In the vicinity of Port Augusta, the gulf becomes very narrow, with a mix of mangrove forest near the southern shores of the study area (see Figure 2.13 below), bare sand in the central portion of the gulf and narrow strip of sea grasses closer to shore.

The Nearshore Marine Aquatic Ecosystem Condition Reports (Environment Protection Authority, 2018) indicates areas bare of seagrass is possibly due to external disturbance such as boat movements. That study has summarised the threats facing the Winninowie marine environment which mainly include agricultural runoff, septic tanks and industrial discharges. Urban runoff was ranked relatively low on the threat score rankings due to relatively the low rainfall of the area. It should be noted this report was published prior to closure of power station Playford B (i.e. industrial discharges). The report notes that closure of the power station will return the temperatures of the far northern gulf to a more natural regime, which is likely to reduce the stress on the ecosystem.

Due to its relative shallow conditions and the distance to the mouth of the Spencer Gulf, the upper gulf makes for a unique marine habitat with increased water temperatures and salinity levels. EPA 2018 found the biounit overall was in fair condition.

Figure 2.13 Mangrove Forest along Spencer Gulf

2.6.2.2. Bird Lake and Pink Lake

Bird Lake and Pink Lake form the Port Augusta salt-lake system, situated to the east of the city centre. The lakes are bisected by the Augusta Highway (National Highway A1) and Transcontinental Railway embankments. The lakes are interconnected through the embankments via a network of small culverts which eventually discharge to Spencer Gulf via a set of culverts at Power Station Road. Unlike most other stormwater outlets in Port Augusta, the lake outlets to Spencer Gulf are not equipped with non-return valve/flap gates and therefore allow ingress of seawater into the lakes during times of high tide. Based on lake-bed levels derived from the DEM and tidal information (see Section 2.4.6), this is likely to occur only during times of relatively high tide, with the lakes mostly otherwise dry.

The lakes receive stormwater discharge from both urban and rural catchments, with Mundallio Creek discharging into the northern tip of Pink Lake. Several relatively large urban stormwater systems discharge into the lakes, including those at Seaview Road, Power Crescent and Carlton Parade.

Extensive remediation work was recently completed on Bird Lake. The natural tidal lake was used as overflow for ash disposal areas during the operation of the Augusta Power Station Playford B. After the closure of the coal plant the lake returned to its natural state with periods where it dried out, causing foul odours from decaying algae. To reduce the odour and increase attractiveness of the area a rehabilitation project was started to bury the algae under a soil cap and introducing native vegetation around the edges of the lake (Port Augusta City Council 2023).

Figure 2.14 Mixed Vegetation at Bird Lake outlet towards Spencer Gulf

2.6.3 Watercourse Assessment

A site visit was undertaken on 13-14 September 2023 to assess the catchment and condition of the major watercourses through the study area. Saltia Creek (at Stirling North), Mundallio Creek (at Racecourse Road) and Sandy Creek (at the Shack Road), were all inspected.

2.6.3.1. Saltia Creek

Saltia Creek was assessed as a predominantly dry channel with a wide floodplain and uncontrolled vegetation. The vegetation consists of mostly grasses and shrubs with scattered trees varying in size. Adjacent to Stirling North the floodplain is restricted by a constructed levee and diversion channel. As shown in Figure 2.11 the levee system starts just north of Stirling North and follows on both sides of Saltia Creek past Augusta Highway protecting Stirling North and surrounding land for approximately 5km. This channel and levee diversion has realigned the creek from its natural flow path which once would have passed through the centre of Stirling North. Rather, the creek is directed to the south under Augusta Highway (via culverts), before discharging into a wide, flat floodplain in the vicinity of Sundrop Farms.

The creek also passes over Quorn Road and McConnal Road, both of which are floodways and reportedly impassable during times of flood. Rudimentary inspection of the levees indicated that they are in relatively good condition, however reports from Council indicate damage in some sections from burrowing rabbits.

There appears to be little ecological value within the realigned sections of the channel adjacent to Stirling North, with the realignment mainly used mainly for utilitarian purposes (i.e. flood prevention). Upstream of the study area however the creek originates in the western side of the Flinders Ranges with upper slopes within the Mount Brown Conservation Park.

Figure 2.15 Saltia Creek channel at the western levee bank shown in foreground

2.6.3.2. Sandy Creek

Sandy Creek is another predominantly dry creek with a wide channel. The creek passes close to the southern end of the Port Augusta Airport runway before passing over both Caroona Road and Shack Road. It is understood both roads are impassible during times of flood.

Inspection of the creek channel at Shack Road indicated the channel is heavily vegetated, consisting mostly of shrubs and grasses. Further upstream aerial photography indicates the vegetation consists of mainly bushes, shrubs and trees varying in size.

2.6.3.3. Mundallio Creek

Similar to Saltia Creek, Mundallio Creek originates from the western slopes of the southern Flinders Ranges. Aerial photography indicates the main creek channel is well defined in the upper reaches but diminishes in size as it approaches Port Augusta. The creek appears to branch out into a wide floodplain downstream of the ranges, particularly downstream of the railway crossing. Inspection of the creek at Racecourse Road indicates it is a relatively small channel (relative to Saltia Creek and Sandy Creek) with scarce and low-lying vegetation of shrubs and grasses within an arid landscape.

2.6.4 Areas of Environmental Importance

The Upper Spencer Gulf Marine Park as part of the Winninowie biounit as described in 2.6.2 with its unique conditions is identified of environmental importance to the region. Another area of environmental importance is the Augusta Lakes salt-lake system including Pink Lake and Bird Lake.

Within the Miranda study area is Winninowie Conservation Park as another location of environmental importance to the region.

2.6.5 Environmental Flows

Saltia Creek, Mundallio Creek and Sandy Creek are all ephemeral watercourses, often dry without a consistent base flow. All creeks passing through the study area are at their most downstream extent, and as such there is no requirement for maintenance of environmental flows prior to discharge into Spencer Gulf.

2.7 Social, Socio-Economic and Cultural Values

2.7.1 Population and Demographics

According to the 2021 census, Port Augusta and its surrounds had a population of 13,515 people. This made it the fourth largest urban area outside of Adelaide after Mount Gambier, Whyalla and Port Lincoln. 83.4% of residents were born in Australia and 20.8% were Aboriginal or Torres Strait Islander.

The most prevalent employment was community and personal service workers (17.7%), professionals (14.9%), technicians and trades workers (14.0%), labourers (13.1%), clerical and administrative workers (11.1%), sales workers (9.3%), machinery operators and drivers (9.3%), and managers (8.3%).

2.7.2 Cultural

The Nukunu, Kujani, Kokatha and Barngarla Aboriginal people have traditional associations (which may include Aboriginal traditional fishing) with the Upper Spencer Gulf region.

DENR (2010) noted that Aboriginal campsites have been located within Winninowie Conservation Park and a further ten campsites have been recorded nearby. Constructed fish traps have been recorded along the shores of the gulf.

The South Australian Heritage Register contains descriptions of local, national and world heritage places in South Australia which are protected under legislation. Fourteen Heritage Places are identified in Port Augusta.

2.7.3 Transport

Port Augusta is at the top of Spencer Gulf, a natural barrier to land transport, leading to the city being considered a ‘crossroads’, at the junction of major road and rail links.

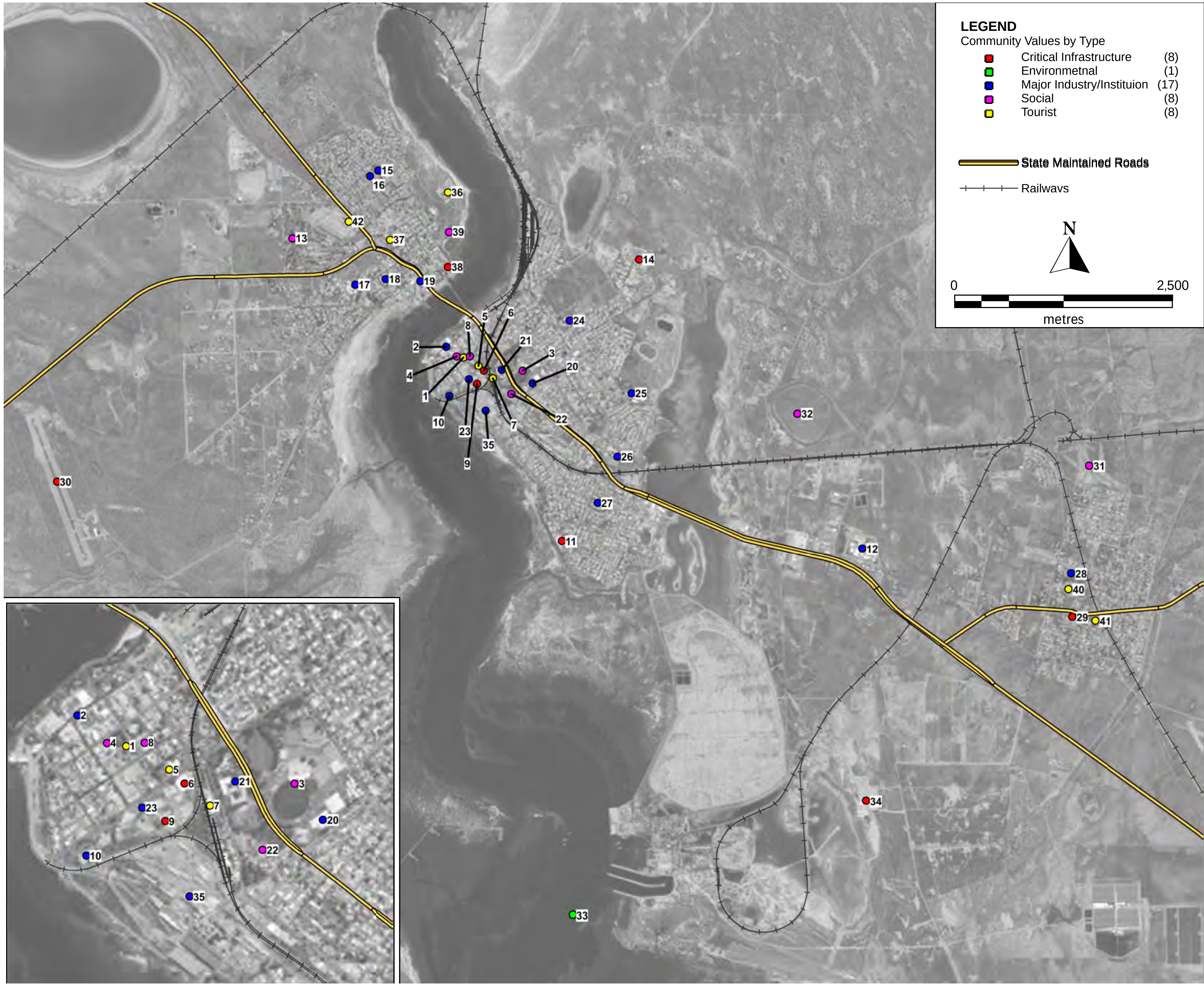
Port Augusta is located at the eastern end of the Eyre Highway to Perth and at the northern end of the Augusta Highway to Adelaide. It is situated at the southern end of the Stuart Highway to Darwin. Port Augusta also forms the junction of major transcontinental rail links, with connections to Perth and Sydney (Indian Pacific) and Adelaide and Darwin (Ghan). Virtually all road and rail traffic across southern Australia passes through Port Augusta across the top of Spencer Gulf.

2.7.4 Values Mapping

A map has been prepared summarising locations within the study area of social, socio-economic and cultural importance, and is shown in Figure 2.16. This includes major industries and institutions, critical infrastructure, tourist, trade and social facilities and routes.

2.8 Development Policy

A map of the planning and design code zones within the study area has been prepared and is shown in Figure 2.17. Development Policy show large swathes of residential surrounding Port Augusta, Port Augusta West and Stirling North surrounded by areas of rural living. Industrial dominates the southern portion of the study area and to the west of Stirling North. The salt lakes and coastline have environmental constraints applied (waterbodies are outlined and shaded grey in Figure 2.17 for reference). Outskirts of the town are zoned for primary production.



ID	Name	Comment
1	Historical Town Centre	Tourist
2	Port Augusta CBD	Major Industry/Instituion
3	Central Oval and Clubhouse	Social
4	Port Augusta Cultural Centre - Yarta Purtli	Social
5	Wadlata Outback Centre	Tourist
6	Port Augusta CFS	Critical Infrastructure
7	Pichi Richi Railway Station	Tourist
8	Port Augusta Bowling Club	Social
9	Port Augusta Police Station	Critical Infrastructure
10	Port Augusta Court	Major Industry/Instituion
11	Port Augusta Hospital	Critical Infrastructure
12	Githabul Port Augusta Prison	Major Industry/Instituion
13	Port Augusta Golf Club	Social
14	Port Augusta SES	Critical Infrastructure
15	Flinders View Primary School	Major Industry/Instituion
16	Port Agusta Special School	Major Industry/Instituion
17	Caritas College	Major Industry/Instituion
18	Port Augusta West Primary School	Major Industry/Instituion
19	Port Augusta West CBD	Major Industry/Instituion
20	Tafe SA	Major Industry/Instituion
21	Port Augusta Secondary School	Major Industry/Instituion
22	Port Augusta Youth Centre	Social
23	Adelaide Rural Clinical School (The Univrsity of Adelaide)	Major Industry/Instituion
24	Carlton School	Major Industry/Instituion
25	Augusta Park Primary School	Major Industry/Instituion
26	Seaview Christian College	Major Industry/Instituion
27	Willsden Primary School	Major Industry/Instituion
28	Stirling North Primary School	Major Industry/Instituion
29	Stirling North CFS	Critical Infrastructure
30	Port Augusta Airport	Critical Infrastructure
31	Sterling North Golf Club	Social
32	Port Augusta Racing Club	Social
33	East Side Snapper Grounds	Environmetnal
34	Davenport Substation	Critical Infrastructure
35	Port Augusta Freight Yards	Major Industry/Instituion
36	Shoreline Caravan Park	Tourist
37	Discovery Park	Tourist
38	Port Augusta Coast Guard	Critical Infrastructure
39	West Augusta Football Club	Social
40	Augusta Caravan Park	Tourist
41	Fuller Views Cabin Park	Tourist
42	Bentley's Cabin Park	Tourist

Data Sources:
Heritage SA (Heritage Sites)
Data SA (Infrastructure)

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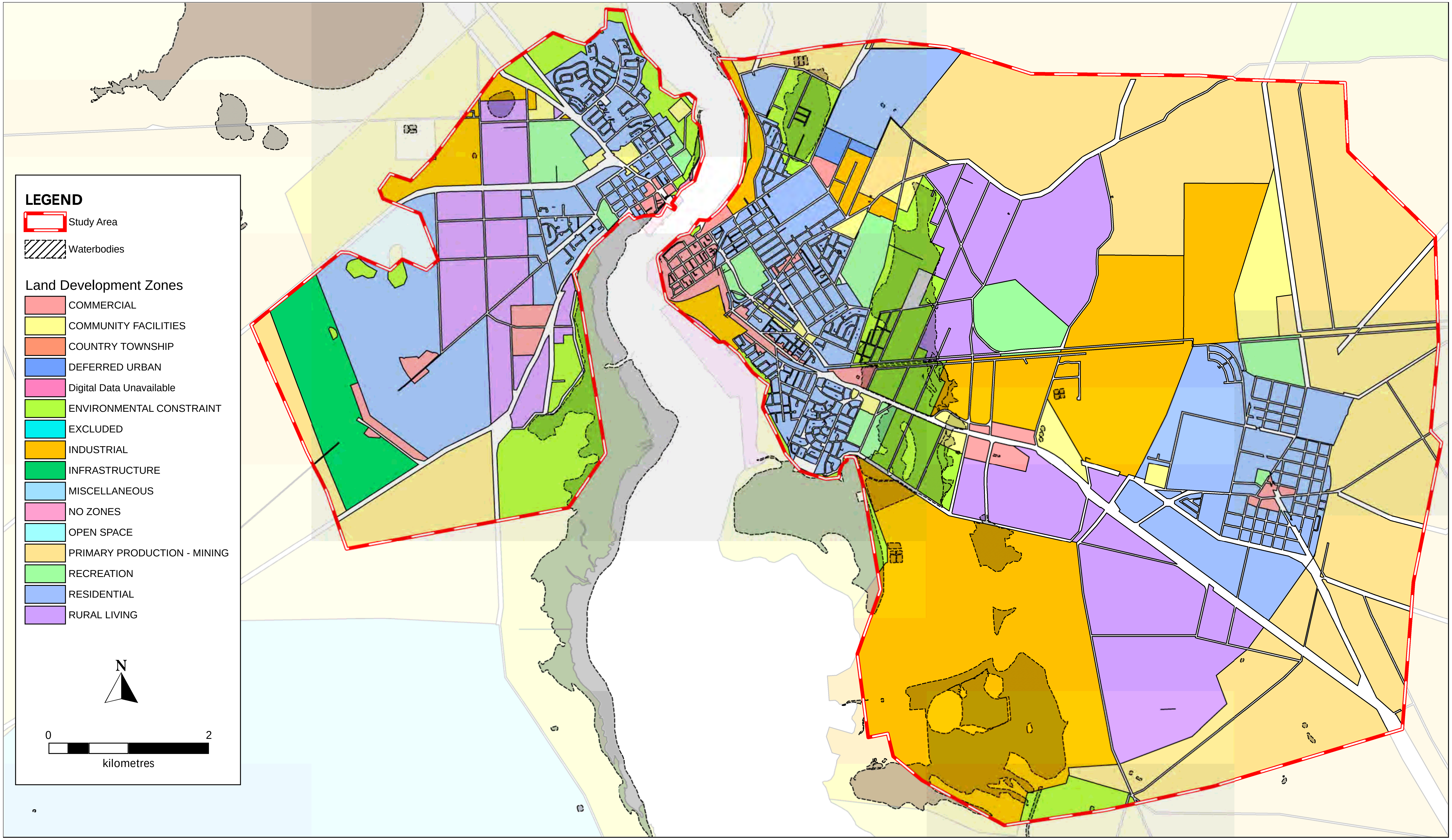
FIGURE 2.16 - SOCIAL, SOCIO-ECONOMIS AND CULTURAL VALUES



Data Sources:
Bing (Aerial Photo)
Data SA (State Maintained Roads, Land Use)

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PORT AUGUSTA STORMWATER MANAGEMENT PLAN

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FIGURE 2.17 - PORT AUGUSTA DEVELOPMENT ZONES

3 Modelling Basis Summary

A modelling basis summary has been prepared, describing the intended modelling approach to be used to identify stormwater risk and issues within the study area. This summary outlines the key methodologies and assumptions proposed for use in the development of this Stormwater Management Plan.

3.1 Selection of Modelling Software

3.1.1 Rural Hydrology

For the large external rural catchments associated with Saltia Creek, Mundallio Creek and, Sandy Creek, a RORB model will be prepared to generate flow hydrographs.

RORB is a "general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce runoff hydrographs at any location. It can also be used to design retarding basins and to route floods through channel networks." (Laurenson et al, 2010).

The RORB models will be created using the MiRORB MapInfo tool. Sub-area boundaries will be delineated using regionally available topographic information, and nodes placed at all areas of interest and the junction of any two reaches. All reach types will be set to natural reaches, and the impervious fraction for each sub-area set to an appropriate level as determined from inspection of aerial photography.

As there are no flow gauges within the key upstream catchments, RORB model parameters will be selected that are both representative of the region and that produce peak flows that 'fit', within reason, to design peak flow estimates established at other gauges in the region. The suitability of the model will also be checked against the Regional Flood Frequency Estimation (RFFE) model published by Australian Rainfall and Runoff.

Temporal patterns will be determined through a Monte Carlo simulation, where thousands of combinations of initial loss factor, temporal pattern and storm duration will be modelled to determine a suitable peak flow hydrograph.

The future development scenario will be based on ultimate development predicted to the year 2100 based on spatial extents as currently delineated by the Planning and Design Code zoning.

3.1.2 Urban Hydrology

For smaller urban catchments within Port Augusta, Port Augusta West, Stirling North and rural catchments not associated with major watercourses, a DRAINS model will be developed to generate flow hydrographs.

As described in the model documentation (Watercom, 2018), DRAINS is a multi-purpose Windows program for designing and analysing urban stormwater drainage systems and catchments. DRAINS can model drainage systems of all sizes, from small to very large (up to 10 km² using multiple sub-catchments with ARR 2016 and ILSAX hydrology, and larger using storage routing model hydrology).

For each identified stormwater inlet pit and/or model inflow point, the contributing subcatchment area will be delineated. The supplied topographic data (DTM) and aerial photography (to identify spoon drains and other subcatchment altering elements) will be used to delineate individual subcatchments. Aerial photography will be used to assess impervious site coverage across the study area, with a number of sample areas chosen, each reflecting a distinct level of urbanisation.

An Initial Loss/Continuing Loss (IL/CL) model will be adopted as the default hydrological model within DRAINS and be used to generate hydrographs for all urban subcatchments. The IL/CL values adopted for this catchment will be based on a regional relationship developed for this catchment as part of the SMP.

Future development within the study area will be based on infill development predictions for 2090 that are expected to be available from Planning and Land Use Services. Should these predictions not be available, the Planning and Design Code overlays in conjunction with the development trend knowledge of Council staff will be used to identify estimated infill development.

3.1.3 Hydraulic Modelling

All flood modelling and mapping will be undertaken using the TUFLOW (Two-dimensional Unsteady FLOW) modelling software. TUFLOW is an industry standard hydraulic modelling software that has been successfully applied to a range of Stormwater Management Plans throughout South Australia. It can produce flood depth, height, velocity and hazard outputs, as well as producing time-stepped results in the 2D domain allowing for the creation of animations.

TUFLOW is specifically oriented towards establishing flow and inundation patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow behaviour is essentially 2 dimensional (2D) in nature and cannot or would be awkward to represent using a 1 dimensional (1D) model (BMT WBM, 2010).

The hydrological and hydraulic models will be linked within TUFLOW, with key inflow hydrographs produced in the RORB and DRAINS models able to be input directly into the TUFLOW model. Hydrographs for the major upstream watercourses will be applied as boundary conditions at the upstream boundary of the model. Hydrographs from the DRAINS model will be applied either directly at stormwater pits or directly onto the surface, depending on the subcatchment being modelled.

The inlet curves used for stormwater pits will be obtained from a hydraulic study of SA road stormwater inlets undertaken by the University of South Australia. Information from design drawings and a site visit will be used to determine a suitable set of inlet curves to use.

Preliminary hydraulic model results will be used to inform the selection of temporal patterns. Initially all ten temporal patterns will be run and flows within the major pipe systems will be utilised to determine median temporal pattern(s).

3.1.4 Water Quality Modelling

The modelling and assessment of water quality infrastructure will be done using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) computer software package developed by the Cooperative Research Centre for Catchment Hydrology.

MUSIC can be used to simulate the quantity and quality of runoff from stormwater catchment and can predict the performance of stormwater quality management systems. The MUSIC model requires user defined meteorological and catchment data to estimate the quantity and quality of stormwater runoff for a given catchment. Model development will be carried out in accordance with the recommendations provided in South Australian MUSIC Guidelines (Water Sensitive SA, 2021)

3.2 Filling Data Gaps

Any identified data gaps in the stormwater asset information will be filled with reference to *Circular 3: Stormwater Asset Data* (Stormwater Management Authority). This document lists a range of stormwater asset attributed and gives a method of estimation or assumption for each to be used when that information is unavailable. Where this guidance is unsuited to the situation, engineering judgement will be used to determine a suitable value.

3.3 Joint Probability Assessment

As part of the Port Augusta SMP a Joint Probability Assessment considering both a stormwater overflow and tidal influences will be undertaken such that an appropriate boundary condition can be applied to the hydraulic (TUFLOW) modelling. The assessment will be undertaken in a two-step process by adapting the Design Variable Method introduced in ARR 2019 Book 6 Chapter 5.

In the first instance, a pre-screening will be undertaken to identify the Zone of Joint Probability and determine the state of dependency within the study area. This includes modelling of varying tidal levels to determine the Joint Probability Zone and its impact on the flood extent. For this instance, sensitivity analysis hydraulic modelling of the critical rainfall duration and varying storm-tides for up to three AEPs will be used to determine the complete dependence and independence flood levels for pre-determined 'points of interest' likely to be affected by tidal conditions (see Table 3.1 below for example of the model combinations). The modelling results for the three different AEPs for both rainfall and storm tide variations will be compared individually (green and blue in Table 3.1) and in combination (red) to determine the extent of the Joint Probability Zone within the study area and sensitivity of flood levels within the catchment to that of receiving tidal conditions. For this purpose, storm-tide conditions are taken from Canute 3 sea level calculator (CSIRO 2023).

Table 3.1 Sensitivity Analysis Scenarios for the Port Augusta SMP based on Book 6, Chapter 5 ARR (2019)

Rainfall Events in AEP (%)	Storm Tide Events in AEP (%)			
	Lower Bound	1EY (2.50mAHD)	2% (3.19mAHD)	1% (3.31mAHD)
No Rainfall				
10%				
2%				
1%				

Following pre-screening and sensitivity analysis, determination of receiving tidal conditions will be selected based on the method described by Austroads (Guide to Road Design Part 5, 2023). This methodology uses a simplified approach from ARR 2019 to identify if the chosen points of interest are either full dependency (small differences between independent and dependent scenarios) or based on informed judgement (significant differences between independent and dependent scenarios).

The following workflow outlines the method adopted in this SMP in more detail:

1. Undertaking hydraulic modelling of varying AEP and storm-tide combinations;
2. Identifying Zone of Joint Probability;
3. Establishing 'points of interest' based on inundation within Zone of Joint Probability
4. Sensitivity Analysis (based on Table 3.1) in accordance with ARR 2019 Book 6 Chapter 5;
5. Deciding on level of dependency at points of interest (complete dependence, partial dependence, complete independence)
6. Selecting tailwaters to be included in the hydraulic TUFLOW model based on level of dependency:
    - For the case of complete dependence, the worst case in storm tide will be adopted as tailwater levels;
    - For complete independence, Mean High Water Springs (MHWS) or Mean Higher High Water (MHHW) tide datum levels (whichever relevant for the study area) will be applied as tailwater levels;
    - In case of partial dependence an informed engineering judgement decision will be made to establish tailwater levels.

3.4 Assessment of Blockage

It is proposed to consider blockage of major watercourse structures according to the following:

- Culvert barrels < 1500 mm wide: 100% blocked;
- Culvert barrels < 3000 mm wide: 50% blocked; and
- Bridges/Culvert barrels > 3000 mm wide: 0% blocked.

For urban stormwater inlets, no blockage factors will be applied to the stormwater network.

3.5 Climate Change

As recommended in ARR 2019, Representative Concentration Pathways (RCP) 8.5 for the year 2090 will be considered in this investigation, as discussed in Section 2.4.3.

3.6 Drainage Performance

The drainage performance of the stormwater network will be assessed using the results of the TUFLOW model. At a number of identified key points within the model, peak flow rates and critical durations will be provided for agreed upon minor and major storm events.

A range of performance measures will be assessed and summarised in a table and a map. The proposed methods for identifying the range of impacts is described below.

3.6.1 Over Floor Flooding

The DTM, supplemented with an assumed floor level of 150mm above DTM surface, will be compared with the water surface elevation results from the flood model for each modelled AEP to determine where over floor flooding has occurred.

3.6.2 High or Extreme Flood Hazard

Flood hazard is defined by the Australian Institute for Disaster Resilience's Flood Hazard Guideline 7-3 (AIDR, 2017) as a relationship between water depth and velocity. This definition breaks hazard into 6 categories, ranging from lower hazard at H1 through to maximum hazard at H6. The TUFLOW model will be configured to produce hazard output for each modelled AEP using this definition. It is proposed to identify all areas of H3 and H4 flooding, labelling these high hazard, and to identify all areas of H5 and H6 flooding, labelling these extreme hazard.

3.6.3 Excessive Gutter Flow Depths and Widths

Excessive gutter flow depths and widths will be determined using the TUFLOW model depth result grids. Suitable depth and width thresholds will be chosen in consultation with Council staff.

3.6.4 Low Freeboard or Upwelling

Incidents of low freeboard or upwelling within the minor network will be identified using the 1D network results within TUFLOW. Suitable freeboard thresholds will be chosen in consultation with Council staff.

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