



NEILLY GROUP

engineering for the environment

DISTRICT COUNCIL OF LOXTON WAIKERIE

STORMWATER MANAGEMENT PLAN - WAIKERIE

AUGUST 2026

Document Control

Details and distribution

Details		
Document Title	Stormwater Management Plan - Waikerie	
Revision Number	2	
Project Reference	24024-1	
Author(s)	AaroHi Singhel, Brent Hennekam Tyson Blaser	Adrian Crocetti Estelle O’Donohue
Distribution	DCLW SMP Steering Committee: District Council of Loxton Waikerie (DCLW), Stormwater Management Authority (SMA)	
Citation	Neilly Group Engineering, 2026. Waikerie SMP: Stormwater Management Plan - Waikerie, prepared by Neilly Group.	

Revision History

Revision	Date	By	Nature of change	Checked By	Approved By
1	30/06/2026	AaroHi Singhel Adrian Crocetti Brent Hennekam Estelle O’Donohue Tyson Blaser	Draft Issue	Estelle O’Donohue	Adrian Crocetti
2	14/08/2026	AaroHi Singhel Adrian Crocetti Estelle O’Donohue	Updated per Council’s Feedback	Estelle O’Donohue	Adrian Crocetti

End User Groups

End user group	Examples identified for this project	Purpose
Strategic decision makers	District Council of Loxton Waikerie (DCLW), Stormwater Management Authority (SMA)	Forward planning, financial forecasting, service standard setting and compliance
Funding agencies	SMA, landscape boards, Department for Infrastructure and Transport	Funding eligibility
Agencies with statutory responsibilities and powers	Landscape boards, Environment Protection Authority, Department for Infrastructure and Transport, SA Water	Statutory and policy compliance
Community	Community groups, residents	Improve understanding, gaining community support, identify responsibilities, opportunities for involvement
Engineers involved in designing, constructing and maintaining mitigation works	Council engineering, asset management and maintenance staff, consultants, contractors	Technical background and support for further investigations
Emergency management planners	State Emergency Service, Police, council emergency management staff	Coordinate flood risk priorities and responses
Land-use planners (strategic planning and planning controls)	Council development staff, Attorney-General's Department (Planning and Land Use Services), SA Planning Commission	Implement planning reform and compliance requirements
Industry with vested interests in the catchment	Land developers	Identify suitability of and requirements for development of land

Executive Summary

The Waikerie Stormwater Management Plan (SMP) has been prepared by Neilly Group for the District Council of Loxton Waikerie to provide a long-term strategy for managing stormwater, reducing flood risk, improving water quality, and strengthening resilience to climate change across the township of Waikerie.

The project was delivered through a staged process comprising data collection, baseline assessment, hydrological and hydraulic modelling, water quality assessment, risk analysis, and the development and evaluation of management responses. Collectively, these stages established a robust technical foundation for identifying and prioritising stormwater management investments.

Stage 1 Information Compilation

Stage 1 focused on data compilation and groundwork for the SMP, including reviewing stormwater assets, LiDAR datasets, and drainage information. The team identified 192 pits and 223 pipes, recalculating lengths from the DEM and noting areas needing survey confirmation.

Early analysis showed no provided basin locations beyond Hart Lagoon and Mary Starr Basin, prompting Council collaboration for volume data. The LiDAR comparison revealed minor discrepancies between the 2021 and 2024 datasets, leading to a combined DEM strategy for modelling. A site visit and community consultation confirmed localised flooding hotspots, informing model boundary extensions. The groundwork allowed modelling preparation to begin, despite delays in condition assessment.

Stage 2 Baseline Assessment of the Catchment

Stage 2 provided a comprehensive assessment of Waikerie's 505-hectare catchment, encompassing the township, surrounding growth areas, and contributing catchments. The catchment comprises an upper plateau (35–50 mAHD), a steep escarpment (approximately 5.5% slope), and a low-lying floodplain (10–12 mAHD) adjacent to the River Murray, where some properties are protected by levees and road embankments. Depressions at Ifould Park and the Community Sports Complex form significant local drainage sinks. Land use analysis indicated that the catchment comprises approximately 43% urban development, 35% horticulture, and 22% undeveloped land.

The assessment found that much of the stormwater network, constructed during the 1960s and 1970s, is undersized for current and future rainfall conditions. Blocked pits, undersized culverts, and disconnected drainage systems contribute to recurring flooding at locations including Mary Starr Drive, Pflaum Terrace, and Ifould Park.

The assessment also highlighted that climate change is expected to increase the frequency and intensity of short-duration storm events, reinforcing the need for adaptable and resilient stormwater infrastructure.

To support future decision-making, an integrated modelling framework was developed using DRAINS for hydrological modelling and TUFLOW for hydraulic analysis. The models represent existing conditions together with future development and climate change scenarios to 2090, providing a consistent basis for evaluating management options.

Stage 3 Identification of Stormwater Management Risks and Issues

Flood Modelling

Flood modelling confirmed many of the issues identified through community and stakeholder consultation. Results demonstrated that Waikerie's stormwater network is undersized, with widespread pipe surcharging occurring during relatively moderate rainfall events.

Significant flooding occurs within depressions at Ifould Park, Coombe Street, Matthews Street and the Community Sports Complex, low-lying areas surrounding Mary Starr Basin, Kirby Street, the Lifestyle Village, and local laneways where runoff exceeds kerb capacity.

High flow velocities along steep road sections increase potential property impacts, while pipe bottlenecks and missing drainage links create extensive overland flow paths. Damage assessments indicate that dozens of properties are vulnerable to inundation, with projected damages increasing substantially under future development scenarios.

Water Quality Modelling

Water quality was assessed using MUSIC modelling, with the township divided into agricultural, commercial, and residential sub-catchments to evaluate existing conditions and potential treatment scenarios. Annual stormwater runoff is estimated at approximately 129.6 ML, carrying significant loads of sediments, nutrients, metals, hydrocarbons, and emerging contaminants that ultimately discharge to the River Murray.

Hart Lagoon currently provides effective removal of gross pollutants; however, opportunities exist to improve treatment performance through expanded Water Sensitive Urban Design (WSUD) measures. The assessment also identified stormwater reuse opportunities, with an estimated annual reuse potential of approximately 55 ML which Hart Lagoon provides up to 40ML per year through its SWHR scheme.

Risk Assessment

Flood risks were assessed under four scenarios representing existing and future development conditions during both minor and major storm events. Risks were grouped and prioritised using a consequence-likelihood framework, using the following categories:

- Safety
- Operational
- Strategic
- Regulatory
- Reputational

The assessment indicates that, without intervention, the number and severity of flood risks will increase as the town grows. Mapping of key risks—including road closures, property damage, public safety hazards, and impacts on sensitive environments—provides a clear basis for prioritising future investment and management actions.

Stage 4 – State of Catchment

Stage 4 synthesised the findings from the preceding investigations into a comprehensive State of Catchment assessment. The report consolidated information on:

- existing conditions
- key risks
- flood modelling outcomes
- water quality outcomes
- future challenges

Stage 4 provides the foundation for the development of the stormwater management objectives, targets, and preferred management responses.

Stage 5 - Stormwater Management Objectives and Targets

A series of stormwater management objectives and performance targets was established to guide future decision-making. Targets were categorised as either absolute or aspirational and are intended to support sustainable stormwater management outcomes that protect the community, enhance environmental values, and align with regional and state planning frameworks.

Stage 6 - Stormwater Management Responses

A range of management responses was developed and assessed against the adopted objectives and targets. Responses were grouped into solution sets based on common catchment characteristics, flow paths, and discharge locations. These were reviewed with Council and the SMP Steering Committee.

Stages 7 - Preferred Management Responses

Neilly Group, in conjunction with the steering committee selected the preferred management responses from the Stage 6 list to further develop the preferred options for assessment. Each preferred response was evaluated through:

- Flood modelling to quantify risk reduction;
- Water quality modelling to assess environmental benefits;
- Assessment of broader social, environmental, and community outcomes;
- Risk reduction assessment;
- Cost–benefit analysis; and
- Multi-Criteria Analysis (MCA) to prioritise investment (management responses).

Implementation of the preferred management responses will deliver a more resilient, efficient, and sustainable stormwater system for Waikerie. The recommended strategy will reduce flood risk, improve water quality, enhance community amenity, and support future growth while protecting the region's environmental assets.

Table of Contents

Executive Summary	iii
Acronyms	xii
1. Introduction	1
2. Baseline Assessment of the Catchment	2
2.1. Study boundary	2
2.2. Topography and land uses.....	2
2.3. Geology and soils	6
2.4. Climate and hydrology	7
2.5. Climate change.....	9
2.6. Stormwater infrastructure	10
2.7. Water Allocation Plan.....	16
2.8. Environmental values	18
2.9. Social, socioeconomic and cultural values	23
2.10. Development policy	24
3. Flood Modelling and Validation	28
3.1. Events and scenarios.....	28
3.2. Hydrology (DRAINS)	28
3.3. Hydraulics (TUFLOW)	34
3.4. Drainage network.....	34
3.5. Adopted parameters	34
3.6. Assumptions and limitations.....	36
3.7. Validation	36
4. Flood Modelling Results	42
4.1. Drainage performance	43
4.2. Flood impacts.....	46
4.3. Flood damages	62
5. Water Quality Modelling	69
5.1. Water Quality Modelling Approach	70
5.2. MUSIC modelling and results.....	72
5.3. Pollutant information	75
5.4. Water demand and supply.....	77
6. Risk Assessment	77
6.1. Risk Assessment	79

7. Stormwater Management Objectives and Targets.....	87
7.1. Guidelines and Policies	87
7.2. Overall Goal.....	87
7.3. Objectives and Targets	88
8. Stormwater Management Responses.....	92
8.1. Summary of strategies	92
8.2. Structural strategies	94
9. Implementation Plan	118
9.1. Prioritisation list	121
9.2. Implementation Plan.....	123
10. Risk Reduction Assessment and Discussion	125
10.1. Residual flood risks	125
10.2. Water Quality Improvements and residual pollutants.....	132
11. Conclusion and Discussion	133
12. References	134
12.1. Reference texts	134
12.2. Websites used as data sources	136
12.3. Tools for modelling and data manipulation	136
Attachment A: Community Consultation Feedback Report.....	137
Attachment B: Modelling Data Input and Critical Locations in Stormwater Network	138
Attachment C: Existing Flood Maps (Scenario A).....	139
Attachment D: Future Flood Maps (Scenario B)	140
Attachment E: Riverine Flood Maps (Scenario B_{ii})	141
Attachment F: Hazard Maps (Scenario A + B).....	142

Figures

Figure 1. Study Area.	3
Figure 2. Topography of Waikerie.	4
Figure 3. Land use distribution map.....	5
Figure 4. Soil horizons at Waikerie (Macumber 2023)	6
Figure 5. Graphical representation of annual rainfall and moving average.	8
Figure 6. Comparison of Waikerie’s monthly rainfall average and monthly evaporation average	8
Figure 7. Existing stormwater infrastructure in Waikerie.....	11
Figure 8. Change (and climate change predictions) to mean temperature since 1950.	13
Figure 9. Locations of known flooding issues.....	15
Figure 10. Areas affected by different policies (MDBA 2021).	17
Figure 11. Population distribution graph of Waikerie	23
Figure 12. Planning & Design Code Zones.....	26
Figure 13. Cultural heritage sites.	27
Figure 14. Directly connected impervious areas for Scenario A.	31
Figure 15. Directly connected impervious areas for Scenarios B & C.	32
Figure 16. Change in directly connected impervious areas (expressed in percentage points).....	33
Figure 17: Topologic sections of Waikerie: (a) a higher plateau, then (b) a steep slope down to the (c) floodplain.	42
Figure 18. Damage Areas.	44
Figure 19. Drain Standard - Scenario A (Existing Conditions).....	45
Figure 20. General flood hazard vulnerability curves (AIDR 2017, p. 10).	47
Figure 21. Flood impact locations - Minor event - Scenario A Existing Conditions.....	50
Figure 22. Flood impact locations - Major event - Scenario A Existing Conditions.....	54
Figure 23. Flood impact locations - Minor event - Scenario B Ultimate Development.	57
Figure 24. Flood impact locations - Major event - Scenario B Ultimate Development.....	61
Figure 25. Existing Waikerie sub-catchments based on land use.....	71
Figure 26. Risk assessment matrix and description of each classification	79
Figure 27. Proposed remediation measuresTable 47. Stormwater Management Responses	95
Figure 28. Modelled flood extent at location of Option A2 under Scenario 5b.....	98
Figure 29. Modelled flood extent for remediation Option A2 (Scenario 5c).	98
Figure 30. Modelled flood extent at location of Option A8 under Scenario 5b.....	100
Figure 31. Modelled flood extent for remediation Option A8 (Scenario 5c).	100
Figure 32. Modelled flood extent at location of Option A10 under Scenario 5b.....	101
Figure 33. Modelled flood extent for remediation Option A10 (Scenario 5c).	101
Figure 34. Modelled flood extent at location of Option A11 under Scenario 5b.....	102
Figure 35. Modelled flood extent for remediation Option A11 (Scenario 5c).	102

Figure 36. Modelled flood extent at location of Option A13 under Scenario 5b.....	103
Figure 37. Modelled flood extent for remediation Option A13 (Scenario 5c).	103
Figure 38. Modelled flood extent at location of Option B1 under Scenario 5b.	105
Figure 39. Modelled flood extent for remediation Option B1 (Scenario 5c).	105
Figure 40. Modelled flood extent at location of Option B4 under Scenario 5b.	106
Figure 41. Modelled flood extent for remediation Option B4 (Scenario 5c).	106
Figure 42. Modelled flood extent at location of Option C1 under Scenario 5b.	108
Figure 43. Modelled flood extent for remediation Option C1 (Scenario 5c).	108
Figure 44. Modelled flood extent at location of Option D2 under Scenario 5b.....	112
Figure 45. Modelled flood extent for remediation Option D2 (Scenario 5c).	112
Figure 46. Modelled flood extent at location of Option D4 under Scenario 5b.....	114
Figure 47. Modelled flood extent for remediation Option D4 (Scenario 5c).	114
Figure 48. Modelled flood extent at location of Option D5 & D6 under Scenario 5b.....	115
Figure 49. Modelled flood extent for remediation Option D5 & D6 (Scenario 5c).	115
Figure 50. Modelled flood extent at Cates St (LHS) and Strangman Rd (RHS) [Option D8] under Scenario 5b.....	116
Figure 51. Modelled flood extent at Cates St (LHS) and Strangman Rd (RHS) for remediation design [Option D8] under Scenario 5c.....	117
Figure 52. River Murray Offtake Locations.....	120

Tables

Table 1 - Number of occurrences that IFD values have been exceeded within the 105-year record.	7
Table 2. Climate change predictions for Murray Bridge Region.....	9
Table 3. Existing stormwater assets in Waikerie.	12
Table 4. Flooding issues advised through community feedback.....	14
Table 5. Listed threatened ecological communities.....	22
Table 6. Loss parameters for hydrologic modelling.....	29
Table 7. Chosen SSP scenarios for the study.....	29
Table 8. Impervious percentages for each land use classification.	30
Table 9. Changes to impervious percentages for the ultimate development scenario.	30
Table 10. Events used for model validation	36
Table 11. Model validation.....	38
Table 12. Details of flood maps and risk register.....	46
Table 13. Impacts Register - Scenario 1a – 18% AEP Existing Conditions	49
Table 14. Impacts Register - Scenario 5a – 1% AEP Existing Conditions	51
Table 15. Impacts Register - Scenario 1b – 18% AEP Ultimate Development.....	55
Table 16. Impacts Register - Scenario 5b – 1% AEP Ultimate Development.....	58

Table 17. Average residential building sizes.....	62
Table 18. Stage-Damage curve for Residential buildings.	63
Table 19. Stage-Damage curve for Commercial buildings.....	64
Table 20. Stage-Damage curve for Industrial buildings.....	64
Table 21. Inundated buildings by depth under Existing Conditions.....	65
Table 22. Inundated buildings by land use under Existing Conditions.	66
Table 23. Direct tangible damages under existing conditions.....	66
Table 24. Direct tangible damages per damage area under Existing Conditions.....	66
Table 25. Total tangible damages under Existing Conditions.	67
Table 26. Inundated buildings by depth under Ultimate Development.....	67
Table 27. Inundated buildings by land use under Ultimate Development.....	68
Table 28. Direct tangible damages under Ultimate Development.....	68
Table 29. Direct tangible damages per damage area under Ultimate Development.....	69
Table 30. Total tangible damages under Ultimate Development.....	69
Table 33. MUSIC modelling for pollutant loads.....	72
Table 34. Scenario 1 pollutant concentrations.....	73
Table 31. MUSIC modelling results for baseline scenario	73
Table 35. MUSIC modelling results for Hart Lagoon Constructed Wetland	74
Table 36. Pollutant reductions at Hart Lagoon wetland.....	74
Table 37. Pollutants, sources and impacts	75
Table 38. Water supply sources.....	77
Table 39. Harvesting capacity at each sub-catchment	77
Table 40. Risk categories	78
Table 41. Risk assessment for Scenario 1a – 18% AEP Existing Conditions.....	80
Table 42. Risk assessment for Scenario 1b – 18% AEP Ultimate Development	81
Table 43. Risk assessment for Scenario 5a – 1% AEP Existing Conditions.....	82
Table 44. Risk assessment for Scenario 5b – 1% AEP Ultimate Development	84
Table 45. Risk ratings distribution	86
Table 46 Stormwater Management Objectives and Targets	88
Figure 27. Proposed remediation measuresTable 47. Stormwater Management Responses	95
Table 48. Solution D1 catchment details.....	110
Table 49. Scenario 4 MUSIC results for existing conditions and ultimate development.....	110
Table 49. Legislations and requirements.....	118
Table 50. Multi-Criteria Analysis (MCA) Framework.....	121
Table 51. Implementation Plan	124
Table 52. Post mitigation risk assessment for Scenario 1c – 18% AEP Future	126
Table 53. Post mitigation risk assessment for Scenario 5c – 1% AEP Future	128
Table 54. Risk ratings distribution – post mitigation	131

Table 55. Water quality results	132
---------------------------------------	-----

Acronyms

Acronym	Meaning
ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AIDR	Australian Institute for Disaster Resilience
AR5 (& AR6)	Fifth (and Sixth) Assessment Report [by the IPCC]
ARR	Australian Rainfall & Runoff (version 4.2)
ASR	Aquifer Storage and Recovery
BOM; The Bureau	Bureau of Meteorology
CCRM	Climate Change Rainfall Modifier
CCTV	Closed-Circuit Television
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCIA	Directly Connected Impervious Area
DCLW	District Council of Loxton Waikerie
DEM	Digital Elevation Model
DU	Deferred Urban
EOC	Emerging Organic Contaminants
EPBC	Environment Protection and Biodiversity Conservation
EY	Exceedances per Year
GL	Gigalitres
GPT	Gross Pollutant Trap
IFD	Intensity-Frequency-Duration
IL	Invert Level
IL-CL	Initial Loss – Continuing Loss
INFFEWS	Investment Framework for Economics of Water Sensitive Cities
IPCC	Intergovernmental Panel on Climate Change
JB	Junction Box
LiDAR	Light Detection And Ranging
MDBA	Murray-Darling Basin Authority
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NWL	Nominal Water Level
RCP	Representative Concentration Pathways
RIA	Remaining Impervious Area
SAPPA	South Australian Property & Planning Atlas
SEP	Side Entry Pit
SGS	Sub Grid Sampling
SMP	Stormwater Management Plan
SSP	Shared Socio-economic Pathway
P&D	Planning and Design
PMST	Protected Matters Search Tool
PWC	Prescribed Water Courses
VC1 to VC6	Value Class (1-6)
WAP	Water Allocation Plan
WSUD	Water Sensitive Urban Design

1. Introduction

The District Council of Loxton Waikerie (DCLW) commissioned Neilly Group to prepare a Stormwater Management Plan (SMP) to establish a coordinated, long-term framework for managing stormwater across the township of Waikerie. The SMP provides a strategic approach to addressing existing drainage and flooding issues, improving stormwater quality, enhancing community resilience to climate change, and supporting sustainable urban growth while protecting the environmental values of the River Murray and its surrounding catchment.

Waikerie occupies a unique landscape extending from the elevated Murray Mallee plateau, across a steep escarpment, to the low-lying River Murray floodplain. This varied topography, together with ageing drainage infrastructure, changing land use, and increasing development pressures, creates complex stormwater management challenges. Localised flooding occurs during intense rainfall events, while runoff carries pollutants that can affect downstream receiving environments. Climate change is expected to increase the frequency and intensity of short-duration storm events, placing additional pressure on the existing stormwater system and reinforcing the need for resilient, adaptable infrastructure.

The purpose of the SMP is to provide an evidence-based strategy for managing these challenges over the long term. The plan identifies existing deficiencies within the stormwater network, assesses current and future flood risks, evaluates stormwater quality and reuse opportunities, and develops a prioritised program of structural and non-structural management responses. The recommendations seek to reduce flood risk to people and property, improve water quality, enhance community amenity, and support future growth while maintaining environmental and economic sustainability.

The SMP has been developed through a comprehensive, staged process that included data collection and validation, catchment assessment, hydrological and hydraulic modelling, water quality modelling, flood risk assessment, stakeholder consultation, and the evaluation of management options. Hydrological modelling was undertaken using DRAINS, hydraulic modelling using TUFLOW, and water quality assessment using MUSIC, enabling the performance of the existing stormwater system and proposed management responses to be assessed under existing conditions, future development scenarios, and projected climate change conditions through to 2050.

The preferred management responses have been evaluated using flood and water quality modelling, risk reduction assessment, cost–benefit analysis, and Multi-Criteria Analysis (MCA). Together, these assessments provide a robust basis for prioritising investment and implementing practical, cost-effective solutions that will improve the long-term performance and resilience of Waikerie's stormwater system.

This Stormwater Management Plan provides Council with a strategic framework to guide future planning, infrastructure investment, maintenance, and funding applications. It establishes a clear pathway for progressively improving stormwater management outcomes, reducing community flood risk, protecting the health of the River Murray, and supporting the sustainable development of Waikerie.

2. Baseline Assessment of the Catchment

The baseline assessment provides a detailed overview of Waikerie's physical environment, stormwater infrastructure, and community context. It establishes a baseline for future modelling, risk assessments, and strategy development to improve stormwater management and climate resilience.

2.1. Study boundary

The Waikerie SMP study area (shown in Figure 1) covers 505 hectares, including the township, growth areas, and contributing catchments. Waikerie is the second largest township in the District Council of Loxton Waikerie, with 936 dwellings and 1,670 residents (ABS 2021). Due to topographic constraints, stormwater is engineered to discharge to the River Murray, making the area subject to the River Murray Water Allocation Plan.

2.2. Topography and land uses

Topography of the study area is shown in Figure 2 and can be broadly categorised as follows:

- **River Boundary and Cliffs** – The River Murray borders the town from southeast to northwest. On the eastern side, steep cliffs over 30 m high line the river until the old pumping station and Rowe Street ferry crossing.
- **Floodplain Area** – Downstream of the ferry, the land is low-lying floodplain (about 10–12 mAHD), protected by flood levees and Ramco Road (around 13.5 mAHD).
- **Low-Lying Residential Zone** – South of Ramco Road/Peake Terrace, extending to Marks Terrace and the football oval, the land remains below flood levels. It includes existing homes and the new Lifestyle Village, with the road itself providing protection.
- **Slope to Higher Ground** – From this area, the land rises steadily to approximately 42 mAHD at a slope of about 5.5%.
- **Upper Town Variation** – The upper town varies between 35–50 mAHD, with notable depressions at the Community Sports Complex, Ifould Park, and vineyards between McCutcheon Street and Ian Oliver Drive.

The 2022 land use data shows that 43% of Waikerie's study area is built-up, 35% is horticulture, and 22% is undeveloped land such as reserves and vacant lots. This reflects actual land use, not zoning, as shown in Figure 3.

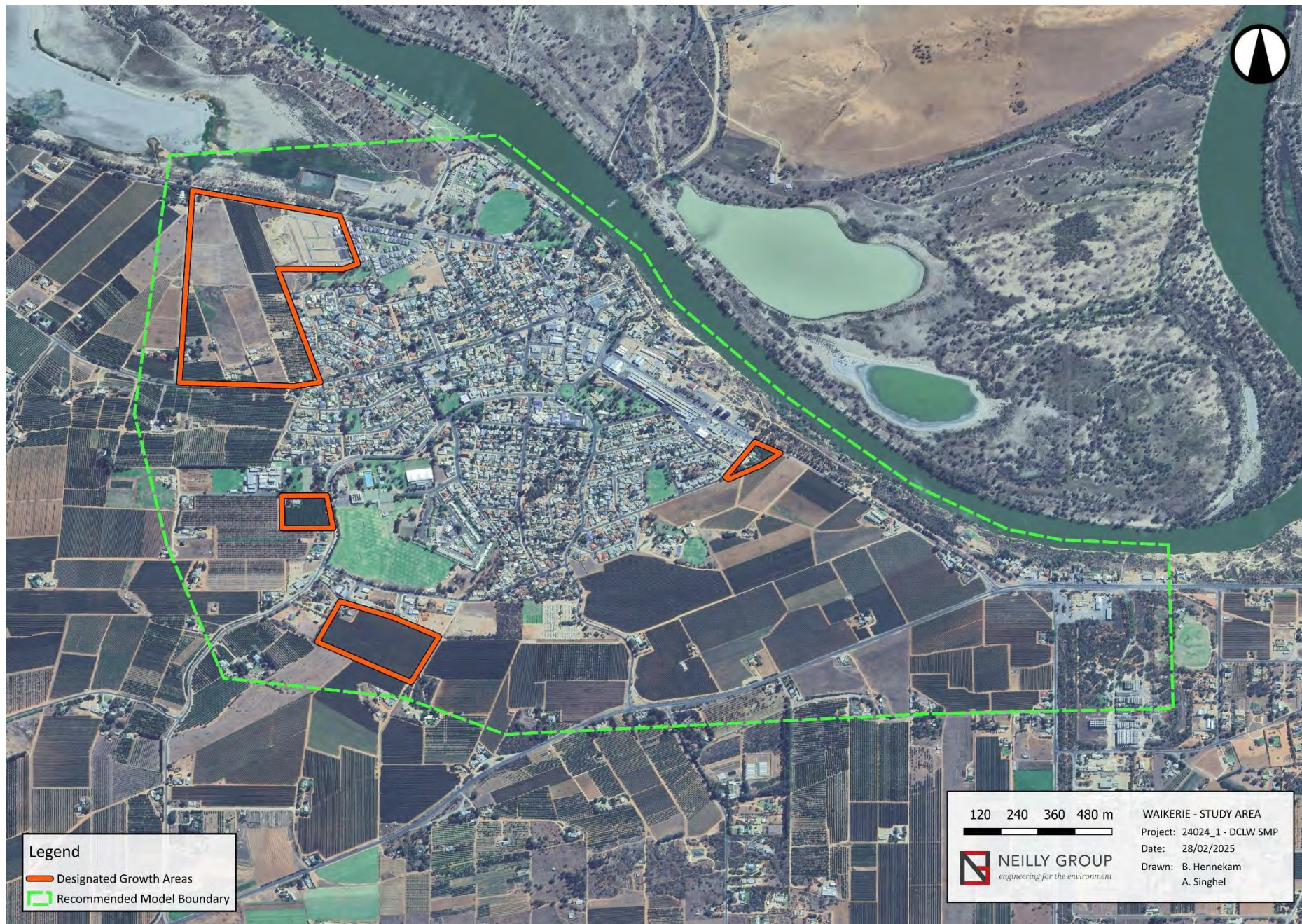


Figure 1. Study Area.

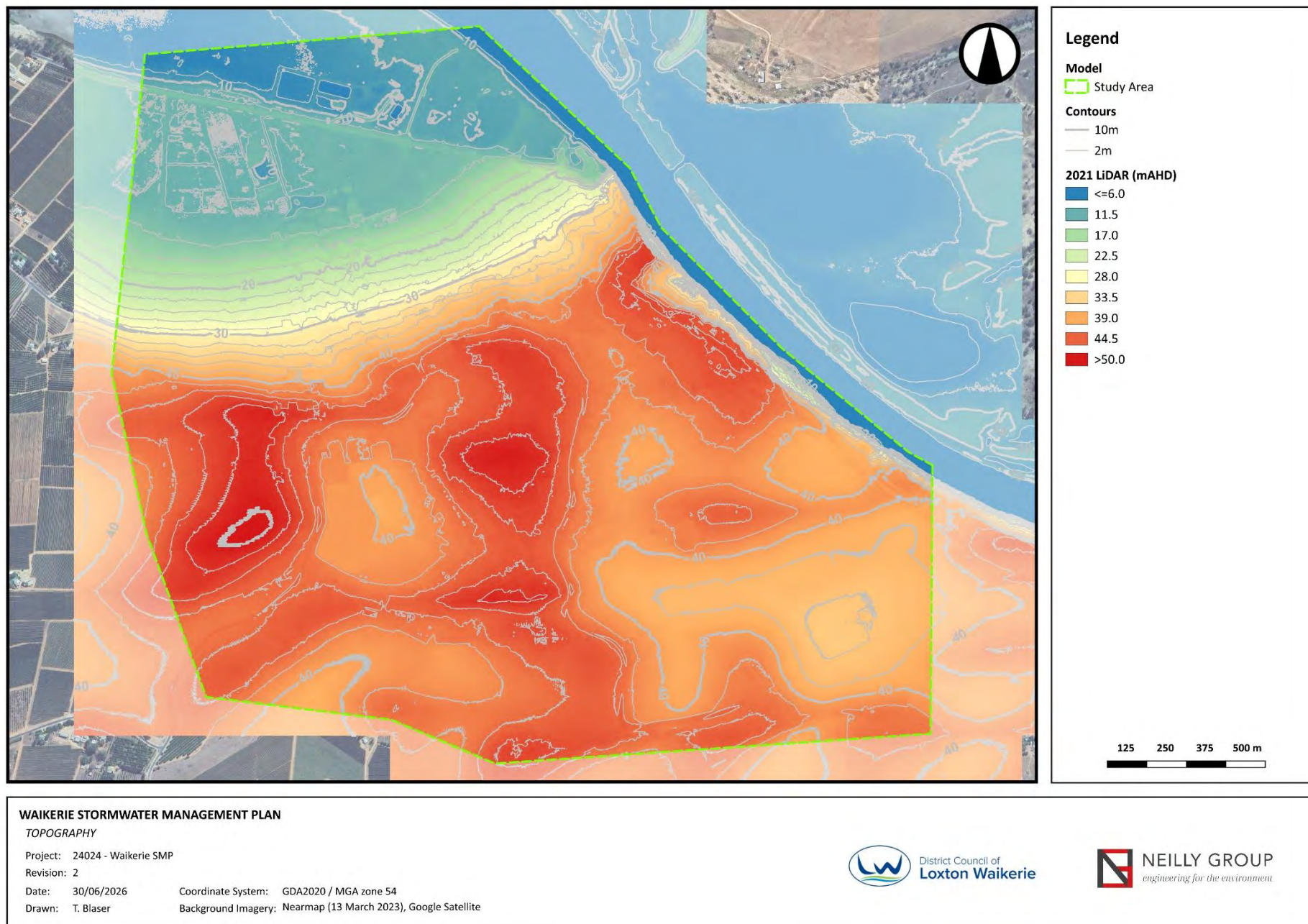


Figure 2. Topography of Waikerie.

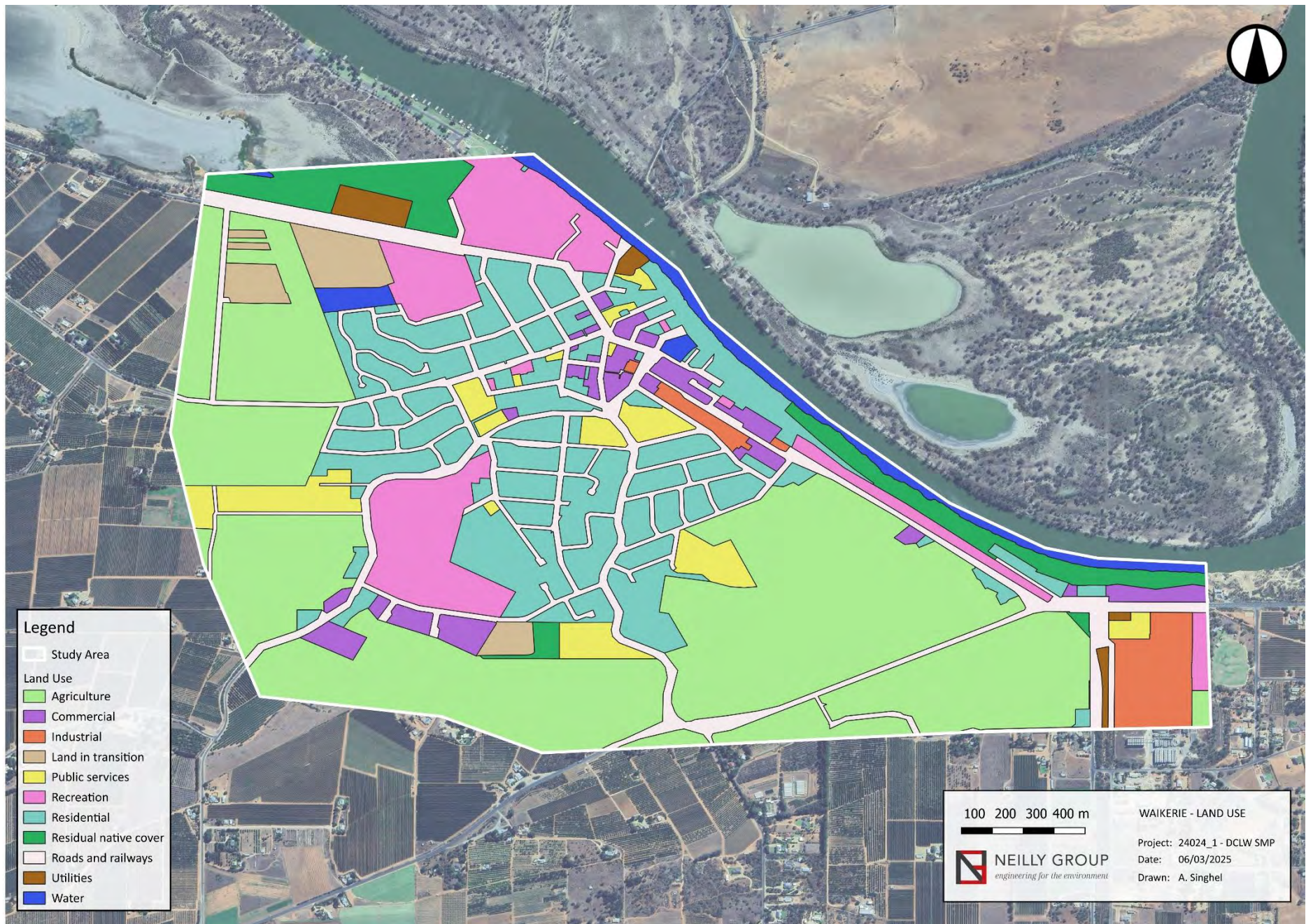


Figure 3. Land use distribution map.

2.3. Geology and soils

Waikerie is settled atop the sand, silt, and clay that compose the Coonambidgal formation level with the water table as visible in Figure 4 (Macumber 2023). Beneath this layer of fine-grained sediment are coarser quartz sands existing in the Monoman formation and calcareous clay throughout the Ettrick formation (Marsden 2006; Hou & Petts 2021). Dry climate and highly frequent drought conditions have dried and hardened shallow soils around the Riverland and diminished the capacity for drainage.

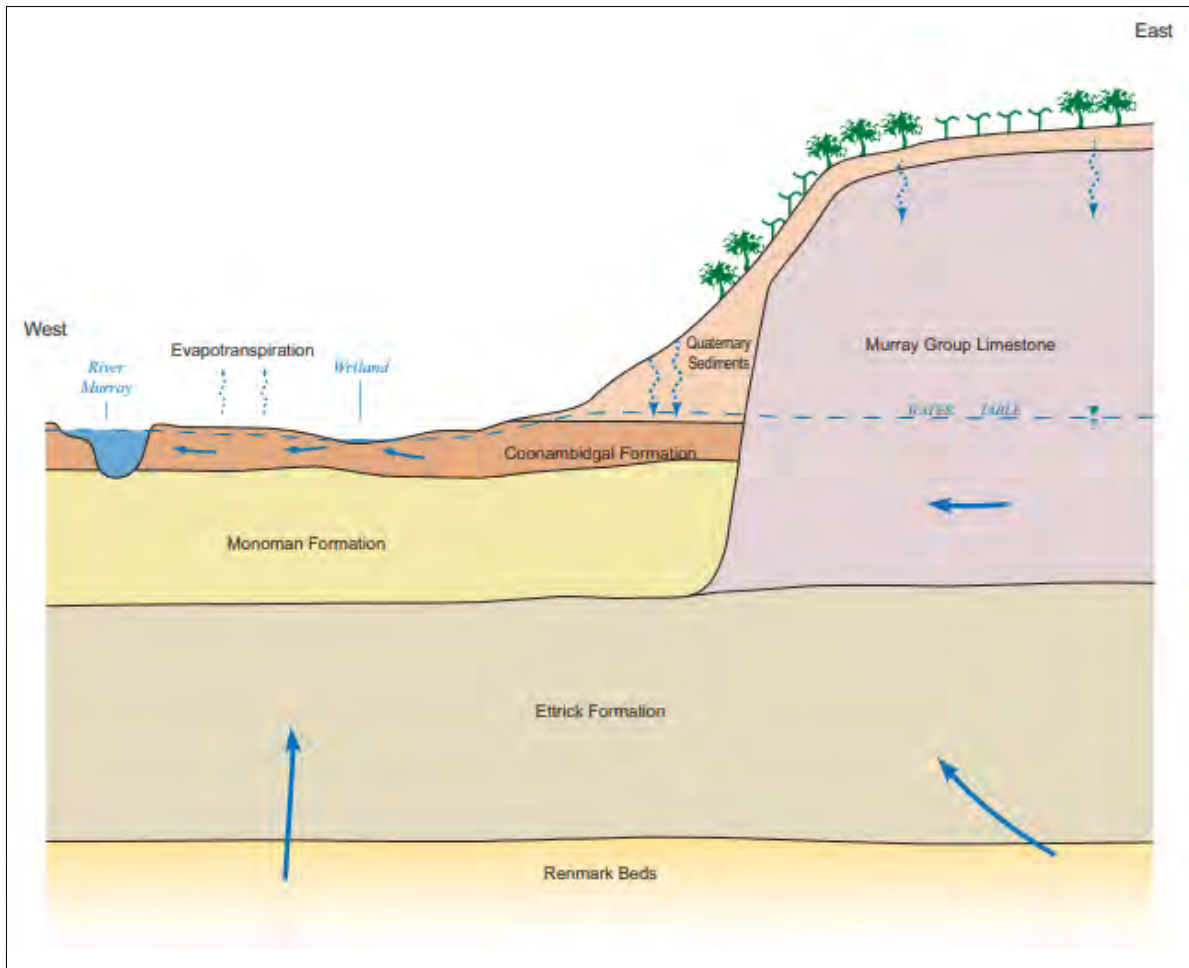


Figure 4. Soil horizons at Waikerie (Macumber 2023)

2.4. Climate and hydrology

Waikerie is located within the arid zone of South Australia, with an average annual rainfall of 270 mm/yr. The Bureau of Meteorology (BOM; The Bureau) has three currently operational weather stations that collect daily rainfall values in the vicinity of Waikerie: Waikerie Council Works Depot [Station ID: 24038] that has operated since 1973, Duffield Ramco [Station ID: 24031] which began operation in 1969, and Waikerie (Eremophila Park) [Station ID: 24029] which also commenced operation in 1969. All three stations record data with a high level of completeness and quality ratings.

Complete climate data was recorded in Waikerie from 1896 to 2001. Data from this weather station [Station ID: 24018] forms climate graphs in Figure 5 and Figure 6 as it has the largest and most complete dataset of the stations in Waikerie. However, evaporation data displayed in Figure 6 is collected from the Gluepot Reserve weather station [Station ID: 24019] since evaporation was not measured in Waikerie from 1896 to 2001.

The Waikerie weather monitoring station has 105 years of data which shows that 24-hr IFDs (Intensity-Frequency-Duration) have not been reached as frequently as expected, as evident in Table 1. This suggests they should perhaps be revised down, and therefore flood modelling using these design values may overestimate flood impacts.

Table 1 - Number of occurrences that IFD values have been exceeded within the 105-year record.

Event	Threshold (mm)	No. occurrences (no. expected)	Years reached
1EY (63.2% AEP)	30.1	78 (105)	(not calculated)
0.5EY	38.9	39 (53)	(not calculated)
20% AEP	52.1	11 (21)	1919, 1936, 1946 x2, 1950, 1954 , 1961, 1989, 1995, 1997 x2
10% AEP	65.1	6 (11)	1919, 1946, 1961 , 1989, 1995, 1997
5% AEP	79.1	1 (5)	1989
2% AEP	100.0	1 (2)	1989
1% AEP	118.0	1 (1)	1989
1-in-500 yr	168.0	1 (0)	1989

Annual rainfall, and the 10-yr moving average, for Waikerie [Station ID: 024018] is shown in Figure 5.

On average, Waikerie receives less than 40 rain days (>1mm) per year (BOM 2025). Evaporation greatly exceeds rainfall all months of the year, Figure 6.

Flooding issues in Waikerie are typically due to shorter duration, high intensity storms. Climate change is expected to decrease overall rainfall, however, increase both the frequency, and intensity, of short bursts of high intensity downpours (BOM & Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2015).

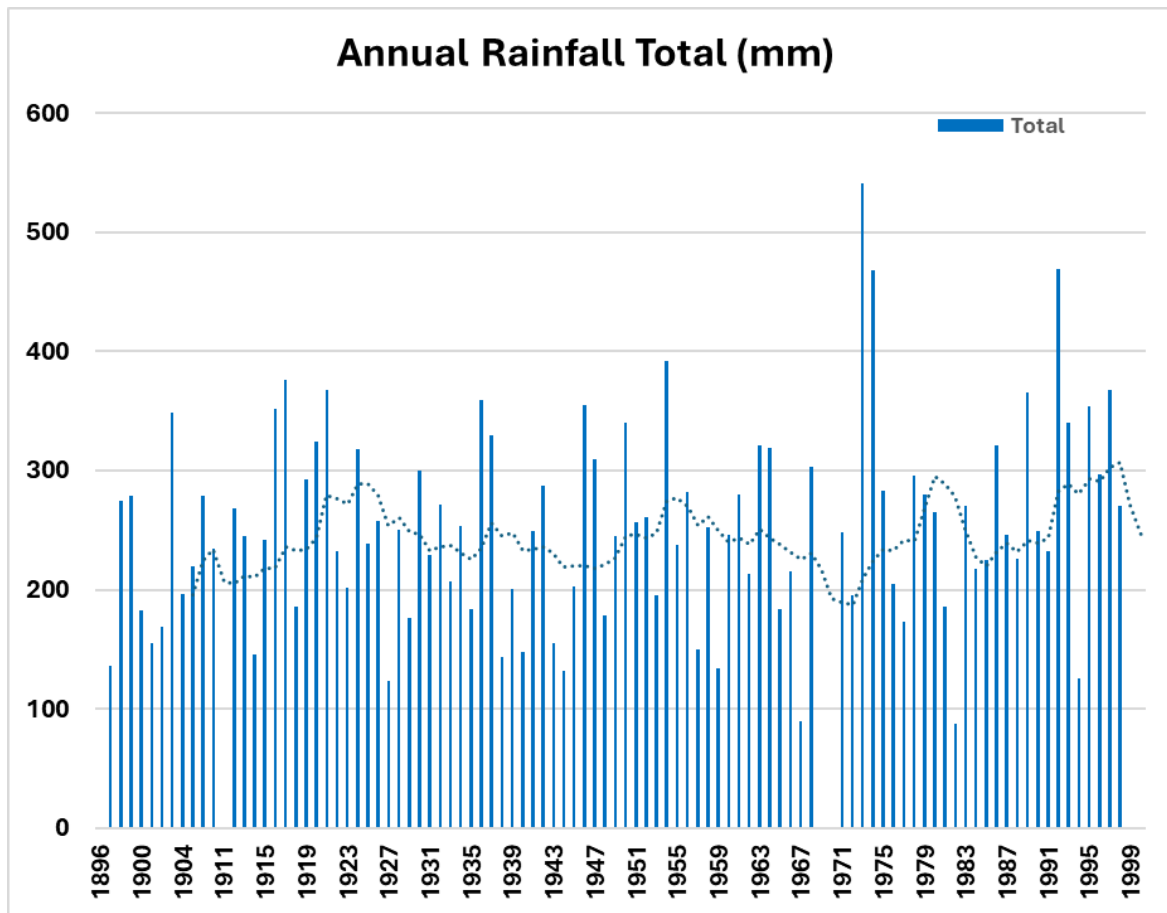


Figure 5. Graphical representation of annual rainfall and moving average.

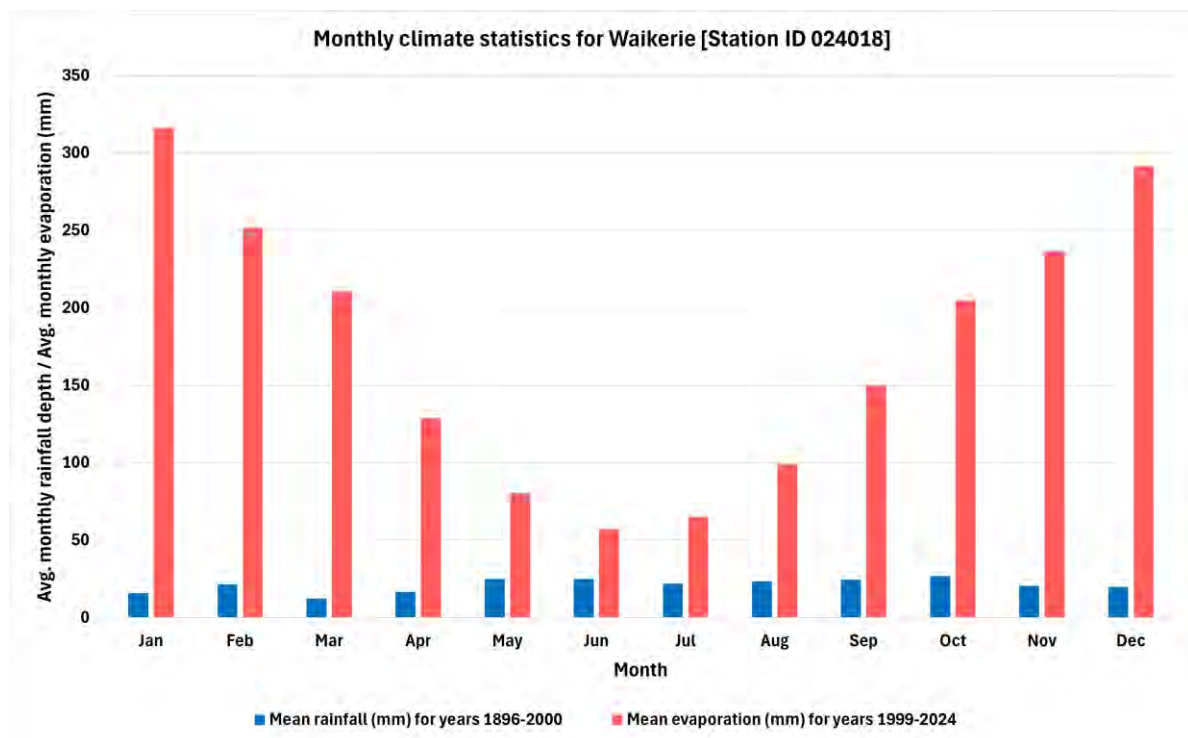


Figure 6. Comparison of Waikerie's monthly rainfall average and monthly evaporation average

2.5. Climate change

The global climate is changing as a direct result of anthropogenic greenhouse gas emissions. Climate change across Australia is expected to alter temperatures, rainfall, and other weather events that will impact the River Murray and Riverland region.

Waikerie is zoned under the 'Murray Basin' region by CSIRO and The Bureau who predict that temperatures and intense weather systems will both increase as average rainfall decreases. Furthermore, drought conditions and fire danger are both expected to worsen according to the 2015 *Climate Change in Australia* technical report.

The climate change predictions for the Murray Basin region made by The Bureau and CSIRO are summarised in Table 2. Three representative concentration pathways* (RCPs) are included in this table: RCP2.6, RCP4.5, and RCP8.5. These scenarios model climate change under increasing intensity of greenhouse gas emissions, with RCP2.6 representing the lowest emission scenario, and RCP8.5 representing the highest.

Table 2. Climate change predictions for Murray Bridge Region

Condition change	2030 RCP4.5	2090 RCP2.6	2090 RCP4.5	2090 RCP8.5
Avg. temperature (°C)	+0.8	+0.9	+1.7	+3.5
Annual rainfall (%)	-4	-3	-7	-8
Winter rainfall (%)	-4	-3	-9	-17
Summer rainfall (%)	-1	-5	-2	+1
Time in drought (%)	+11	+16	+18	+21
Soil moisture (%)	-1.5	Not recorded	-3	-5.5
Runoff (%)	-10	Not recorded	-14	-26
Severe fire danger days	3.6	Not recorded	3.8	5.3

Under RCP4.5, climate change is expected to have the following effects on Waikerie's long-term weather by 2090 (CSIRO, BOM 2015):

- The average annual maximum temperature will increase from 25.4°C to 27.1°C, with the average maximum summer temperature to reach 34.5°C (BOM 2025).
- Annual rainfall will decline from 270 mm/yr to only 251.1 mm/yr, with the greatest loss occurring in winter months.
- Rainfall intensity is expected to increase as synoptic weather systems originating in tropical regions travel further south.
- Time in drought will increase by nearly 20% as the number of rain events decline and become more intense. This is a direct causation of an additional 3-4 severe fire danger days each year in Waikerie.

- Both soil moisture and runoff will decrease as warmer temperatures and less rainfall contribute to enhanced evapotranspiration.

Stormwater infrastructure in Waikerie must therefore be planned to withstand the demanding conditions induced by global climate change.

** Note that the Intergovernmental Panel on Climate Change (IPCC) changed its preferred modelling scenarios from Representative Concentration Pathways (RCPs) in the Fifth Assessment Report (AR5) to Shared Socioeconomic Pathways (SSPs) in AR6. These scenarios share the same assumed levels of radiative forcing in the year 2100 (e.g., RCP4.5 $\approx$ SSP2-4.5); however, the new SSP framework incorporates more socioeconomic complexity, leading to a broader range of potential outcomes. For more details, see: <https://environment.govt.nz/what-you-can-do/climate-scenarios-toolkit/climate-scenarios-list/ipccs-ssp-rcp-scenarios/>.*

2.6. Stormwater infrastructure

2.6.1. Existing infrastructure

GIS layers of the stormwater infrastructure in Waikerie were provided by Council, and updated during a Condition Assessment, which took the opportunity to confirm pit types, depths and pipe sizes. Figure 7 shows the updated stormwater network, and Table 3 lists the different asset quantities (including Water Sensitive Urban Design (WSUD) assets).



WAIKERIE STORMWATER MANAGEMENT PLAN

EXISTING STORMWATER INFRASTRUCTURE

Project: 24024 - Waikerie SMP

Revision: 3

Date: 30/06/2026

Coordinate System: GDA2020 / MGA zone 54

Drawn: B. Hennekam

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 7. Existing stormwater infrastructure in Waikerie.

Table 3. Existing stormwater assets in Waikerie.

Asset Type	Description	Quantity	
Pipes	150 mm dia	1 -	18 m
	225 mm dia	14 -	157 m
	300 mm dia	57 -	840 m
	375 mm dia	52 -	1,491 m
	450 mm dia	58 -	3,052 m
	525 mm dia	5 -	352 m
	600 mm dia	16 -	1,387 m
	750 mm dia	6 -	232m
	825 mm dia	4 -	193 m
	900 mm dia	12 -	920 m
Box culverts	< 900 mm wide	7 -	243 m
	=> 900 mm wide	4 -	59 m
Pits	Side entry pit (SEP)		124
	Grated inlet		28
	Field gully		1
	Junction Box (JB) *		50
Pumps	N/A		1
WSUD assets	Detention Basins		1
	Wetlands		1

** Note that junction boxes have been inserted at every change of direction and pipe junction in the provided shapefile that could not be confirmed during the Condition Assessment.*

There are three main underground pathways that drain Waikerie's stormwater runoff:

- 1) A large system drains water from the western edge of town towards the Hart Lagoon wetland and stormwater reuse system.

From West Rd and to the south, this passes directly to a swale inlet to the wetland. The development to the north of West Rd first flows into the Mary Starr Drive detention basin, with overflows routing overland via open swales before passing under Ramco Rd to join the inlet swale to the Hart Lagoon wetland.

- 2) A second system drains McCoy St and Peake Terrace plus the bottom of Henderson St into the second inlet swale to the Hart Lagoon wetland.
- 3) A third system drains much of the southeast section of town out to the cliffs beside Ian Oliver Drive.

The rest of the town drains via kerb and channel flow, including several disconnected smaller systems that simply direct runoff under roads then spill them out on the other side to continue their journey.

Most of the major trunk mains through town date back to the 1960's and 1970's, and by 1986 almost all of the exiting critical pathways had been added. Additions since 1990 are largely the extension of Cates Ave, McCoy St, the Mary Starr development and extending the third section to start from the industrial area adjacent the river. Some pipes along Ian Oliver Drive are listed as being constructed in the 1960's, however, so it is possible this area has been upgraded rather than extended.

Figure 1.6.2 of the ARR (Book 1, Chapter 6, Section 6.4.1) shows that the climate has changed significantly since the 1980's – see Figure 8 - and it is likely much of the town's stormwater infrastructure is undersized for expected future conditions.

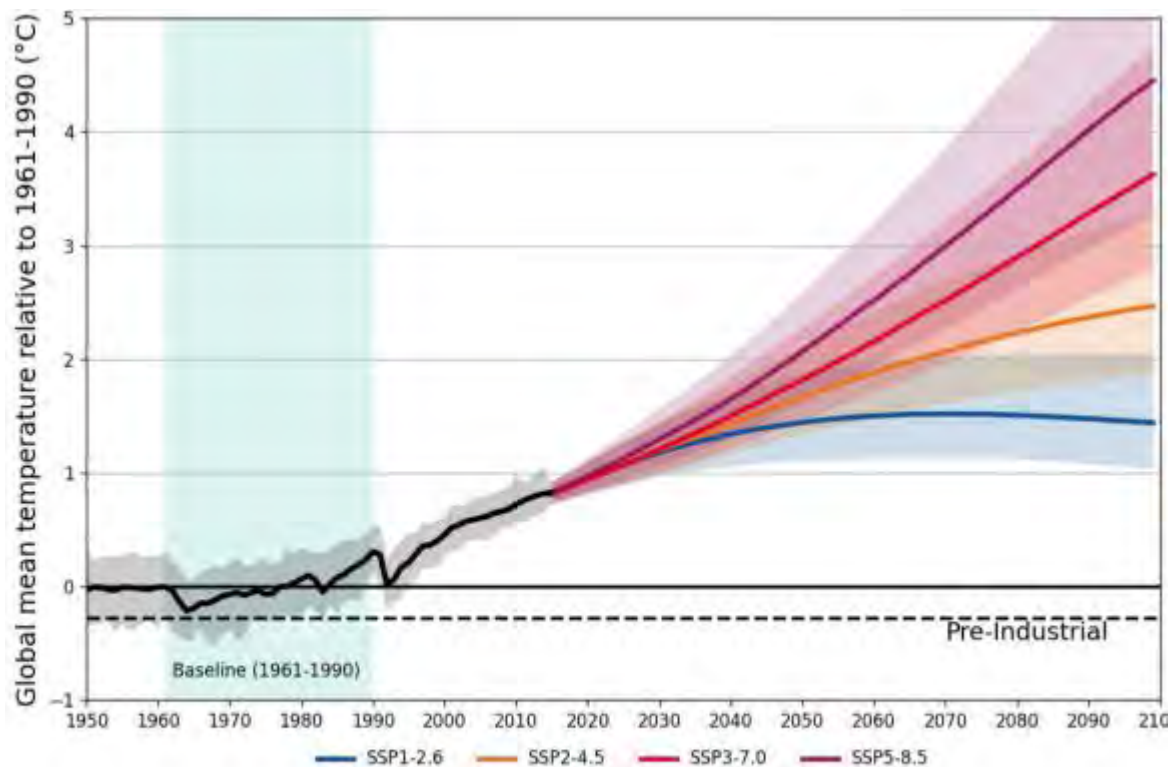


Figure 1.6.2. Projected temperature increases associated with AR6 socioeconomic pathways relative to 1961-1990 and their associated uncertainty²

Figure 8. Change (and climate change predictions) to mean temperature since 1950.

2.6.2. Known flood issues

There are several known flooding issues, shown in Figure 9, below, that have been obtained through two channels, as described in the following subsections.

2.6.2.1. Previous investigations

The 2023 study by Neilly Group (Neilly Group 2023) investigated flooding issues at 5 known locations. The study concluded that flooding at these locations is largely predicted due to local topography,

which suggests that improvements of the stormwater network – either through increased capacity or better capture potential – can alleviate issues.

It is also worth noting that upon inspection in December 2024, it was discovered that the SEP on Wohling St, adjacent Ifould Park, was (a) very shallow, and (b) filled with debris that blocked entry to the underground stormwater network. Assessment on site was that fixing this issue alone (improving the efficiency of this single pit) would likely reduce flooding significantly in the Ifould Park region.

Council have advised that the kerb at Matthews St has been upgraded from a rollover kerb to a stand-up kerb to help reduce flooding at this location.

Note also that there is a pump installed at the Community Sports Complex to pump water up from that depression back to Cates Ave. No outlet pipe was observed at the indicated location, however Council representatives have confirmed that the pump does connect to this line.

2.6.2.2. Community consultation

Community consultation undertaken by DCLW via a community web portal at the start of this project, which provided an additional four locations where drains cannot cope during larger events, or runoff was causing problems. A further three locations were added following resident feedback during the Condition Assessment. This feedback is outlined in Table 4, below. Refer to Attachment A for more details.

Table 4. Flooding issues advised through community feedback.

Location	Issue
From community web portal	
Mary Starr Drive	Drains at the bottom of Mary Starr cannot cope in heavy down pours. Floods the road, our driveway becomes covered and the road becomes covered in thick mud and sand. Even comes behind our property from west road.
Pflaum Terrace	Extensive damage to business caused by runoff stormwater from Pflaum Terrace and Campbell Terrace.
Blake Road	Rain causing parts of dirt road to wash away leaving large potholes across the whole road.
Lawrie Terrace	Water on road due to rain & irrigation from Blake Road to Smith Drive.
Feedback received during Condition Assessment	
Gaeta Road	<i>"[SEP] cannot cope" – note that this SEP turned out to be completely full of topsoil.</i>
Lawrie Terrace	Pipe / culvert under Lawrie Terrace at the crossing is undersized, and flooding occurs on the western footpath
Miller St	A pipe runs through the resident's property (and the one behind) between Miller Road and Jacobs Street. There is a grate opening in his backyard that often surcharges during rain events. <i>Note that it was very full during the condition assessment.</i>

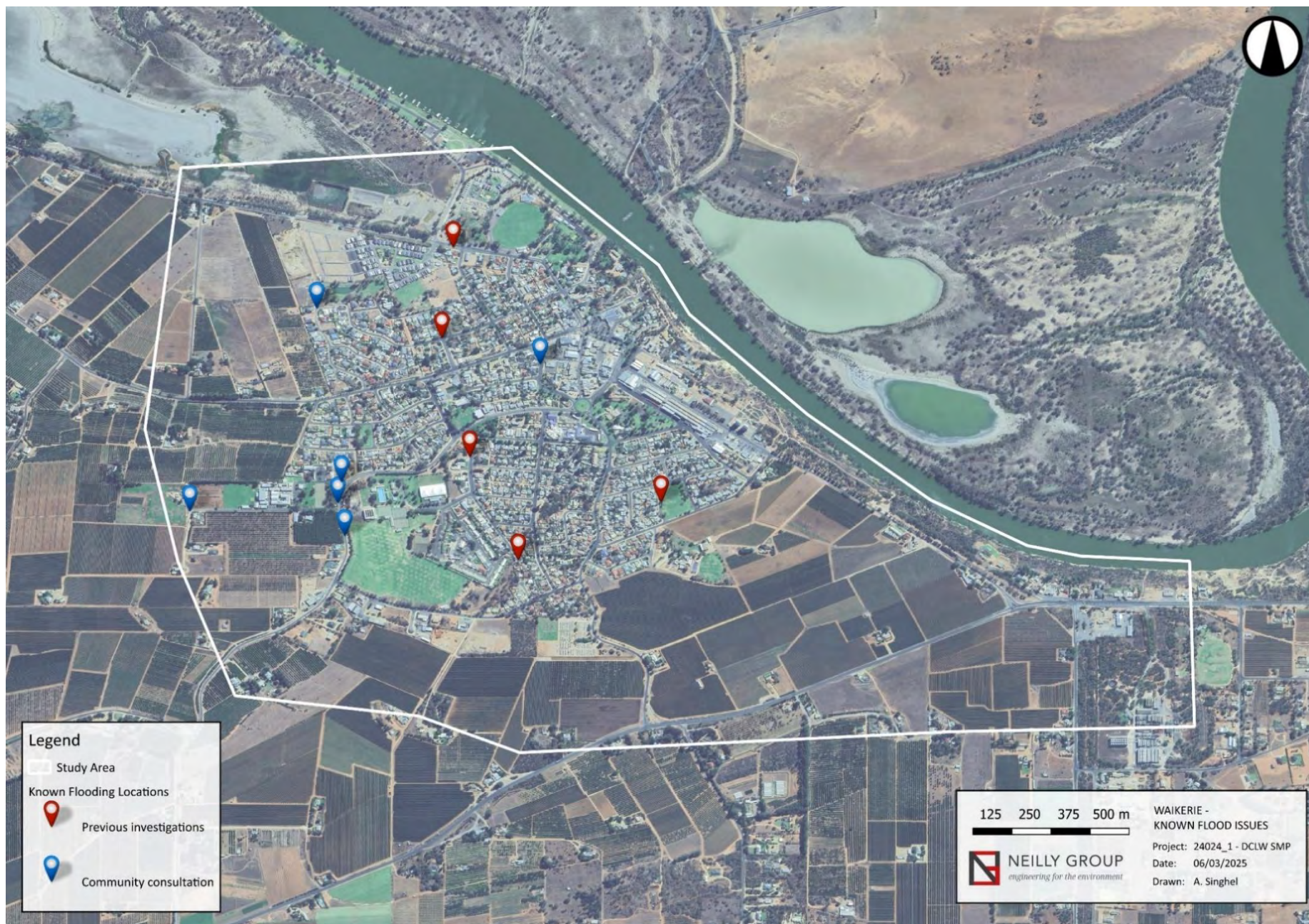


Figure 9. Locations of known flooding issues.

2.7. Water Allocation Plan

The Water Allocation Plan (WAP) for the River Murray Prescribed Watercourse (PWC) was regulated to protect the environmental, social and cultural aspects of the River Murray and boost the economic conditions. The aim of WAP is to supply clean water to the public and outlines how the River Murray water resources should be managed, focusing on principles for the take and use of water.

Its objectives include providing allocations for water-dependent ecosystems, ensuring equitable and sustainable water distribution, and promoting efficient use. The WAP prevents the loss of refuge habitats and aquatic life, protects water quality, and addresses issues such as soil salinity and acid sulphate soils. Figure 10 shows the portion of the study area that falls within the PWC. The remaining area falls under the Murraylands and Riverland Landscape Board's Water Affecting Activities (WAA) Control Policy (2011).

Per Murray-Darling Basin Authority (MDBA) 2021, country towns, including Waikerie, are entitled to total of 50 GL/yr (combined) for all consumptive purposes, and an additional 50 GL/yr is allocated for urban water supply by SA Water. The township receives water from the River Murray for various purposes, including stock and domestic use, urban water supply, irrigation, industrial activities, dairy farming, and environmental land management.

Engineering solutions likely to be recommended in the SMP will all be regulated according to the WAA Policy, rather than the WAP.

2.7.1. Water Affecting Activities

2.7.1.1. Stormwater capture and reuse

Adoption of stormwater capture and reuse strategies can reduce the town's reliance on external water sources. Implementing rainwater harvesting (e.g. rainwater tanks) and reuse systems (e.g. irrigation, toilets and laundry connections), will decrease dependence on potable water and help conserve freshwater from the River Murray.

Capturing stormwater can reduce runoff carrying pollutants into River Murray and mitigate the risk of localised flooding in urban areas. It will also ease the pressure on the stormwater drainage system and support sustainable urban water management. Furthermore, reusing captured runoff promotes a healthier environment, provides water for irrigation and landscaping, and benefits urban ecosystems.

2.7.1.2. Applicable regulations

Infrastructure relating to stormwater capture, detention, reuse and discharge is considered a WAA in the WAA Policy 2021, and are regulated according to Section 3 of the policy.

Proposed solutions will include assessment against the regulations in the SMP to aid in project planning.

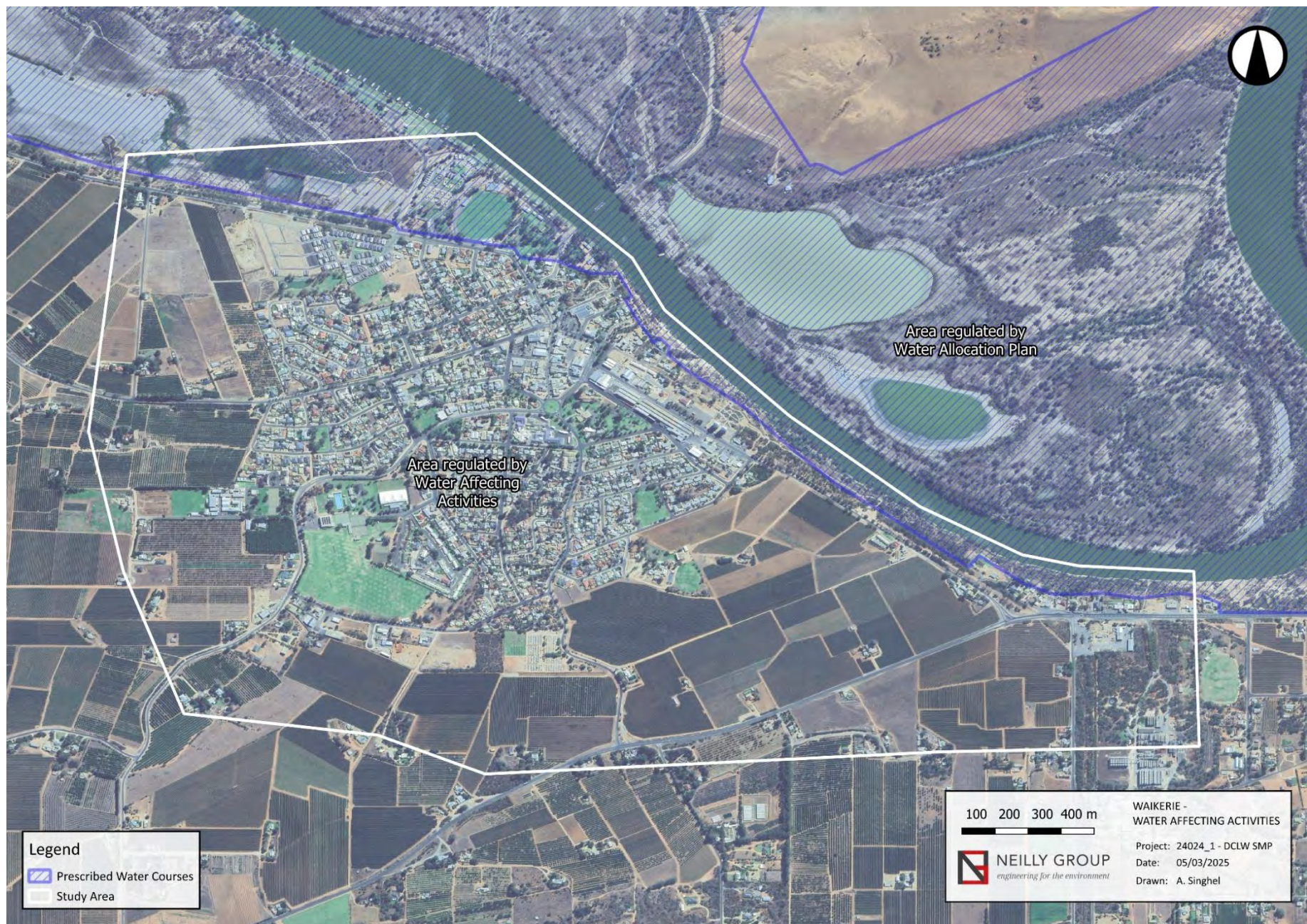


Figure 10. Areas affected by different policies (MDBA 2021).

2.8. Environmental values

2.8.1. Water quality

Water quality is a key environmental value within the Riverland, where urban stormwater runoff can directly influence the health of local waterways, wetlands and the River Murray. Urban development increases the extent of impervious surfaces such as roads, car parks and rooftops, resulting in greater runoff volumes, higher peak flows and reduced infiltration.

Stormwater runoff can transport a range of pollutants, including sediments, nutrients, hydrocarbons, heavy metals, litter and pathogens, into receiving environments. These pollutants can degrade water quality, impact aquatic ecosystems, reduce recreational values and contribute to the deterioration of River Murray water resources.

Stormwater management must balance water quality protection with opportunities for stormwater harvesting and reuse. Harvesting stormwater can provide a valuable alternative water source for irrigation of public open spaces, streetscapes, sporting facilities and other municipal uses, reducing reliance on River Murray allocations and other water supplies. However, stormwater intended for reuse must be appropriately treated to achieve the required water quality objectives and managed in accordance with relevant South Australian and Australian guidelines.

The SMP seeks to improve the quality of stormwater entering the drainage network and receiving waters through the application of water-sensitive urban design (WSUD) principles. The plan promotes the capture, treatment and beneficial reuse of stormwater while maintaining appropriate conveyance for flood management. Stormwater treatment measures will aim to reduce pollutant loads before discharge or reuse, thereby protecting downstream environmental values, including the River Murray and associated wetlands.

Potential management measures include the installation of raingardens, bioretention systems, vegetated swales, gross pollutant traps and permeable pavements. These measures can effectively reduce concentrations of sediments, nutrients and other urban pollutants, while also moderating runoff volumes and flow velocities. Retention and detention systems should be designed to achieve water quality objectives while maintaining adequate flow pathways and avoiding adverse impacts on downstream hydrology.

Where stormwater is discharged to waterways, energy dissipation structures, appropriately designed outlets and the establishment of native riparian vegetation can assist in minimising erosion and sediment transport. Riparian vegetation provides additional benefits by filtering runoff, stabilising soils, enhancing habitat connectivity and improving the ecological condition of waterways. Through the implementation of these measures, the SMP aims to protect and enhance water quality outcomes across the catchment while supporting sustainable stormwater reuse and the long-term health of the River Murray system.

2.8.1.1. Water quality assessment

Water quality assessment will be modelled using eWater's Model for Urban Stormwater Improvement Conceptualisation Version X (MUSIC). MUSIC is the industry standard for modelling water quality and WSUD treatment train effectiveness. MUSIC modelling will be undertaken to model existing water quality parameters, and then to model proposed effectiveness of the different solutions put forward in the SMP.

2.8.1.2. Types of pollutants and their sources

Suspended sediments

Suspended sediments are fine particles, like silt, clay and organic matter that degrade the quality of water by reducing light penetration. Suspended solids cause turbidity and lead to disruption of the aquatic environment. The sources of suspended solids include:

- Eroded and washed soil from construction sites
- Sediment-laden agricultural runoff, particularly from areas lacking vegetation and with ploughed soil
- Sediments released from natural erosion during heavy rainfall
- Sediments from exposed land, due to logging and deforestation
- Sediments from mismanaged waste disposal areas and landfills

Nutrients

Nutrients, especially nitrogen and phosphorous, when present in excess creates imbalance in nutrient cycles and ecosystem functions. The sources include

- Farmlands rich in fertilisers and animal manure
- Urban landscapes with fertilisers application on lawns and golf courses
- Poorly maintained septic systems with leakages
- Industrial discharge
- Atmospheric deposition of nutrients, especially nitrogen, from vehicle exhaust, industrial emissions, etc.

Gross pollutants

Gross pollutants are large waste material and cause significant harm to water quality and surrounding environment. The sources of gross pollutants are as follows:

- Litter and trash from public spaces, recreational areas and urban areas
- Waste from commercial and industrial sites
- Roads and highways with plastic bags and vehicle debris
- Construction debris
- Improper disposal of waste and poor management
- Wastewater overflow from improperly managed wastewater systems

Other contaminants

Metals

Metals often bind to sediments, leading to deposition and degradation of environment. Presence of harmful metals in stormwater runoff pose risks to natural resources and surrounding ecosystems. Metals can originate from various sources including vehicle emission, industrial activities, construction sites and atmospheric deposition. Lead and nickel often generate from vehicle emissions. Activities in the automotive industry release many metals. For instance, copper from manufacturing and repairing brake pads and zinc from manufacturing tires. Lead often comes from paints at construction sites or older infrastructure, chromium from metal plating and leather tanning and cadmium is released as a by-product from battery production.

Hydrocarbons

Contamination of stormwater by hydrocarbon indicates presence of petroleum-based products. These contaminants are sourced from urban and industrial areas where traffic and fuel consumption is common. Hydrocarbons can enter stormwater system from various pathways, such as fuel spills, industrial discharge, urban runoff and deposits from vehicle emissions.

Emerging Organic Contaminants (EOCs)

The term Emerging Organic Contaminants (EOCs) described new or previously less understood organic compounds that are now gaining attention due to their impacts on environment and public health. These contaminants can be sourced from pharmaceuticals, personal care products, industrial materials, pesticides and herbicides and other synthetic compounds.

2.8.1.3. Impact of pollutants

Receiving waters

Suspended sediment insertion to the River Murray increases water turbidity and hence restricts light penetration to support the photosynthesis of benthic vegetation (Rutherford et al. 2019). This prevents the growth of macrophytes that feed native fish and limits the development of submerged shrubs that control erosion. Suspended sediments in stormwater may settle on the riverbed and bury established flora, preventing the gas exchange that allows submerged flora to access oxygen.

Excess nitrogen and phosphorus contribute to a population boom of phytoplankton that raise levels of organic matter and consequently reduce oxygen in the River Murray (Verhoeven, Khan, & Evans 2024). Eutrophication in stagnant water like the River Murray in low rainfall years spawns blue-green algae (cyanobacteria) that multiplies exponentially. Cyanobacteria near the water surface impedes light penetration to macrophytes and can inhibit food sources for fish, waterbirds, and amphibians. Moreover, cyanobacteria are organic matter that draw oxygen from the water, reducing its quality and the health of its benthic ecosystems.

Gross pollutants may accumulate on the banks of the River Murray and continue to pollute land systems and waterways. Gross pollutants smother vegetation and prevent exposure to sunlight and carbon dioxide for photosynthesis. Declining growth of riverine vegetation hinders the growth and diversity of River Murray fauna. The consumption of gross pollutants by riverine fauna like fish and waterbirds may choke these animals or cause a plethora of digestive issues.

Excessive accumulation of metal cause toxicity, resulting in disruption of natural processes and ecological functions. The presence of hydrocarbons and EOCs can disrupt the aquatic habitat. EOCs can cause endocrine imbalance and disruption, affecting reproduction, growth and survival rates of aquatic fauna.

Stormwater reuse and impacts on settlement

Adequate treatment and proper reuse of stormwater can reduce reliance on potable water systems and freshwater resources. If not treated properly, collected runoff can nurture pathogens and harbour pollutants, posing risk to public health. Reusing untreated stormwater for irrigation and landscape watering can inadvertently harm local ecosystems by introducing pollutants and possibly invasive species into the environment.

Stormwater drains are primarily designed to redirect runoff and prevent accumulation. Gross pollutants may settle in stormwater pipes and catch suspended sediment to form sediment deposits. The sediment builds up in these drains creates obstruction limiting flow of stormwater through urban channels and causing flooding. Prolonged stagnation of stormwater can weaken the foundations of pipes and other urban infrastructure, escalating the risk of damage and expensive repairs. Sediment deposits can accumulate within stormwater drains and pipes, leading to blockages, reduced flow efficiency, and the increased need for regular maintenance. The deposition of sediment can cause corrosion which strains infrastructure and increase cost of maintenance. Blockages and damage within the drains and pipes can lead to sewer overflows, resulting in environmental pollution. This poses a risk to public health, surrounding structures and nearby ecosystems.

Water-dependent ecosystems

The pollutants and sediments in stormwater are capable to infiltrate groundwater supplies, potentially compromising groundwater quality and affecting local water sources. Sediment accumulation clogs soil pores and reduces rate of water infiltration. Consequently, there is a decline in rate of groundwater recharge and supply. Some sediments may carry harmful contaminants, like pesticide and heavy metals, which can have long-term effects on water quality. Excessive seepage of sediments raises turbidity of water making it unsuitable for consumption and irrigation. Excessive nutrients runoff reduces oxygen levels and increases the risk of nutrient pollution. Nutrient pollution causes eutrophication and acidification of groundwater and disrupts the aquatic ecosystems.

The sediment deposition can lead to destabilisation of soil and degradation of soil structure. The loss in structure reduces the soil's ability to retain moisture. The aggregation of sediments limits the process of soil aeration and causes soil compaction, leading to restricted microbial activity and root growth and increased surface runoff. The deposition of harmful contaminations along with sediment can pollute the soil and harm the ecosystem.

The build-up of nutrients can disrupt the natural life cycles and create soil imbalances. Consequently, this can lead to poor soil quality and reduced productivity and fertility. Nutrient pollution in soil can be determined by increased pH and increased salinity. Nitrogen and phosphorus present in stormwater may drain into groundwater deposits and reduce water quality. In stagnant water bodies, eutrophication is significantly more prominent and may induce cyanobacterial growth that salinises and acidifies groundwater (Mosley et al. 2023). In Waikerie, a major decline of groundwater quality could impinge both agricultural and horticultural growth.

Contamination of wetlands and floodplains from stormwater runoff can reduce the water holding capacity, leading to more frequent flooding. In addition, wetlands are healthy water-dependent ecosystems that store carbon. However, when exposed to pollutants and contaminants, wetlands can diminish the ability to capture and store carbon.

Hydrocarbons and EOCs can degrade water quality, making it unusable for consumption, recreational activities, irrigation and agriculture. Metals, hydrocarbons and EOCs can accumulate in soil and groundwater and impinge plant growth. Possibly, these contaminants can enter the food chain and poses health risks to human.

2.8.2. Threatened Ecological communities

The Protected Matters Search Tool (PMST), under Environment Protection and Biodiversity Conservation (EPBC) Act 1999, was launched to identify threatened/sensitive ecological communities in and around the region of Waikerie. The community identification and status are shown in Table 5.

Table 5. Listed threatened ecological communities

Community name	Threatened category	Presence text
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered	Community may occur within area
Mallee Bird Community of the Murray Darling Depression Bioregion	Endangered	Community likely to occur within area
Plains mallee box woodlands of the Murray Darling Depression, Riverina and Naracoorte Coastal Plain Bioregions	Critically Endangered	Community may occur within area

(Source: Protected Matters Search Tool, 03 March 2025)

2.8.3. Watercourse assessment

2.8.3.1. River Murray

The state of the River Murray is generally considered to be poor, heavily impacted by human activities – especially the introduction of the locks in the mid-1930's which led to decades of constant water levels. These constant water levels have severely deteriorated bank conditions and the health of riparian vegetation through two mechanisms:

1. Constant water levels remove the natural flow variability that supports healthy soils and vegetation. Soils above the pool level gradually dry out, vegetation - a key part of binding soils together – begins to die and banks become more unstable leading to increased erosion.
2. Boat wake becomes concentrated on specific sections of the weakened bank further increases erosion.

However, the effects of this are largely outside of the study area –protected by the cliffs and the temporary levee raised along Leonard Norman Drive.

Community amenity is provided along the waterfront running from the ferry crossing past the caravan park to the houseboat moorings, and the new Hart Lagoon wetland. This study considers the area bounded by Leonard Norman Drive, plus the wetland which serves as the final destination for ~75% of the town's stormwater runoff.

2.8.3.2. Hart Lagoon

Hart Lagoon is a large natural wetland and floodplain to the northwest of the town of Waikerie that receives approximately 75% of the town's stormwater runoff. The Hart Lagoon constructed wetland

and stormwater reuse project captures and treats this water, reusing the majority for irrigation of local parks and gardens to reduce the town's reliance on the River Murray.

The series of treatment and storage ponds overflows into Hart Lagoon and has been designed to reduce pollutant levels and receive flows that are estimated to pre-development. For the purposes of this project, only changes to the expected outflows from the wetland to the greater Hart Lagoon will be assessed and commented on.

2.9. Social, socioeconomic and cultural values

Waikerie's climate and abundance of natural environments have a major beneficial impact on its social and economic values (DCLW 2019). Waikerie's riverfront living opportunities and tight-knit community lifestyle appeals to both retirees and tourists. The retirement community in Waikerie is noticeably more substantial than that of families and professionals, evident in Figure 11.

Retirees and tourists value the views and activities offered by the River Murray, like riverfront walking trails, fishing, and water sports. Waikerie's community culture stems from local businesses that dominate shopfronts across the town, as well as its many sporting clubs and retirement communities.

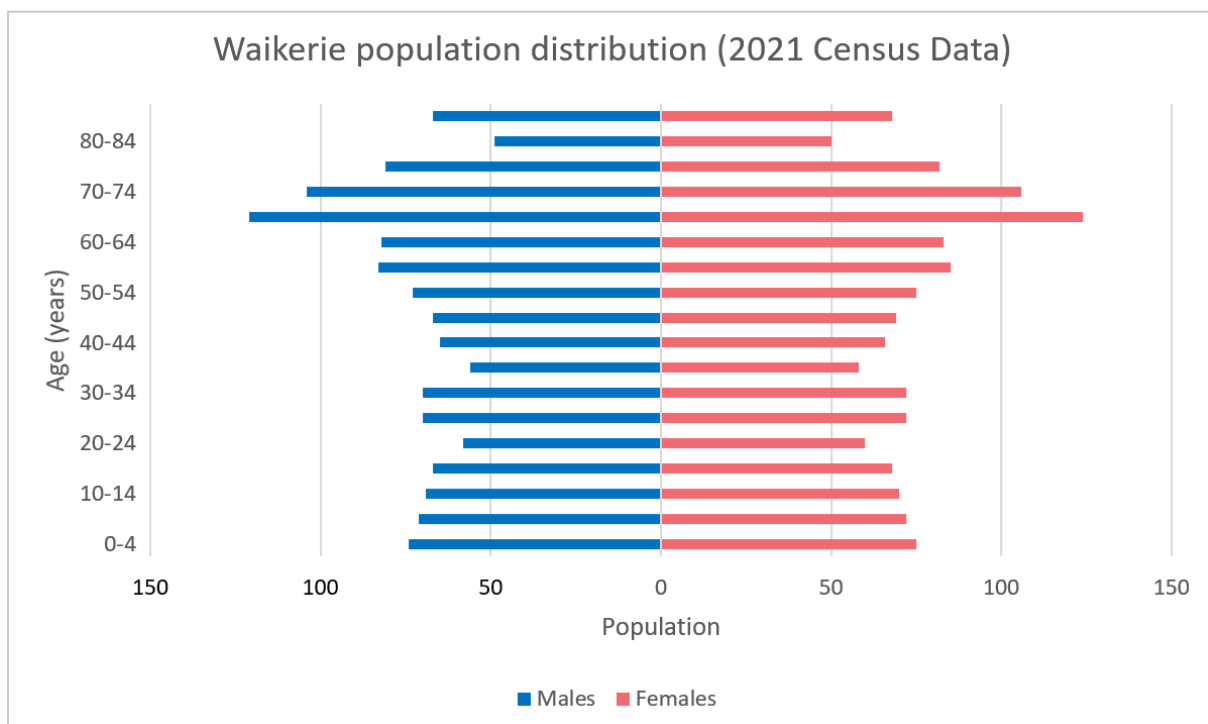


Figure 11. Population distribution graph of Waikerie

Waikerie's primary employment industries are agriculture, retail, and healthcare. Agriculture is the primary employer in Waikerie, employing 23.8% of its residents and contributing to 41% of the region's economy (DCLW 2019). Healthcare and retail services are crucial in Waikerie to provide essential goods and services to the town's aging population.

Waikerie showcases its culture in the form of artwork in numerous galleries and renowned silo painting. The rich history of the town is presented at the Waikerie Institute, Pioneer Memorial

Gardens, and Machinery Preservation Society. Waikerie's main attractions are the many camping locations, clifftop walks, and lookout sites along the River Murray.

Waikerie is settled on Ngawait land near the Ngarkat, Ngarrindjeri, and Erawirung mobs across the Riverland. Waikerie was originally named "Wei Kari" by custodians on the Ngawait land whose livelihoods were supported by the resources of the River Murray for millennia. The Ngawait people place significant cultural and spiritual value on the River Murray and its natural environments, particularly among historically inhabited sites that showcase middens, canoe trees, and clay stoves (DEW 2024).

2.10. Development policy

A map outlining the Planning and Design Code (P&D) zones for the township of Waikerie has been created and is presented in Figure 12. The P&D zones shapefile is sourced from the Department of Housing and Urban Development.

The P&D zones map highlights the predominance of rural horticulture. A caravan and tourist park is located in the north of Waikerie. Smaller areas are designated for rural living, neighbourhood, rural neighbourhood, and infrastructure zones. Additionally, there are minor portions allocated to recreation and other uses.

2.10.1. Council's Growth Management Plan

Waikerie is a service centre offering retail, cafes, education, healthcare, sports facilities, and accommodation to support its population and surrounding areas. The Waikerie Community Sports Complex and secondary facilities provide diverse recreational options, while the town's layout and open spaces promote walkability and healthy, active lifestyles for residents. The town is well-equipped with infrastructure, including water, electricity, and a Community Waste Management System (CWMS).

Per council's Growth Management Plan (DCLW 2024), the strategies focus on creating a vibrant and connected township by maintaining a compact, mixed-use, walkable neighbourhood that encourages social interaction and reduces car dependence. Coordinated signage and marketing efforts will help attract visitors from the Sturt Highway, positioning the town as a gateway to the Riverland. Protecting scenic areas and ecological corridors will enhance the town's visual appeal. Additionally, revitalising the main street through strategic investment and rejuvenation will help improve the town's overall atmosphere and attract more visitors. Key priorities include upgrading the eastern riverfront for better connectivity, developing an events plan to attract visitors, diversifying housing options for affordability, and increasing public art installations. A coordinated signage and marketing strategy will draw visitors from the Sturt Highway, aiming to enhance the town's liveability, cultural appeal, and tourism engagement.

The Growth Management Plan (DCLW 2024) outlines three regions of focus Residential Growth areas, Future Employment areas and Future Proof Land area. A set of five services are termed as supporting infrastructure requirements of three residential and one employment growth areas. The services include wastewater, potable water, communications, electricity and traffic.

The Future Proof Land Area is proposed for rezoning from neighbourhood to Deferred Urban to preserve the land for future development, supporting population growth and providing a logical extension of the township near the Waikerie Lutheran Primary School. Considering current population trends, the Council has chosen a medium growth scenario for Waikerie and has adequate land available for the next 10 to 15 years.

2.10.2. Value mapping

Figure 13 illustrates locations of cultural heritage significance at Waikerie. The heritage places shapefile is sourced from the Department of Housing and Urban Development. Per this dataset, historical site categorised, Former Irrigation Pumping Station Chimney, is the only site recorded for heritage importance at Waikerie

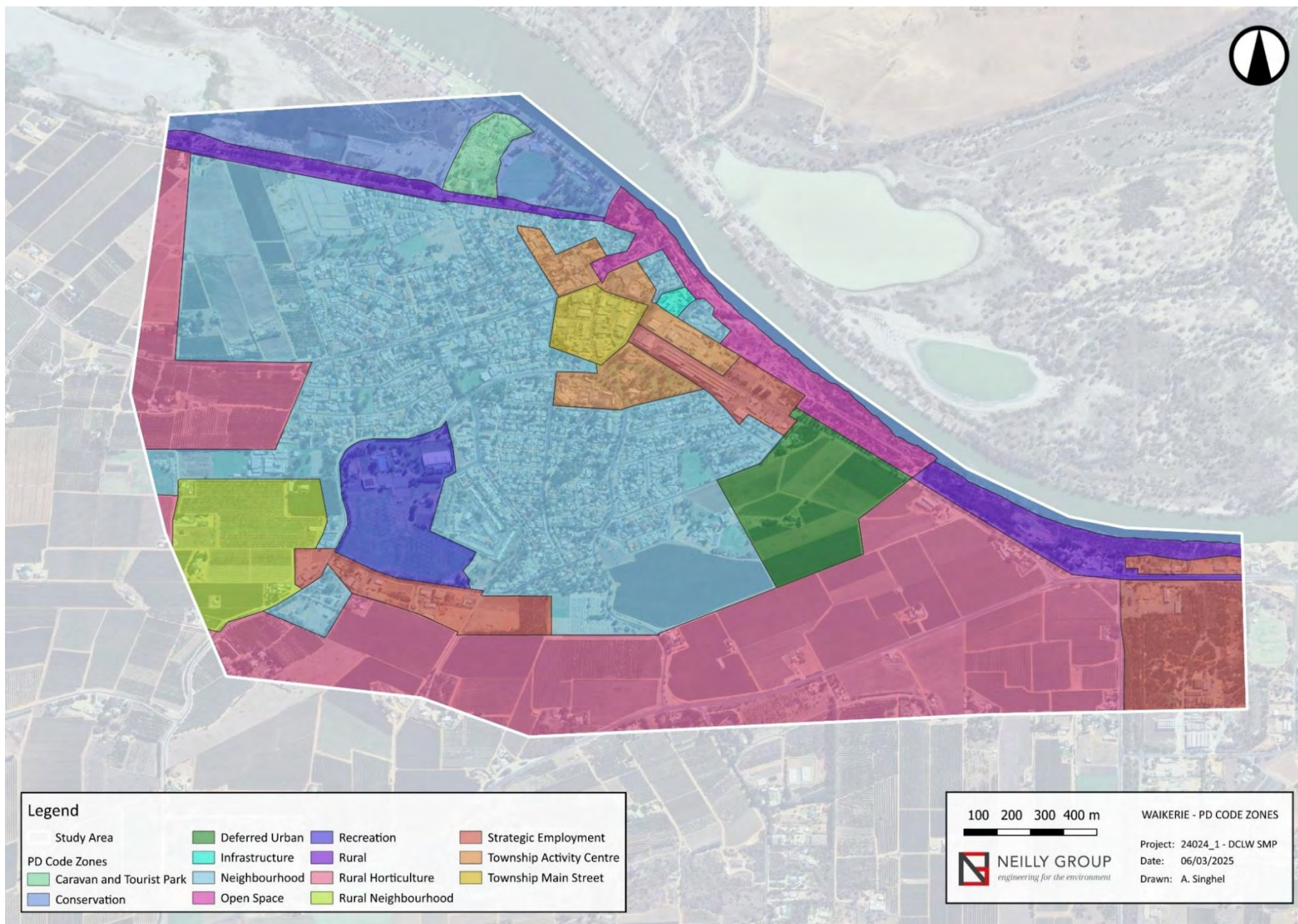


Figure 12. Planning & Design Code Zones



Figure 13. Cultural heritage sites.

3. Flood Modelling and Validation

Flood modelling was undertaken to provide a detailed analysis of the township's stormwater drainage performance under existing and future growth scenarios. The modelling integrates DRAINS for hydrology and TUFLOW (1D/2D) for hydraulics, leveraging updated LiDAR datasets (2021 and 2024), verified pipe and pit data from field inspections, and rainfall inputs based on Australian Rainfall and Runoff (ARR v4.2) guidelines. The outputs provide a comprehensive understanding of drainage system performance, overland flow paths, and vulnerabilities, validated through field observations and community feedback.

3.1. Events and scenarios

Flood modelling was undertaken for the following events and scenarios.

Events:

1. 18% AEP
2. 10% AEP
3. 5% AEP
4. 2% AEP
5. 1% AEP
6. 0.2% AEP (modelled as the 1-in-500 yr event)

The flood impact assessment undertaken throughout this report recognises the minor event as 18% AEP and the major event as 1% AEP.

Scenarios:

- a. **Existing conditions** – existing conditions, using hydrologic inputs modified (*using SSP1-2.6 and the year 2030 – see Section 3.2.2*) to reflect changes that have already occurred as a result of climate change, per latest ARR recommendations.
- b. **Ultimate development** – existing infrastructure, assuming future development and future climate change conditions to the year 2100.
- c. **Post mitigation** – proposed remediation designs, modelled with future development and future climate change conditions to the year 2100.

Note- Throughout this report, events will be referred to by Event-Scenario combinations, e.g. 1a refers to the 18% event under existing conditions.

Durations:

All available storm durations from the 10-minute to the 72-hour storm were modelled, plus the 96-hr storm was modelled for a few selected events as necessary upon viewing results. Critical duration was then determined uniquely across the entire model area.

3.2. Hydrology (DRAINS)

Hydrology was modelled using DRAINS, simulating runoff volumes and timing from individual sub-catchments. Impervious/pervious ratios were derived from GIS and aerial imagery. Hydrographs for each sub-catchment were generated and exported for hydraulic analysis, ensuring runoff behaviour reflected local conditions.

3.2.1. IL-CL model

Table 6 presents the final loss parameters adopted for the model. A detailed description of the IL-CL model development is included in Attachment B.

Table 6. Loss parameters for hydrologic modelling.

	Initial Loss (mm)	Continuing Loss (mm/hr)
EXISTING CONDITIONS		
(Recommended multiplier)	1.04	1.08
Impervious Area	2	0
Pervious Area	36	2.5
FUTURE CONDITIONS		
(Recommended multiplier)	1.07	1.17
Impervious Area	2	0
Pervious Area	37	2.7

3.2.2. Rainfall Data

Rainfall data was downloaded from the ARR Data Hub and the Bureau of Meteorology (the Bureau) website. Rainfall depths were then modified using Watercom's CCRM to reflect conditions (see Table 7). Design rainfall depths for all scenarios are provided in Attachment B.

Table 7. Chosen SSP scenarios for the study

Scenario	Shared Socio-economic Pathway (SSP) Scenario	Target Horizon (/Design) Year
Current conditions	SSP1-2.6 Low emissions/warming, "Sustainability"	2030 <i>Midpoint of 'current/near-term horizon'</i>
Future conditions	SSP2-4.5 Moderate emissions/warming, "Sustainability"	2090 <i>Midpoint of 'long-term horizon'</i>

3.2.3. Catchments

Catchments were determined for each stormwater inlet location, where water can enter the underground network. Additional catchments were also defined for large areas where there is no stormwater network in locations where it was considered a pit may be warranted. For locations where two side entry pits are connected via a short length of pipe, the catchment area of the upstream pit was determined, and downstream pits, which have negligible catchment areas, were included within the catchment area of the next inlet location downstream.

3.2.3.1. Pervious and impervious percentages of catchments

Catchments were set up using the 'Abbreviated data' method. Catchment imperviousness was determined by visually assessing aerial imagery and categorising blocks according to density.

Percentages for sample sub-areas were determined, then averaged to produce approximate percentages for each classification – shown in Table 8.

These were converted to raster layers for Directly Connected Impervious Area (DCIA) and Remaining Impervious Area (RIA), representing ‘Paved %’ and ‘Supplementary %’, respectively, then zonal statistics was then used for the sub-catchment to determine unique impervious percentages for each sub-catchment. DCIA values across the study area for existing conditions are shown in Figure 14.

Table 8. Impervious percentages for each land use classification.

Classification	Paved (%)	Supplementary (%)	Pervious (%)
Road / other isolated DCIA	100	0	0
RIA (isolated buildings)	0	100	0
Very high density	90	0	10
High density	70	15	15
Med-high density	55	15	30
Medium density	50	10	40
Low density	30	10	60

3.2.3.2. Updated pervious and impervious percentages for future scenarios

The ultimate development scenario projected changes to the current conditions by considering the following sources:

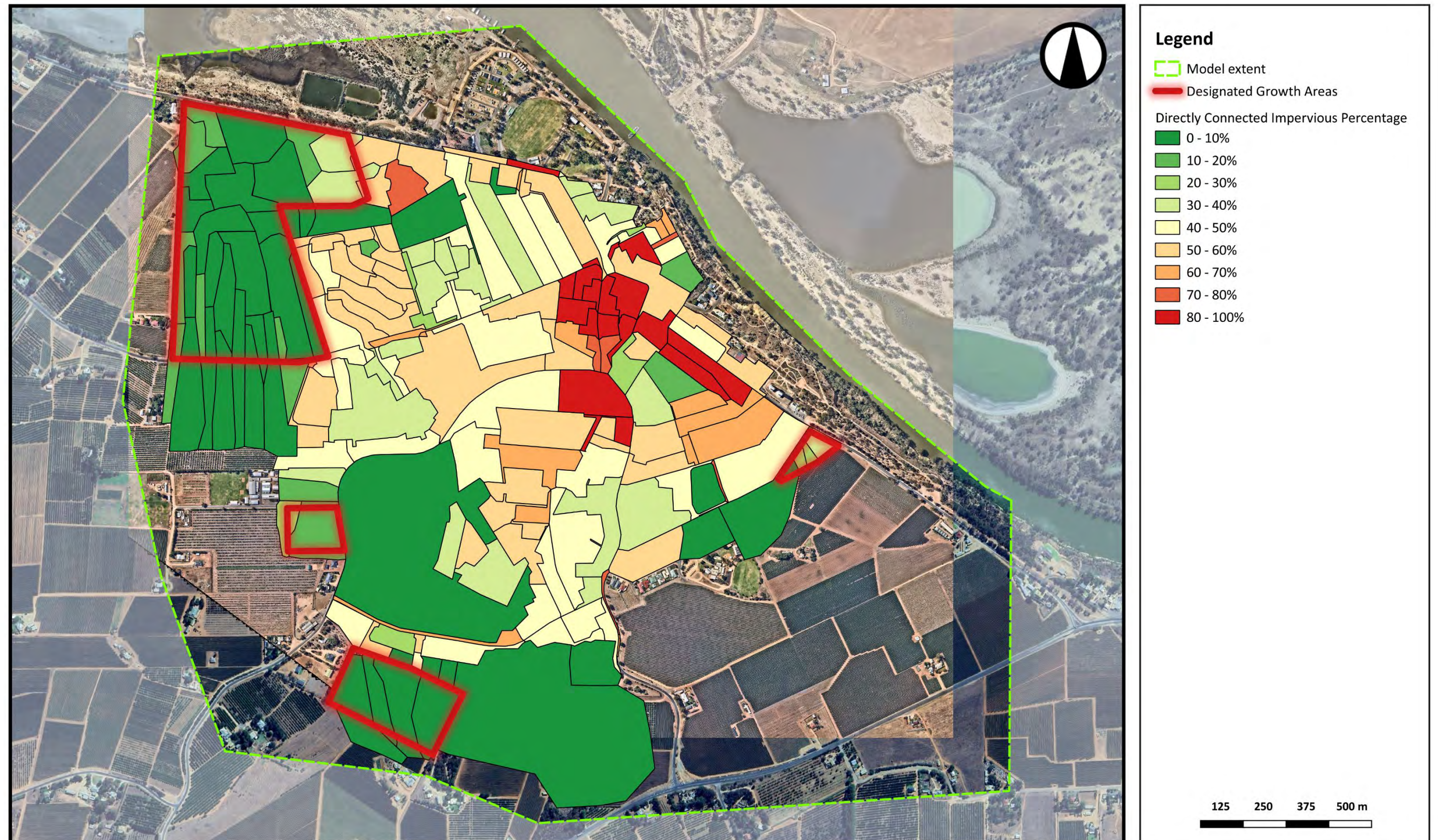
1. Council’s Growth Plan (DCLW & URPS, 2024)
2. The online South Australian Property & Planning Atlas (SAPPA)
3. Population Projections for South Australia and Regions – 2021 to 2051 (PlanSA 2023)

Calculation of population increase and changes to land classification for the ultimate development scenario can be found in Attachment B.

Changes were then made to impervious percentages for the ultimate development scenario, which are shown in Table 9 below. The percentages for Low and Medium Density areas were increased slightly to accommodate additional outbuildings. The resulting DCIA values for ultimate development are shown in Figure 15; the change in percentage points (e.g. 30% → 50% expressed as 20% change) is shown in Figure 16.

Table 9. Changes to impervious percentages for the ultimate development scenario.

Classification	Paved (%)	Supplementary (%)	Pervious (%)
Medium density	52.5 (+2.5%)	10	37.5
Low density	35 (+5%)	10	55



WAIKERIE STORMWATER MANAGEMENT PLAN

DIRECTLY CONNECTED IMPERVIOUS AREA - SCENARIO A

Project: 24024 - Waikerie SMP

Revision: 1

Date: 30/06/2026

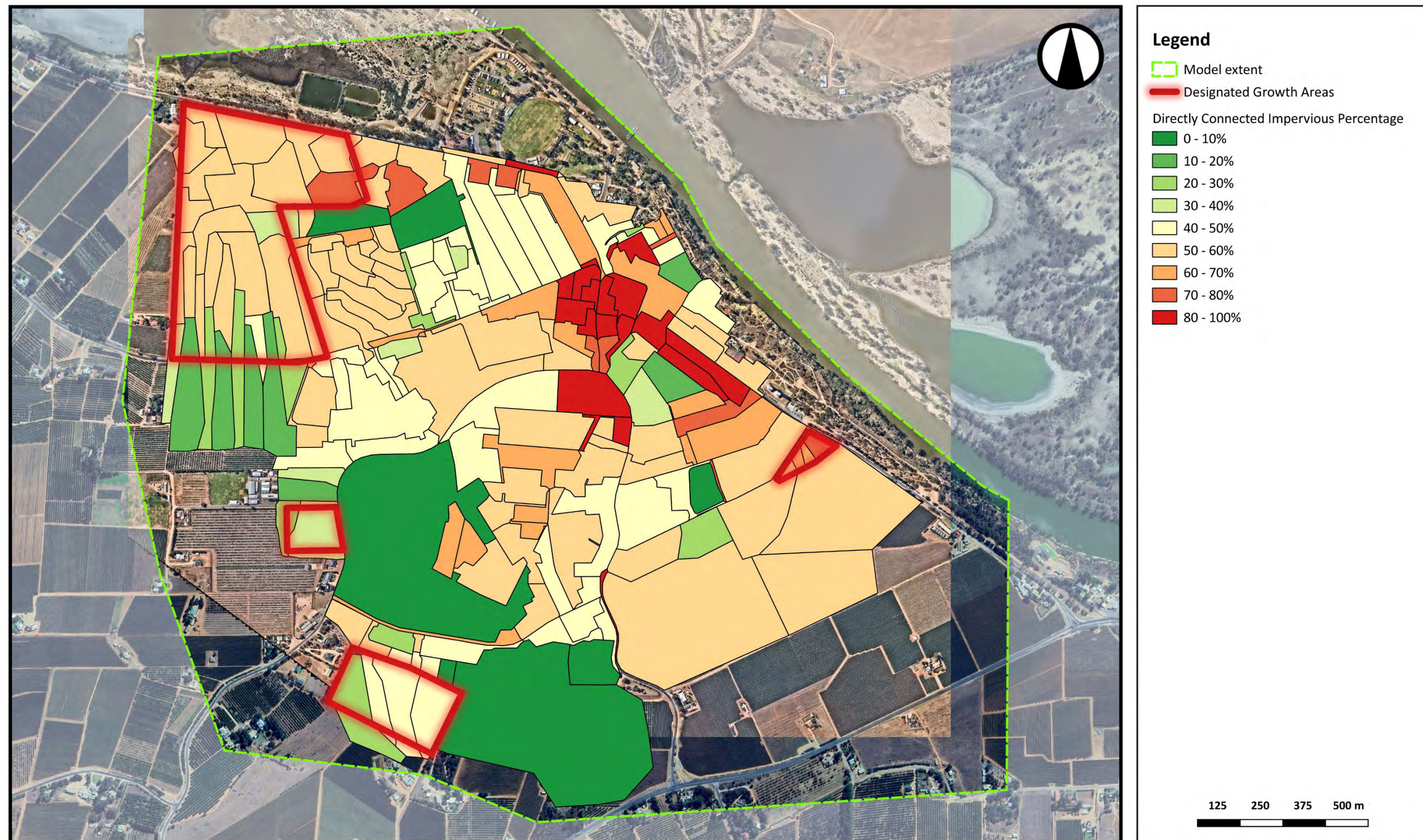
Coordinate System: GDA2020 / MGA zone 54

Drawn: B. Hennekam

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 14. Directly connected impervious areas for Scenario A.



WAIKERIE STORMWATER MANAGEMENT PLAN

DIRECTLY CONNECTED IMPERVIOUS AREA - SCENARIO B + C

Project: 24024 - Waikerie SMP

Revision: 1

Date: 30/06/2026

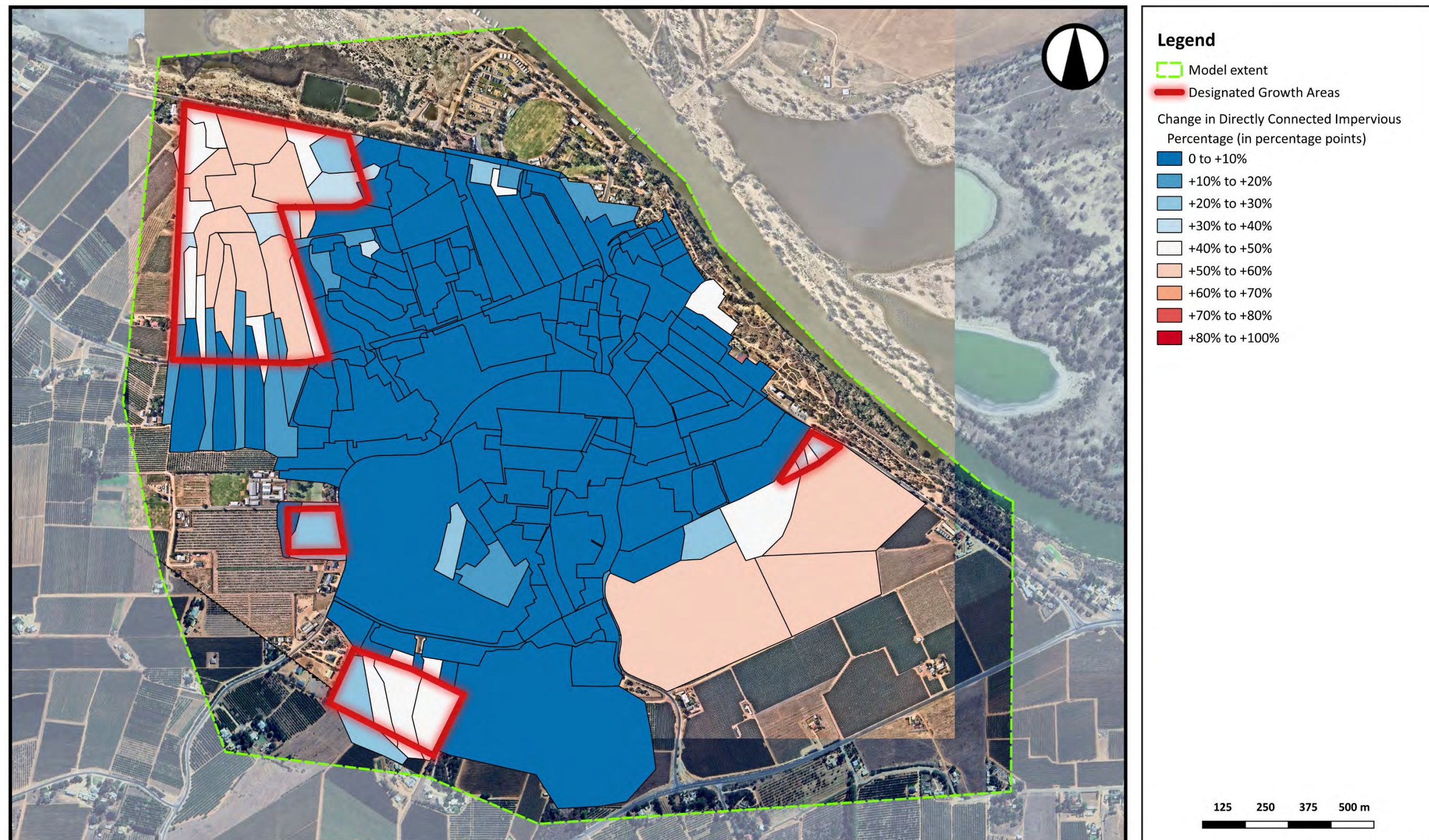
Coordinate System: GDA2020 / MGA zone 54

Drawn: B. Hennekam

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 15. Directly connected impervious areas for Scenarios B & C.



WAIKERIE STORMWATER MANAGEMENT PLAN

CHANGE IN DIRECTLY CONNECTED IMPERVIOUS AREA

Project: 24024 - Waikerie SMP

Revision: 1

Date: 30/06/2026

Coordinate System: GDA2020 / MGA zone 54

Drawn: B. Hennekam

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 16. Change in directly connected impervious areas (expressed in percentage points).

3.3. Hydraulics (TUFLOW)

Hydrographs from DRAINS were imported into TUFLOW, which integrates 1D pipe network hydraulics with 2D surface flooding modelling. This allowed detailed simulation of both underground capacity and overland flow paths. Road profiles, basin storage, and terrain features were incorporated to accurately predict flooding depth, extent, and duration.

An initial model was developed and calibrated in consultation with Council, using the equivalent of a known storm event for which Council have photographic evidence.

All ten (10) temporal patterns, across 20 durations of all six (6) events were modelled and assessed to determine critical durations across the study area, allowing for spatial variations in observed maximums.

3.4. Drainage network

Council provided shapefiles of the drainage network in Waikerie, which was updated during a Condition Assessment prior to the commencement of modelling. The updated network information was used as the basis for modelling, with additional information obtained from Council, where possible, or infilled using assumptions based on professional judgement in line with current best practice principles, for example missing invert levels were assumed using the formula:

$$\text{Surface} - 600\text{mm cover} - \text{pipe diameter}$$

Where measured values were available, these were preferenced for the surface level in the above calculations: if not, the Digital Elevation Model (DEM) from the LiDAR was used. Levels were then assessed and adjusted via linear interpolation, where necessary, to ensure continuation of gravity flow.

All outlets to rivers or basins were assumed free draining.

3.5. Adopted parameters

3.5.1. Model domain and resolution

The model domain was set to encompass the whole town, planned growth areas and their respective contributing catchment areas. The 2D model used a 4m cell size, with Sub Grid Sampling (SGS) set to the resolution of the DEM. SGS is a relatively new feature within TUFLOW, that allows water to enter a cell based on the lowest point along its side walls, not just based on the cell centre elevation, which allows for greater accuracy in modelling with larger cell sizes.

The final model used TUFLOW's Quadtree feature, which allows for higher resolution in determined model areas, to reduce cell sizes around the road network to a cell size of 1m to optimise water-pit interactions.

3.5.2. Digital Elevation Model

The model's Digital Elevation Model (DEM) was built using 2024 LiDAR data where available, with 2021 LiDAR filling gaps. No adjustments were made at the join, which was typically less than +/- 100 mm, and only affected approximately 5% of the entire model domain – at the south-western corner. The join cuts across Growth Area 4, but does not appear to impact results in any noticeable way.

3.5.3. Topographic modifications

To better represent true ground conditions, the following topographic adjustments were made:

- The open channel adjacent to Goodchild St was modelled in the 1D domain to allow for more accurate representation of the channel shape.
- The 2021 LiDAR surface was stamped over the 2024 surface at the Mary Starr basin, as there was less water in the basin at this time and shows the base surface for most of the basin. (Note that care was taken to retain the changes to the basin outlet structure and overflow pathway.
- Fencelines were added as break lines on laneway boundaries to better reflect flows down laneways, per Council's preference.
- For the riverine flood scenario, the levee that cuts the Hart Lagoon wetland complex was filled in and the one-way gate at the outlet of the pipe from the sediment bay to the main wetland closed off, per design and Council intentions in such an event.

3.5.4. Surface roughness

TUFLOW models bed resistance using GIS "Materials" layers that specify the Manning's surface roughness coefficients (n values) to be used at any given location. The categories of areas used for this project, and the corresponding Manning's n values can be found in Attachment B.

3.5.5. Basins

There are two main permanent waterbodies in Waikerie – the Mary Starr Basin, and the Hart Lagoon wetland and stormwater harvesting system (all future references to "Hart Lagoon" or "the Hart Lagoon system" in the remainder of this report refer to this system, and not the larger natural wetland that it feeds into).

The Hart Lagoon system was constructed in 2024 is shown empty in the 2024 LiDAR. The Mary Starr Basin has approximately 1.7m additional water in it, above the level shown in the 2021 LiDAR, which looks close to empty. Therefore, the 2021 LiDAR has been used to patch the DEM, however the 2024 level has been set as the initial water level for the basin. Design Nominal Water Levels (NWL's) have been used for the Hart Lagoon System.

3.5.6. Inflows

The model used hydrographs from DRAINS placed directly at pits in the 2D model. TUFLOW then routed water into the underground network using its standard pit inlet routines (curves), based on the Engelund loss approach, with any excess flowing overland. To capture areas without enough drainage or with high roadside flows, extra catchments and sub-catchments were added, and their hydrographs were placed directly in the 2D model to improve accuracy and support planning.

3.5.7. Pumps

The only pump within the network is connected to the depression at the Community Sports Complex. The exact outlet of this pump is unknown, although it has been confirmed that it sends water to the upper Cates St section of the network.

Modelling assumptions have been used in line with previous modelling work, outlined below:

- Initial status – OFF (starts when wet)
- Pump rate – 25 L/s
- Outlet diameter – 100 mm
- Outlet location – Double SEP (#SWN0387) in front of the Lutheran Social Centre (Cates St)

3.6. Assumptions and limitations

The modelling approach is appropriate for a study of this scale but includes assumptions that limit its use for detailed, site-specific assessments.

Urban sub-catchments were assumed to drain to the fronting street. Available stormwater information for the Lifestyle Village was incorporated; however, detailed future assessments should rely on the developer's drainage model.

Limited information was available for some drainage connections, culverts and kerb cut-throughs. Where possible, these were included based on available data or aerial imagery; otherwise, they were excluded. The Waikerie Football Club drainage was not modelled as it operates independently of the broader stormwater network.

Pipe sizes and directions were verified during field inspections, with unconfirmed assets either removed or retained based on available data. Recommendations include CCTV inspections of critical pipelines to confirm capacity and condition.

Pipe invert levels (ILs) were determined using measured values where possible, supplemented by calculations or DEM estimates, and adjusted to ensure gravity flow through linear interpolation, as described in Section 3.4. The model followed industry-standard IL-CL methods, while soil and groundwater interactions, such as seepage from unlined basins, were not modelled.

3.7. Validation

Model validation was undertaken in conjunction with council, in the absence of recorded flow data, using photography from the event on 24 Nov 2021. Bureau records show the following rainfall total for this period (see Table 10), which is the rainfall total for the 24hrs to 9am on the date recorded.

Table 10. Events used for model validation

Station Name	Waikerie Council Works Depot	Duffield Ramco	Waikerie (Eremophila Park)
Station ID	24038	24031	24029
Distance from Waikerie	2.5 km	15.0 km	19.3 km
Rainfall (mm)			
24 Nov 2021	No Data	2.8	15.2
25 Nov 2021	No Data	12.0	10.0

The absence of data for the Council Depot station, and variance between the other two, makes it difficult to determine actual rainfall for this event – especially considering Bureau data is recorded at 24-hr intervals.

Council staff estimated about 40mm fell in 2 hours, with Eremophila Park records suggesting prior rainfall had already saturated the catchment.

Council confirmed the model results were broadly accurate but highlighted areas needing adjustments to better reflect observed flooding, including:

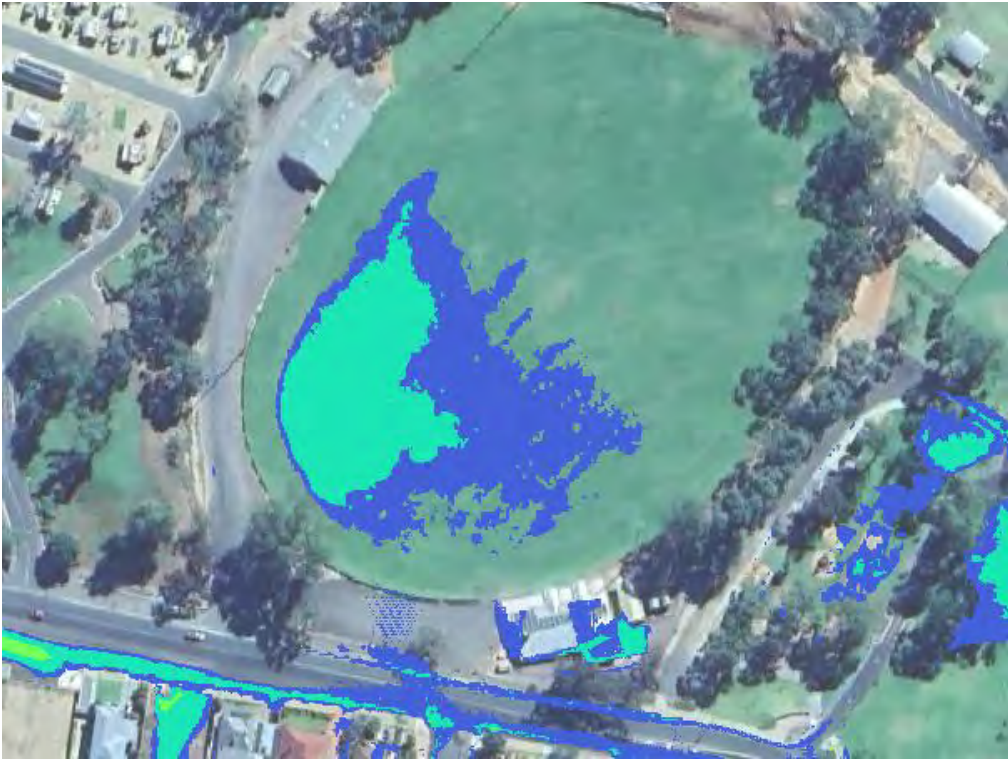
- More water along laneways from Coombe Terrace to Peake Terrace.
- Overland flows from a partially blocked open channel pipe connection.
- Increased flooding on Pflaum Terrace, Strangman Rd, and Miller St.
- Kerb overtopping on Cates Ave and water flowing into vineyards near Smith Dr and the cemetery.

Model adjustments included:

- Adding fencelines to keep flows within laneways (to correct DEM smoothing).
- Splitting flow inputs to show realistic flow paths and kerb overtopping.
- Removing unverified pipes, allowing surface surcharging (Pflaum Terrace).
- Expanding Quadtree areas for better flow representation.

The final validated model results and comparison photos are presented in Table 11.

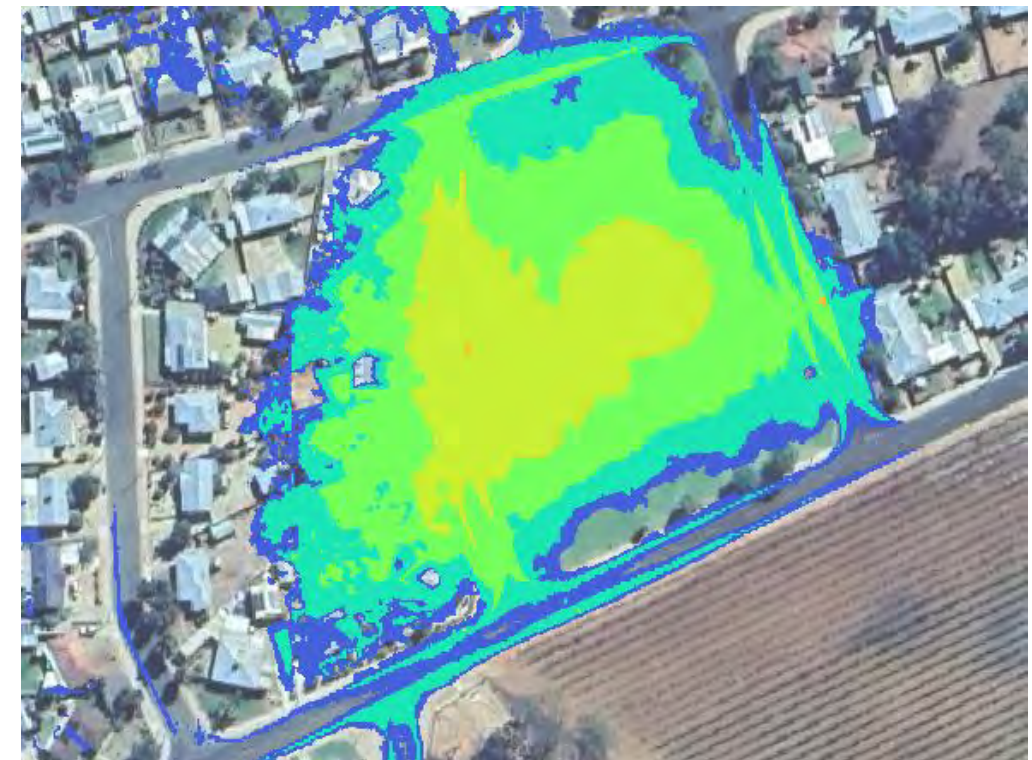
Table 11. Model validation.

Photo(s) from event		Model results
Looking from football club carpark over oval.		
		
Looking north-west across the intersection of McCutcheon & Barclay St.		
		

Ifould Park, viewed from Dunning St.



Viewed from Jacobs St, looking north up Wohling St



Photo(s) from event

Cates St, looking south towards Lutheran Social Centre



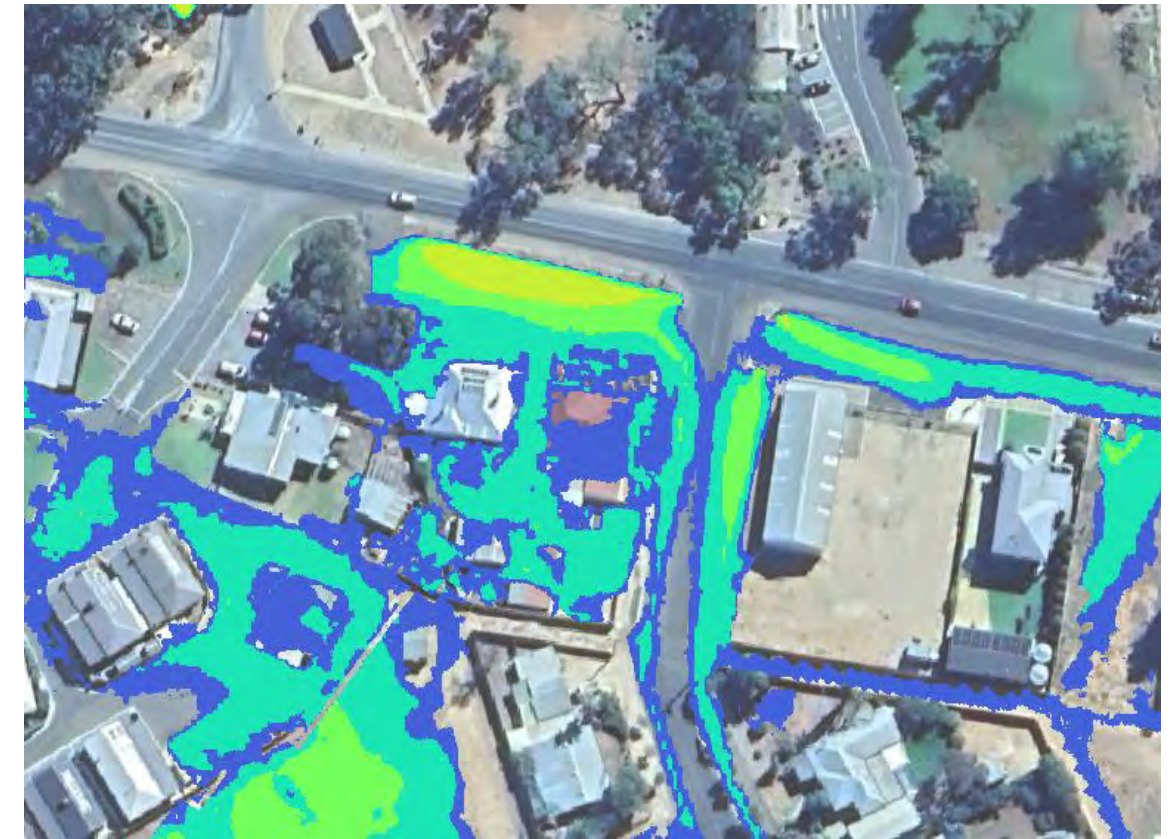
Model results



Kirby St, looking west towards 45-47 Peake Terrace



Looking south towards Coombe Terrace



4. Flood Modelling Results

Flood maps for all modelled events are in Attachment C (Existing Conditions) and Attachment D (Ultimate Development).

Waikerie can be divided into three main areas:

- **Upper section (A):** High plateau
- **Middle section (B):** Steep slope between upper and lower areas
- **Lower section (C):** Floodplain

These sections are shown in Figure 17.

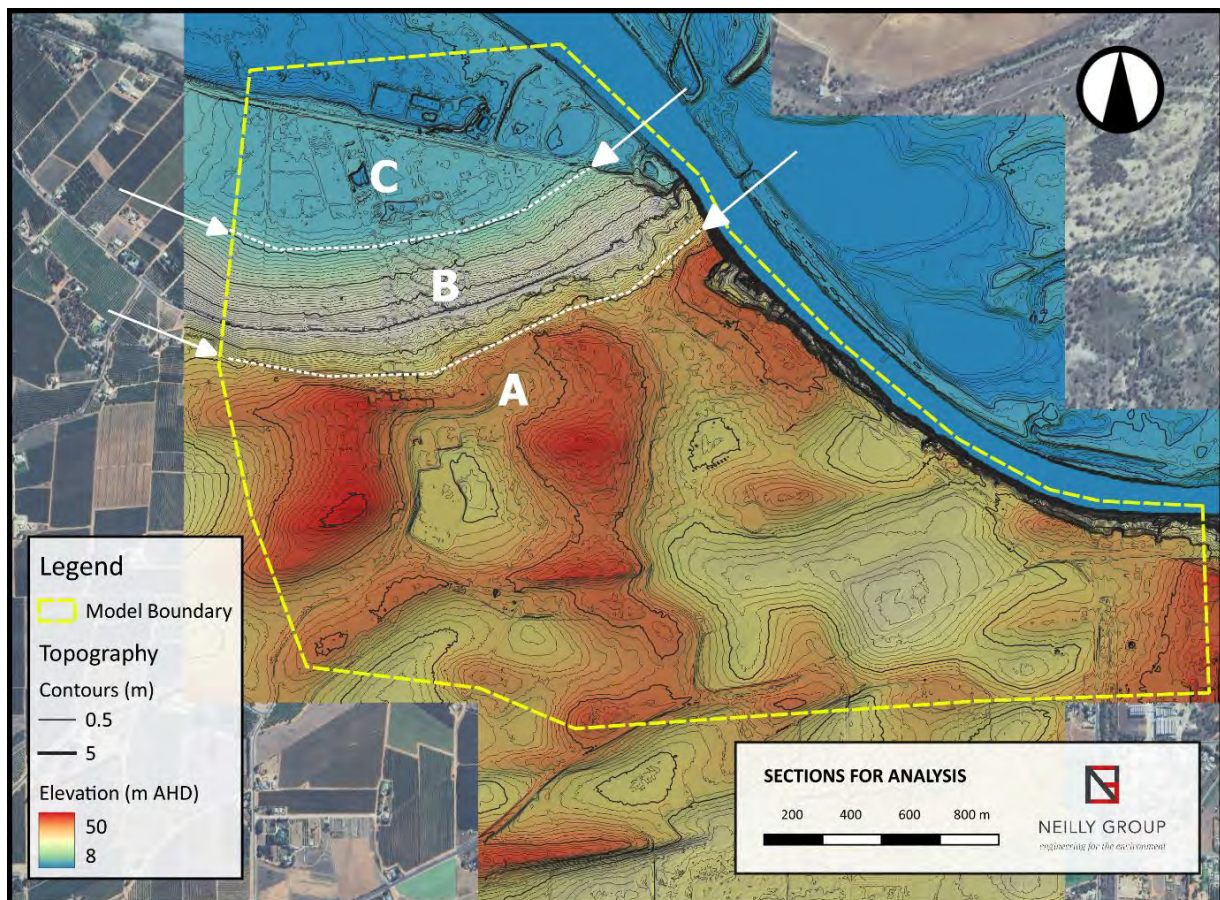


Figure 17: Topologic sections of Waikerie: (a) a higher plateau, then (b) a steep slope down to the (c) floodplain.

General observations across the different sections are:

- **Upper section:** Significant flooding occurs in local depressions, with less flooding along roads and properties leading into them.
- **Middle section:** Little flooding is seen, but roads and laneways show high flow velocities.
- **Lower section:** Local flooding occurs in parklands and at Kirby St's base. Flooding starts along Mary Starr Drive and into the Lifestyle Village at 10% AEP. The Hart Lagoon system manages all modelled flows, with the high-flow bypass activating at 5% AEP.

A detailed flood impact assessment focused on **18% AEP (minor)** and **1% AEP (major)** events; results follow in later sections.

4.1. Drainage performance

For analysis, Waikerie has been divided into 8 Damage Areas (Figure 18):

- **Damage Area 1** covers the entire Lifestyle Village, even though it drains to two outlets, as most flows return to the same pipe. Minimal damage is expected on the western edge. The village's stormwater modelling is assumed to be part of its development.
- **Damage Area 5** shows flooding only from south of Peake Terrace, as no rainfall hydrographs were applied.
- **Damage Area 8** was only partly modelled in the Existing Scenario (Scenario A).

Drainage performance was assessed using pipe surcharging. A "Drain Standard" was assigned to pipes based on the least frequent event causing surcharging (Figure 19).

Critical locations within the stormwater network, together with the critical storm duration and peak flow rate for each pipe, are provided in Attachment B.

The town's stormwater network is old and undersized for current development and climate conditions.

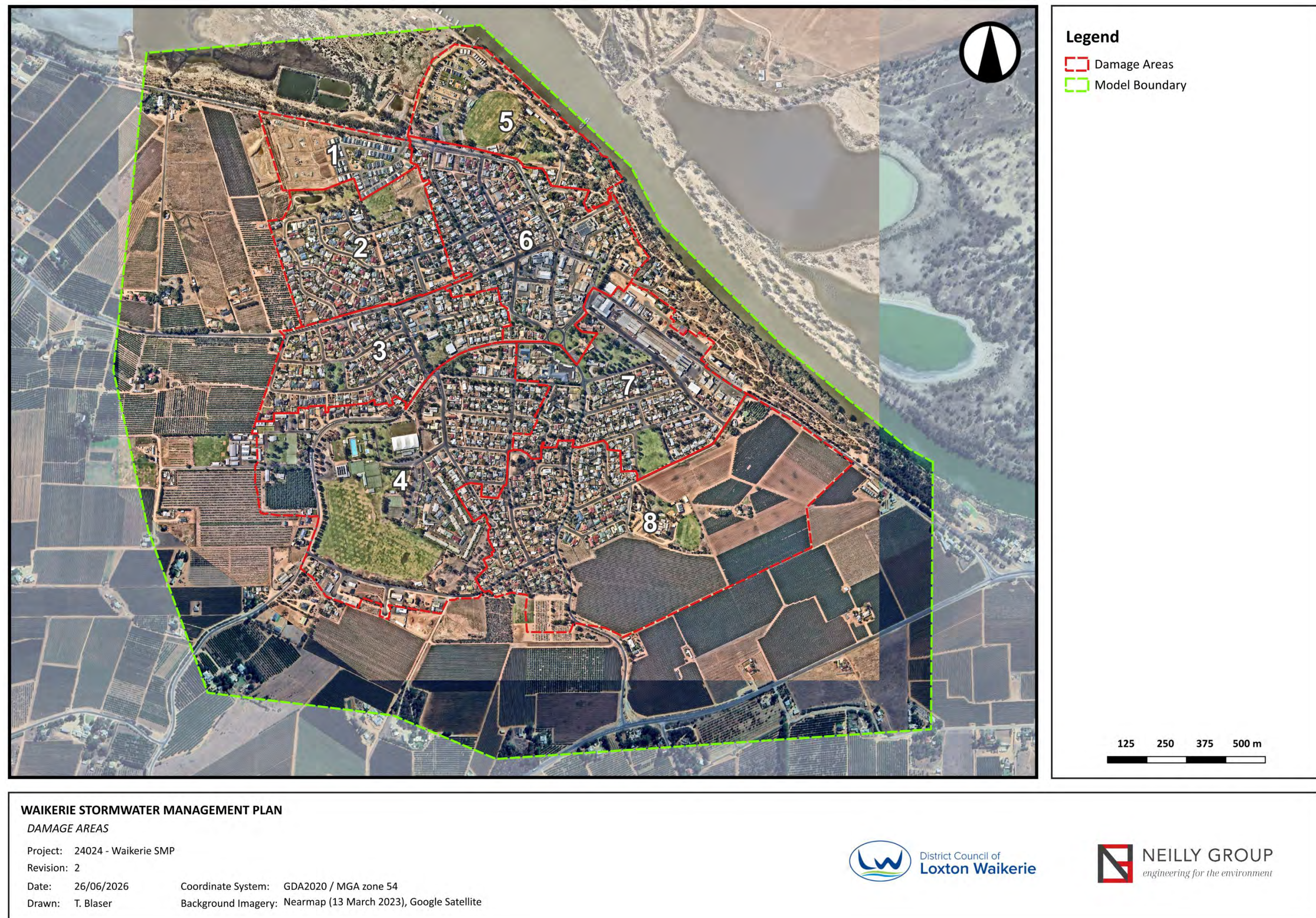


Figure 18. Damage Areas.

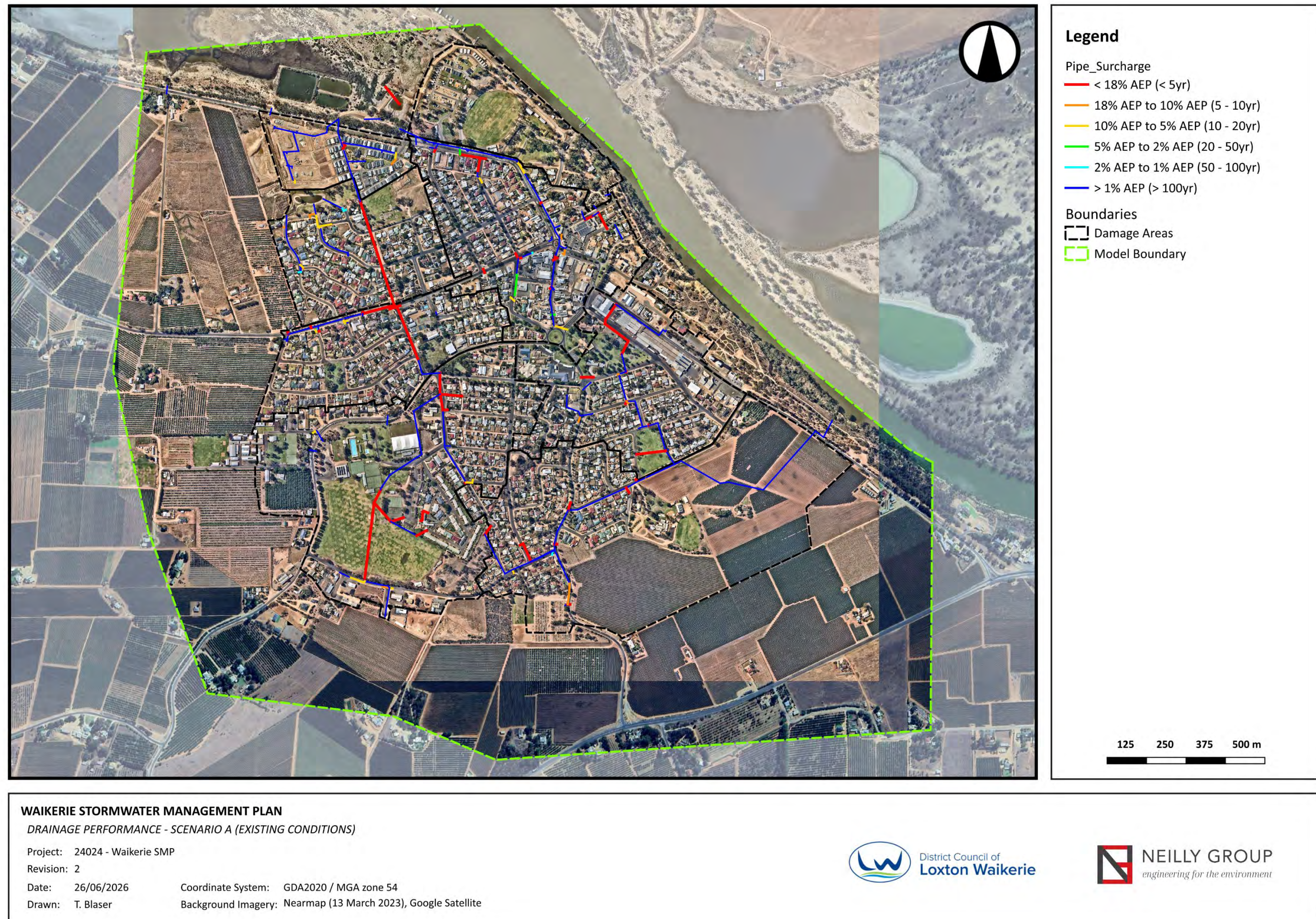


Figure 19. Drain Standard - Scenario A (Existing Conditions).

4.2. Flood impacts

Resulting flooding was assessed for the following criteria:

- Flooding of allotments (300 mm depth minimum threshold)
- Excessive gutter flows
 - Depths: 300 mm minimum threshold
 - Widths: considered as a car needing to leave the lane to avoid.
- Road closures (full road width flooded, min. 300 mm depth)
- Flood islands (isolated areas with safe no escape route – includes areas where residents cannot safely exit the property)
- Basin performance / overflows
- Any inundation of critical infrastructure sites: emergency services, power and water infrastructure
- Any inundation of socially, culturally or environmentally sensitive sites

Over-floor flooding has not been included in this section and is discussed in Section 5.4.

Flood maps and a register of impacts are provided for the minor (18% AEP) and major (1% AEP) events, under both Existing Conditions and Ultimate Development. Details are provided in Table 12, below.

Table 12. Details of flood maps and risk register.

Scenario		Figure	Table
1a	18% AEP - Existing Conditions	Figure 21	Table 13
5a	1% AEP - Existing Conditions	Figure 22	Table 14
1b	18% AEP - Ultimate Development	Figure 23	Table 15
5b	1% AEP - Ultimate Development	Figure 24	Table 16

A complete set of flood mapping results, for all modelled scenarios, is provided in Attachment C (Existing Conditions) and Attachment D (Ultimate Development).

4.2.1. Flood hazard

Flood hazard analysis has been undertaken following *Guideline 7.3 Flood Hazard*, from the Australian Disaster Resilience handbook collection (Australian Institute for Disaster Resilience (AIDR) 2017). Flood hazard is defined in this guideline based on a combination of the flooding depth and the velocity of floodwaters. Six categories break this down into levels - H1, generally safe; to H6, unsafe for vehicles and people, all building types vulnerable to failure – as shown in Figure 20.

The maximum hazard classification for each impact location is included in the Impact Registers.

This report considers categories H3 and H4 as “**High hazard**”, and H5 and H6 as “**Extreme hazard**”. Additional areas of high or extreme hazard risk in the minor or major event, which are not identified in the impact registers, include:

This report considers categories H3 and H4 as “**High hazard**”, and H5 and H6 as “**Extreme hazard**”. Additional areas of high or extreme hazard risk in the minor or major event, which are not identified in the impact registers, include:

- Kerbs and laneways in the “Middle section”, that run downhill from West Rd / Coombe Terrace in the Major event along the following streets
 - Henderson St
 - Peake Terrace
 - Kirby St
- Pflaum Terrace and Stanley St, in the Major event
- The open channel adjacent Goodchild Street
- Minor areas at many pit locations, (see Section 4.1 and Attachment B).
- Flows leading into pits, notably at the following locations during the Major event
 - Edwards Crescent, Wilton Ct, & Mary Starr Drive
 - Stanley & Harden Streets
 - Heming & Cates Streets
 - Civic Avenue (near Police Station)

Complete hazard mapping results are provided in Attachment F.

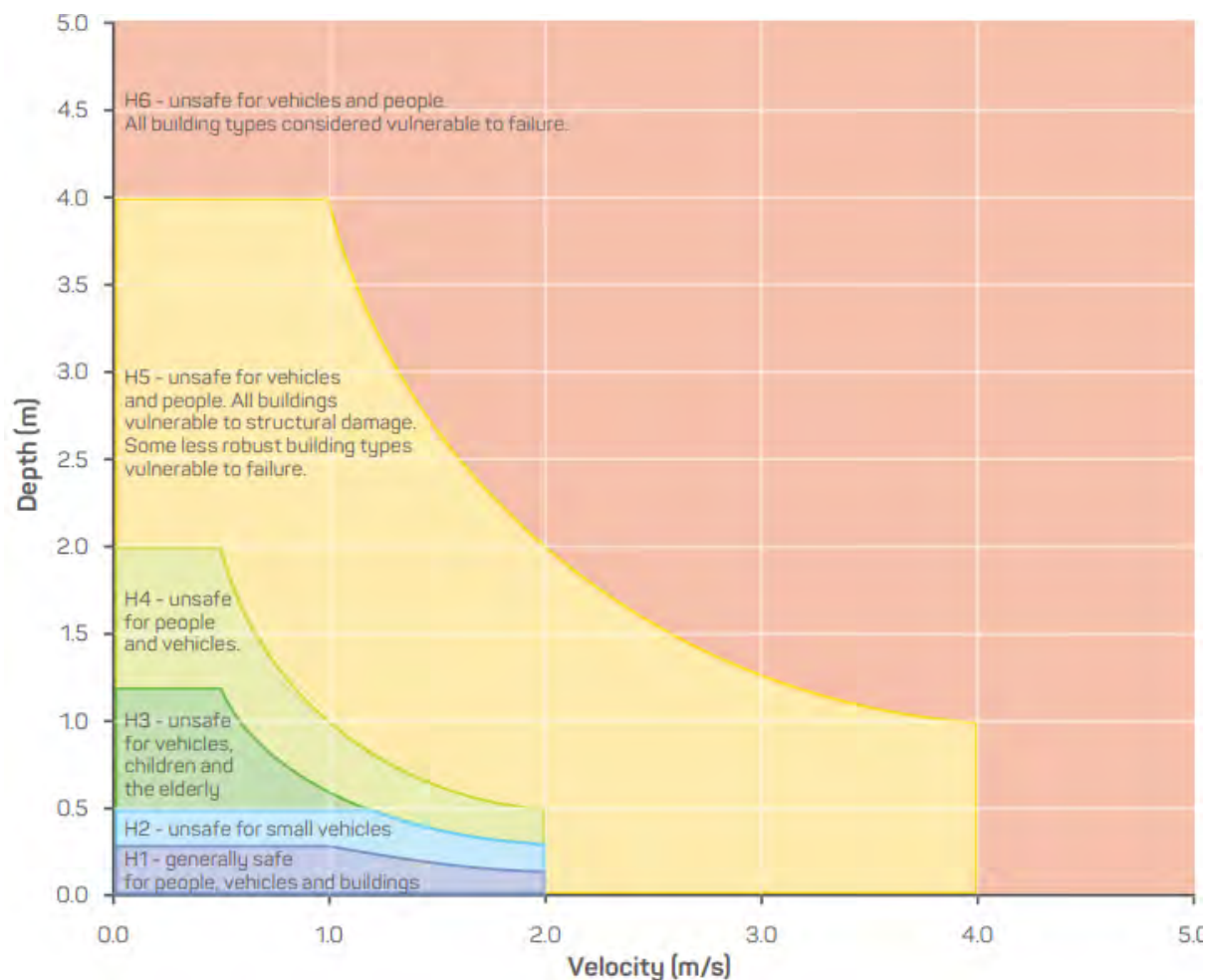


Figure 20. General flood hazard vulnerability curves (AIDR 2017, p. 10).

4.2.2. Basins

The study area has two detention basins:

- Hart Lagoon wetland complex
- Mary Starr Drive basin near Apex Park

Neither basin overflows during minor events. In major storms, Hart Lagoon uses its high-flow bypass. The Mary Starr basin overtops on the north side, spilling into the Lifestyle Village, and also spills to the east onto Apex Park. This happens in both Existing and Ultimate Development scenarios.

4.2.3. Open channel

The open channel adjacent Goodchild St overflows in all modelled events. Following conversations with Council It was modelled with 80% blockage at the headwall to reflect subsurface pipe conditions connecting to a buried junction box (JB) under Peake Terrace.

The model shows overflows at:

- The lower end near Peake Terrace
- Near SEP outlets at a low point along the channel's northern edge (based on LiDAR)

Overflow is expected onto the walking track in both Existing and Ultimate Development scenarios, for both minor and major storms, but ponding depth stays under 300mm.

4.2.4. Flood Impacts Registers

Table 13. Impacts Register - Scenario 1a – 18% AEP Existing Conditions

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (mm)	Max Hazard rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Ponding over road and between houses	Ponding greater than 300 mm		15	362	H1
2-1	Apex Park (North-eastern end)	Ponding in low point of park along fenceline	Inundation of culturally sensitive site		318	385	H2
2-2	2 West Rd	Ponding in backyard	Flooding of allotments		87	722	H3
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Inundation of culturally sensitive site	47	75	591	H3
3-1	17 West Rd	Significant gutter flows	Excessive gutter flows	18	38	637	H3
3-2	5A West Rd	Significant gutter flows	Excessive gutter flows	22	46	976	H4
3-3	Bottom of Stanley St	Ponding across bottom of street (above grate)	Excessive gutter flows	12	25	1,576	H5
4-1	Top of Cates Ave / Lutheran club	Significant gutter flows	Excessive gutter flows	24	64	1,073	H3
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Inundation of culturally sensitive site		41	444	H2
4-3	Community Sports complex	Ponding between oval and tennis court areas. Flows into Warrawee Lodge (Rotary Dr).	Inundation of culturally sensitive site		7,115	1,846	H4
5-1	Machinery Museum	Ponding on grassed area	Inundation of culturally sensitive site		96	454	H2
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Excessive gutter flows	36	125	505	H2
7-1	Civic Centre grounds	Ponding in low point of park	Inundation of culturally sensitive site		425	391	H2
7-2	Ambulance station	Ponding in driveway	Inundation of critical infrastructure		55	186	H1
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park	Inundation of critical infrastructure		127	131	H1
7-4	Wohling St / Ifould Park	Significant ponding over entire park and adjacent roads	Flooding of allotments Excessive gutter flows Road closures Flood Islands Inundation of culturally sensitive site	85	2,264	1,589	H5
8-1	Ian Oliver Drive	Ponding adjacent to road	Flooding of allotments	33	97	585	H2



WAIKERIE STORMWATER MANAGEMENT PLAN

FLOOD IMPACT LOCATIONS - MINOR EVENT (18% AEP) - EXISTING

Project: 24024 - Waikerie SMP

Revision: 2

Date: 26/06/2026

Drawn: T. Blaser

Coordinate System: GDA2020 / MGA zone 54

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 21. Flood impact locations - Minor event - Scenario A Existing Conditions.

Table 14. Impacts Register - Scenario 5a – 1% AEP Existing Conditions

ID	Location	Description	Impact type	Length (m)	Area (m²)	Max. Depth (m)	Max Hazard rating
1-1	Lifestyle Village (South-western end, residences 74-75)	Ponding over road and between houses	Flooding of allotments Excessive gutter flows Road closures Flood islands	25	294	463	H2
1-2	Lifestyle Village (Central, village hub)	Ponding over road and onto paths	Excessive gutter flows Road closures Flood islands	62	382	437	H2
1-3	Lifestyle Village (North-eastern end, residences 40 and 41)	Ponding over road and between houses	Excessive gutter flows Road closures Flood islands	36	214	886	H3
1-4	Lifestyle Village (North-western end, residences 48-52)	Ponding over road	Flooding of allotments Excessive gutter flows Road closures Flood islands	68	610	944	H3
1-5	Lifestyle Village (Western end, residences 61-63)	Ponding over road	Flooding of allotments Excessive gutter flows Road closures Flood islands	31	209	465	H2
1-6	Peake Tce (adj. Lifestyle Village)	Ponding in swale adjacent road	Ponding greater than 300 mm	12	19	335	H1
1-7	Lifestyle Village (Residence 88)	Ponding around house	Flooding of allotments Excessive gutter flows Road closures Flood islands	221	6,215	909	H3
2-1	Apex Park (Northern end)	Ponding in low point of park along fenceline	Inundation of culturally sensitive site	183	4,947	563	H3
2-2	2 West Rd	Ponding in backyard	Flooding of allotments		152	932	H3
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Inundation of culturally sensitive site	73	174	917	H5
2-4	31 Mary Starr Drive	Minor ponding in backyard (pool)	Flooding of allotments		33	754	H2
2-5	Bottom of Mary Starr Drive	Significant ponding along gutter	Excessive gutter flows Road closures Flood islands	112	962	1,293	H4
2-6	Mary Starr Basin & swale	Basin and swale both overtop	Stormwater assets Inundation of culturally sensitive site		6,144	2,947	H5
3-1	17 West Rd	Significant gutter flows	Excessive gutter flows	51	126	986	H3

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (m)	Max Hazard rating
3-2	5A West Rd	Significant gutter flows	Excessive gutter flows	35	125	1,385	H4
3-3	Bottom of Stanley St	Significant gutter flows (full street width)	Excessive gutter flows Road closures	14	26	1,193	H6
4-1	Top of Cates Ave	Significant gutter flows and ponding in Lutheran Church	Flooding of allotments Excessive gutter flows Inundation of culturally sensitive site	49	1,754	1,357	H5
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Flooding of allotments Inundation of culturally sensitive site	15	102	528	H2
4-3	Community Sports complex	Ponding between oval and tennis court areas. Flowing into Warrawee Lodge (Rotary Drive).	Flooding of allotments Excessive gutter flows Road closures Flood islands Inundation of culturally sensitive site		31,081	2,684	H5
4-4	Bowling club	Ponding on green	Flooding of allotments Inundation of culturally sensitive site		70	379	H2
4-5	Traffic lights on Lawrie Tce	Ponding adjacent to road	Flooding of allotments Inundation of culturally sensitive site	48	284	478	H2
4-6	Warrawee Lodge (Eastern end)	Ponding against the eastern fenceline	Inundation of culturally sensitive site	82	1,221	697	H3
4-7	Elders Way	Ponding at the carpark at the end of the street	Flooding of allotments Excessive gutter flows	11	48	1,112	H4
5-1	Machinery Museum	Ponding on grassed area	Inundation of culturally sensitive site		466	845	H3
5-2	Football oval	Minor ponding on oval	Inundation of culturally sensitive site		459	348	H2
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Flooding of allotments Excessive gutter flows Road closures Flood islands	88	784	1,015	H4
6-2	Bottom of Kirby St (West of 41 Peake Terrace)	Significant gutter flows (not on road)	Excessive gutter flows	39	173	971	H4
6-3	41 Peake Tce	Ponding in depression between Peake Terrace and service road	Excessive gutter flows	33	133	1,422	H3
7-1	Civic Centre grounds	Ponding over grassed area	Inundation of culturally sensitive site		1,646	504	H2
7-2	Ambulance station	Ponding in driveway	Inundation of critical infrastructure		56	187	H1

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (m)	Max Hazard rating
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park	Flooding of allotments Inundation of critical infrastructure		511	189	H1
7-4	Wohling St / Ifould Park	Significant ponding over entire park and adjacent roads	Flooding of allotments Excessive gutter flows Road closures Flood islands Inundation of culturally sensitive site		27,949	1,721	H5
7-5	Medical Centre (1 Strangman Rd)	Significant gutter flows	Excessive gutter flows	17	34	528	H4
7-6	10 Dowling St	Significant gutter flows	Excessive gutter flows	39	178	442	H2
7-7	9 Miller St	Ponding in backyard and into laneway	Flooding of allotments Inundation of culturally sensitive site	47	289	481	H2
7-8	16 Miller St	Significant gutter flows	Excessive gutter flows	12	29	712	H3
7-9	Civic Ave near RV dump point	Significant gutter flows	Excessive gutter flows	12	18	667	H2
7-10	Civic Ave near Nippy's/Mitre 10	Significant gutter flows	Excessive gutter flows	10	16	850	H2
8-1	Ian Oliver Drive	Ponding adjacent to road	Flooding of allotments	54	520	744	H2
8-2	Bottom of Burns St	Significant gutter flows on both sides of road, overtopping road	Excessive gutter flows Road closures	43	16	685	H3
8-3	Tiller Crescent	Ponding on the northern end of the cul-de-sac	Excessive gutter flows	9	306	710	H2
8-4	Cates St (bottom of cul-de-sac)	Significant gutter flows	Excessive gutter flows	6	10	547	H2



WAIKERIE STORMWATER MANAGEMENT PLAN

FLOOD IMPACT LOCATIONS - MAJOR EVENT (1% AEP) - EXISTING

Project: 24024 - Waikerie SMP

Revision: 2

Date: 22/06/2026

Drawn: T. Blaser

Coordinate System: GDA2020 / MGA zone 54

Background Imagery: Nearmap (13 March 2023), Google Satellite

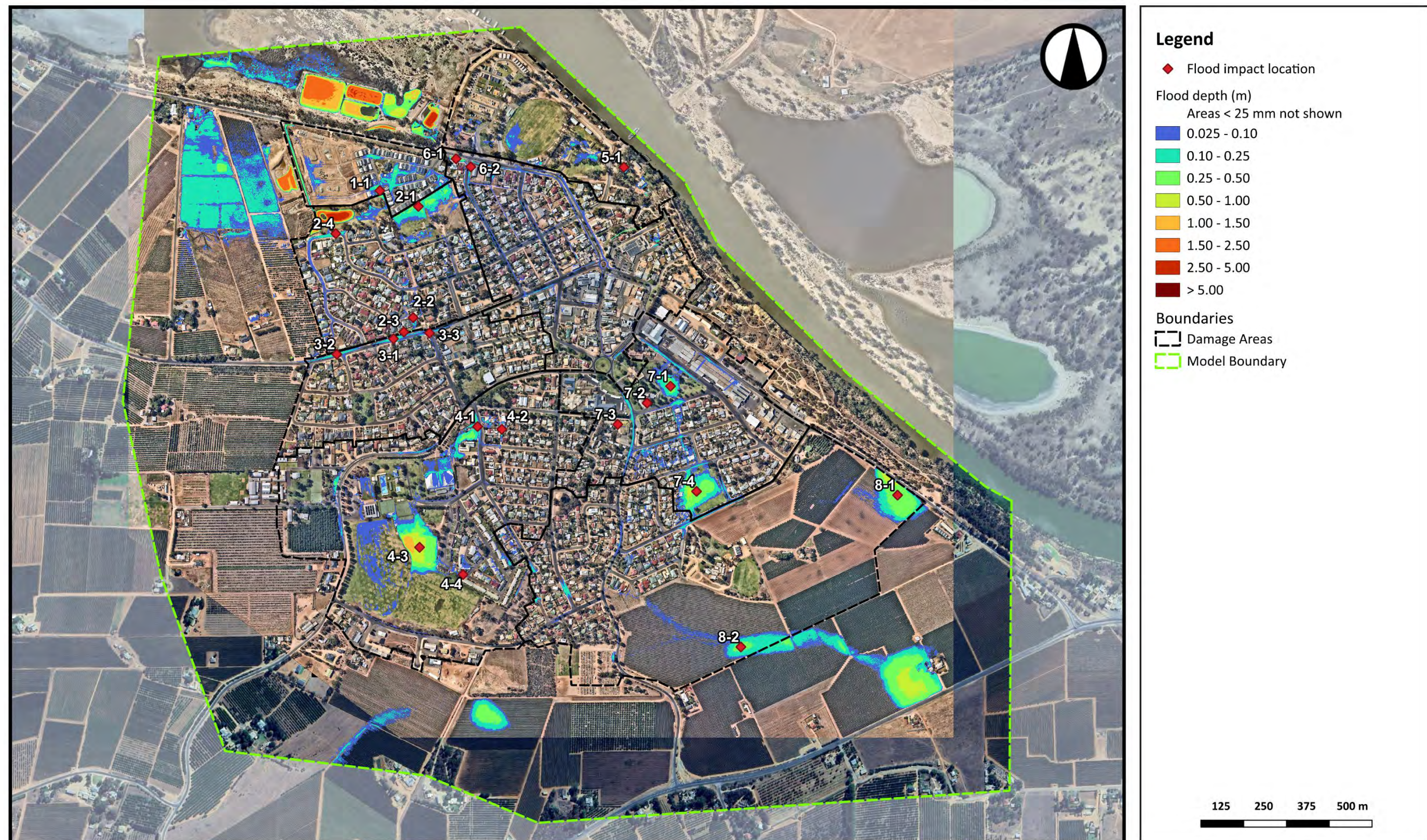


Figure 22. Flood impact locations - Major event - Scenario A Existing Conditions.

Table 15. Impacts Register - Scenario 1b – 18% AEP Ultimate Development

ID	Location	Description	Impact type	Length (m)	Area (m²)	Max. Depth (m)	Max Hazard rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Minor ponding between houses	Ponding greater than 300 mm Flooding of allotments		30	369	H1
2-1	Apex Park (North-eastern end)	Ponding in low point of park along fenceline	Inundation of culturally sensitive site		362	387	H2
2-2	2 West Rd	Ponding in backyard	Flooding of allotments		96	749	H3
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Inundation of culturally sensitive site	59	92	614	H3
2-4	Bottom of Mary Starr Drive	Significant ponding along gutter	Excessive gutter flows		33	530	H3
3-1	17 West Rd	Significant gutter flows	Excessive gutter flows	23	64	863	H3
3-2	5A West Rd	Significant gutter flows	Excessive gutter flows	20	44	728	H3
3-3	Bottom of Stanley St	Significant gutter flows	Excessive gutter flows	12	20	913	H5
4-1	Top of Cates Ave / Lutheran club	Significant gutter flows and ponding in Lutheran Church	Flooding of allotments Excessive gutter flows Inundation of culturally sensitive site	25	118	1067	H4
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Flooding of allotments Inundation of culturally sensitive site		42	447	H2
4-3	Community Sports complex	Ponding between oval and tennis court areas	Inundation of culturally sensitive site Flooding of allotments		7,898	1,891	H4
4-4	Elders Way	Ponding at the carpark at the end of the street	Excessive gutter flows		13	569	H3
5-1	Machinery Museum	Ponding on grassed area	Inundation of culturally sensitive site		98	456	H2
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Excessive gutter flows	39	160	535	H3
6-2	Bottom of Kirby St (41 Peake Terrace)	Significant gutter flows (not on road)	Excessive gutter flows	14	12	435	H2
7-1	Civic Centre grounds	Ponding in low point of park, over grassed area	Inundation of culturally sensitive site		446	393	H2
7-2	Ambulance station	Ponding in driveway	Inundation of critical infrastructure		55	186	H1
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park	Inundation of critical infrastructure Flooding of allotments		158	134	H1
7-4	Wohling St / Ifould Park	Ponding over road and some of park	Flooding of allotments Excessive gutter flows Road closures Flood islands Inundation of culturally sensitive site		3,729	1,565	H5

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (m)	Max Hazard rating
8-1	Ian Oliver Drive	Ponding adjacent to road	Flooding of allotments	88	5,711	1,008	H3
8-2	41 Strangman Rd	Ponding in vineyard (away from structures)	Flooding of allotments		383	415	H2



WAIKERIE STORMWATER MANAGEMENT PLAN

FLOOD IMPACT LOCATIONS - MINOR EVENT (18% AEP) - FUTURE

Project: 24024 - Waikerie SMP

Revision: 2

Date: 26/06/2026

Drawn: T. Blaser

Coordinate System: GDA2020 / MGA zone 54

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 23. Flood impact locations - Minor event - Scenario B Ultimate Development.

Table 16. Impacts Register - Scenario 5b – 1% AEP Ultimate Development

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (m)	Max Hazard rating
1-1	Lifestyle Village (South-western end, residences 74-75)	Ponding over road and between houses	Flooding of allotments Excessive gutter flows Road closures Flood islands	25	310	467	H2
1-2	Lifestyle Village (Central, village hub)	Ponding over road and onto paths	Excessive gutter flows Road closures Flood islands	64	414	442	H2
1-3	Lifestyle Village (North-eastern end, residences 40 and 41)	Ponding over road and between houses	Excessive gutter flows Road closures Flood islands	36	202	836	H3
1-4	Lifestyle Village (North-western end, residences 48-52)	Ponding over road	Flooding of allotments Excessive gutter flows Road closures Flood islands	68	617	944	H3
1-5	Lifestyle Village (Western end, residences 61-63)	Ponding over road	Flooding of allotments Excessive gutter flows Road closures Flood islands	31	217	470	H2
1-6	Peake Tce (adj. Lifestyle Village)	Ponding in swale adjacent road	Ponding greater than 300 mm	20	57	383	H2
1-7	Lifestyle Village (Residence 88)	Ponding around house	Flooding of allotments Excessive gutter flows Road closures Flood islands	243	8,592	1,109	H4
1-8	Lifestyle Village Men's Shed	Ponding around shed	Flooding of allotments Inundation of culturally sensitive site		16	331	H1
1-9	Lifestyle Village (NW intersection)	Ponding at pits 1-8, 2-1, & 3-1	Excessive gutter flows Road closures Flood islands	25	113	820	H3
2-1	Apex Park (Northern end)	Ponding in low point of park along fenceline	Inundation of culturally sensitive site	185	4,990	565	H3
2-2	2 West Rd	Ponding in backyard	Flooding of allotments		154	935	H3
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Inundation of culturally sensitive site	74	176	926	H5
2-4	31 Mary Starr Drive	Minor ponding in backyard (pool)	Flooding of allotments		33	753	H2

ID	Location	Description	Impact type	Length (m)	Area (m ²)	Max. Depth (m)	Max Hazard rating
2-5	Bottom of Mary Starr Drive	Significant ponding along gutter	Excessive gutter flows Road closures Flood islands	117	972	1,192	H4
2-6	Mary Starr Basin & swale	Basin and swale both overtop	Stormwater assets Inundation of culturally sensitive site		6,301	2,950	H5
3-1	17 West Rd	Significant gutter flows	Excessive gutter flows	55	132	1,143	H3
3-2	5A West Rd	Significant gutter flows	Excessive gutter flows	36	128	1,413	H4
3-3	Bottom of Stanley St	Significant gutter flows	Excessive gutter flows Road closures	15	32	1,254	H6
4-1	Top of Cates Ave	Significant gutter flows and ponding in Lutheran Church	Flooding of allotments Excessive gutter flows Inundation of culturally sensitive site	59	1,766	1,312	H4
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Flooding of allotments Inundation of culturally sensitive site	15	102	529	H2
4-3	Community Sports complex	Ponding between oval and tennis court areas. Flowing into Warrawee Lodge (Rotary Drive).	Flooding of allotments Excessive gutter flows Road closures Flood islands Inundation of culturally sensitive site		31,175	2,688	H5
4-4	Bowling club	Ponding on green	Flooding of allotments Inundation of culturally sensitive site		68	378	H2
4-5	Traffic lights on Lawrie Tce	Ponding adjacent to road	Flooding of allotments Excessive gutter flows Inundation of culturally sensitive site	48	283	478	H2
4-6	Warrawee Lodge (Eastern end)	Ponding against the eastern fenceline	Inundation of culturally sensitive site	83	1,247	702	H3
4-7	Elders Way	Ponding at the carpark at the end of the street	Flooding of allotments Excessive gutter flows	12	52	804	H3
5-1	Machinery Museum	Ponding on grassed area	Inundation of culturally sensitive site		466	845	H3
5-2	Football oval	Minor ponding on oval	Inundation of culturally sensitive site		347	345	H2
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Flooding of allotments Excessive gutter flows Road closures Flood islands	87	856	1,043	H4

ID	Location	Description	Impact type	Length (m)	Area (m²)	Max. Depth (m)	Max Hazard rating
6-2	Bottom of Kirby St (West of 41 Peake Terrace)	Significant gutter flows (not on road)	Excessive gutter flows	39	186	902	H4
6-3	41 Peake Tce	Ponding in depression between Peake Terrace and service road	Excessive gutter flows	33	135	1,422	H3
7-1	Civic Centre grounds	Ponding over grassed area	Inundation of culturally sensitive site		1,641	504	H2
7-2	Ambulance station	Ponding in driveway	Inundation of critical infrastructure		56	187	H1
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park	Flooding of allotments Inundation of critical infrastructure		519	189	H1
7-4	Wohling St / Ifould Park	Significant ponding over entire park and adjacent roads	Flooding of allotments Excessive gutter flows Road closures Flood islands Inundation of culturally sensitive site		27,970	1,765	H5
7-5	Medical Centre (1 Strangman Rd)	Significant gutter flows	Excessive gutter flows	24	45	485	H4
7-6	10 Dowling St	Significant gutter flows	Excessive gutter flows	38	171	441	H2
7-7	9 Miller St	Ponding in backyard and into laneway	Flooding of allotments Inundation of culturally sensitive site	46	271	480	H2
7-8	16 Miller St	Significant gutter flows	Excessive gutter flows	13	32	954	H3
7-9	Civic Ave near RV dump point	Significant gutter flows	Excessive gutter flows	15	26	749	H3
7-10	Civic Ave near Nippy's/Mitre 10	Significant gutter flows	Excessive gutter flows	11	19	817	H3
8-1	Ian Oliver Drive	Ponding adjacent to road, entering vineyard	Flooding of allotments	159	9,703	1,143	H3
8-2	Bottom of Burns St	Significant gutter flows on both sides of road	Excessive gutter flows Road closures	43	320	705	H3
8-3	Tiller Crescent	Ponding on the northern end of the cul-de-sac	Excessive gutter flows	9	16	672	H2
8-4	Cates St (bottom of cul-de-sac)	Significant gutter flows	Flooding of allotments	6	11	591	H2
8-5	41 Strangman Rd	Ponding in vineyard (away from structures)	Flooding of allotments		5,757	549	H2



WAIKERIE STORMWATER MANAGEMENT PLAN

FLOOD IMPACT LOCATIONS - MAJOR EVENT (1% AEP) - FUTURE

Project: 24024 - Waikerie SMP

Revision: 2

Date: 22/06/2026

Drawn: T. Blaser

Coordinate System: GDA2020 / MGA zone 54

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 24. Flood impact locations - Major event - Scenario B Ultimate Development.

4.3. Flood damages

An important part of the development of a Stormwater Management Plan is the estimation of damages caused by different flood events. This allows for more informed decision-making and cost-benefit analysis when assessing remediation options, and actions during events.

Flood damages for this SMP were informed by the CRC for Water Sensitive Cities' "Investment Framework for Economics of Water Sensitive Cities" (INFFEWS) Value Tool. The package provides a number of Stage-Damage curves produced for the Brisbane River Strategic Floodplain Management Plan (State of Queensland, 2018). These values have been updated to reflect 2025 prices, and to consider Waikerie's location in the SA Riverland.

4.3.1. Damage categories

Damages from flooding typically include both tangible and intangible damages, and direct and indirect damages. Combined these form four categories:

1. Direct tangible damages – typically material damage caused by the flood
2. Indirect tangible damages – typically disruptions due to the flood
3. Direct intangible damages – direct damages that cannot be objectively quantified or valued
4. Indirect intangible damages – indirect damages that cannot be objectively quantified or valued

The methodology described above has been used to estimate direct damages, with direct damages taken directly from the values calculated, and indirect estimates produced using the proportions of direct damages recommended within the Value Tool.

Indirect damages have not been estimated, due to the difficulty of doing so, and the lack of guidance available. It has been noted in other studies that these values often match, or exceed, those of tangible damages.

4.3.2. Affected buildings

The value tool considers residential, commercial and industrial buildings separately. Flood damages to rural properties and transport infrastructure have not been considered in the report.

4.3.2.1. Residential buildings

Residential buildings in the tool are categorised as Small (<140 m²), Medium (140-210 m²) or Large (>210 m²). Average residential building sizes were assessed for all sub-catchments, which found that all the average building size for each fell between 140-210 m², see Table 17, so the Medium category was used for the whole study area.

Table 17. Average residential building sizes.

Sub-catchment	Average residential building size (m ²)
1	190
2	210
3	210
4	200

Sub-catchment	Average residential building size (m ²)
5	170
6	170
7	150
8	160
ALL	190

Stage-Damage curves are supplied for six (6) house types:

1. Fully detached single storey (slab-on-ground)
2. Fully detached single storey (on stumps)
3. Fully detached single storey (highset)
4. Fully detached double storey
5. Multi-unit single storey
6. Multi-unit double storey

Due to the lack of information available for this distinction, all houses were assumed 'Fully detached single storey (slab-on-ground)', which is consistent with our knowledge of the town and what was observed on site. Floor level survey has not been undertaken, so slab heights were assumed to be 150 mm above the ground surface to be consistent with Australian Standards.

The tool provides separate curves for internal damage, external damage and structural damage. These values were added together to provide a single value for each stage. The final, adjusted, stage-damage curve used for direct tangible damages for residential buildings is shown in Table 18.

Table 18. Stage-Damage curve for Residential buildings.

Flood Depth (m)	Direct Tangible Damage Estimate
Up to 0.1	\$85,524
0.1 to 0.15	\$113,327
0.15 to 0.25	\$165,574
0.25 to 0.5	\$229,361
0.5 to 1.0	\$268,840
1.0 to 1.5	\$293,584
1.5 to 2.5	\$333,737
2.5 to 5.0	\$376,747

4.3.2.2. Commercial buildings

The tool provides stage-damage curves for commercial buildings under three sizes – 'Small' (<186 m²), 'Medium' (186 to 650 m²) and 'Large' (>650 m²) – and five value classes:

1. VC1 (Very low) – e.g. Florists, garden centres, vehicle sales areas, schools, churches
2. VC2 (Low) – e.g. Cafes/takeaway, service stations, pubs, second hand goods, clubs

3. VC3 (Medium) – e.g. Chemists, musical instruments, printing, electronic goods, clothing
4. VC4 (High) – e.g. Bottle shops, cameras
5. VC5 (Very High) – e.g. Pharmaceuticals, electronics.

The average commercial building size was determined as 325 m² (Medium). For the purposes of estimating flood damages, it has been assumed that all commercial buildings are VC2 (Low), given that VC1 and VC2 would account for the vast majority of commercial buildings in Waikerie.

The final, adjusted, stage-damage curve used for direct tangible damages for commercial buildings is shown in Table 19.

Table 19. Stage-Damage curve for Commercial buildings.

Flood Depth (m)	Direct Tangible Damage Estimate
Up to 0.1	\$56,959
0.1 to 0.15	\$77,617
0.15 to 0.25	\$125,034
0.25 to 0.5	\$178,574
0.5 to 1.0	\$286,439
1.0 to 1.5	\$366,704
1.5 to 2.5	\$431,446
2.5 to 5.0	\$593,300

4.3.2.3. Industrial buildings

Industrial buildings are not represented in this tool, however the State of Queensland (2018) report – from which the value tool was produced – states that while internal and structural damages for commercial and industrial properties can vary significantly depending on the property type, the structural damages are generally comparable. For this reason, damages to industrial properties have been determined in the same manner as commercial properties.

For industrial properties, the average building size is 3,135 m², so the 'Large' category has been assumed. For 'Large' commercial values, the tool provides values per square metre. The Value Class was also assumed as VC2 (Low).

The final, adjusted, stage-damage curve used for direct tangible damages for industrial buildings is shown in Table 20.

Table 20. Stage-Damage curve for Industrial buildings.

Flood Depth (m)	Direct Tangible Damage Estimate (per square metre)
Up to 0.1	\$14
0.1 to 0.15	\$21
0.15 to 0.25	\$98
0.25 to 0.5	\$290

Flood Depth (m)	Direct Tangible Damage Estimate (per square metre)
0.5 to 1.0	\$698
1.0 to 1.5	\$1,186
1.5 to 2.5	\$1,804
2.5 to 5.0	\$3,350

4.3.3. Scenario A (Existing Conditions) damages

4.3.3.1. Affected properties

Building footprints were download from Google Earth Engine, then verified to a level suitable for flood damage estimation. Zonal statistics were used to determine if any part of the building was impacted by flood waters. The flood depth was determined as the average flood height impacting the building, with damages reduced by half for buildings with 50% or less of the floor area affected.

The total number of buildings impacted under existing conditions are shown in Table 21, summarised into depth categories. Table 22 shows the breakdown per building type.

Table 21. Inundated buildings by depth under Existing Conditions.

Flood depth range* (m)	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
0 - 0.1	68	91	118	158	186	260
0.1 - 0.15	0	1	5	4	9	13
0.15 - 0.25	2	1	1	2	3	17
0.25 - 0.5	0	2	1	6	7	10
0.5 - 1.0	0	0	2	3	3	9
1.0 - 1.5	0	0	0	0	2	2
1.5 - 2.5	0	0	0	0	0	0
2.5 - 5.0	0	0	0	0	0	0
Total	70	95	127	173	210	311

* For residential buildings, flood depth is taken as the depth above floor level.

The results above show that even in rarer events, the majority of buildings are only affected up to 100 mm.

Table 22. Inundated buildings by land use under Existing Conditions.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	23	44	73	116	151	242
Commercial	40	44	46	49	51	59
Industrial	7	7	8	8	8	10
Total	70	95	127	173	210	311

For the more frequent events, most affected buildings are commercial or industrial buildings, due to the assumption that these sit at ground level, while residential buildings are afforded some protection by the underlying slabs. From the 5% AEP event and rarer, the number of affected residential properties increases dramatically.

If commercial buildings also sit slightly elevated, these numbers could reduce significantly.

4.3.3.2. Direct tangible damage estimates for Scenario A (Existing Conditions)

Using the determined stage-damage curves, the damages under Scenario A are shown by land use (Table 23) and sub-catchment (Table 24) for each modelled event.

Table 23. Direct tangible damages under existing conditions.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	\$1.5m	\$3.2m	\$5.6m	\$9.8m	\$13.5m	\$23.1m
Commercial	\$1.5m	\$1.9m	\$2.3m	\$2.7m	\$3.0m	\$3.5m
Industrial	\$0.1m	\$0.1m	\$0.1m	\$0.1m	\$0.1m	\$0.2m
Total	\$3.1m	\$5.2m	\$8.0m	\$12.6m	\$16.5m	\$26.8m

Table 24. Direct tangible damages per damage area under Existing Conditions.

Damage Area	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
1	\$0.3m	\$0.9m	\$1.9m	\$3.3m	\$3.8m	\$6.1m
2	\$0.4m	\$0.6m	\$0.9m	\$1.1m	\$1.6m	\$2.9m
3	\$0.0m	\$0.0m	\$0.0m	\$0.0m	\$0.0m	\$0.1m
4	\$0.8m	\$1.2m	\$1.9m	\$2.5m	\$2.8m	\$4.1m
5	\$0.2m	\$0.2m	\$0.3m	\$0.3m	\$0.3m	\$0.3m
6	\$0.6m	\$0.7m	\$1.1m	\$1.5m	\$1.9m	\$3.3m
7	\$0.8m	\$1.3m	\$1.6m	\$2.8m	\$4.2m	\$6.1m
8	\$0.1m	\$0.2m	\$0.3m	\$0.7m	\$1.4m	\$3.4m
Outside of these areas	\$0.0m	\$0.0m	\$0.1m	\$0.4m	\$0.5m	\$0.6m
Total	\$3.1m	\$5.2m	\$8.0m	\$12.6m	\$16.5m	\$26.8m

The results above show that most of the damages are contained within a few damage areas, in line with known flooding hotspots due to natural depressions, namely Ifould Park, the Community Sports complex and along the bottom (north) of Peake Terrace. It should be noted that Damage Area 1 is likely over-estimated, as noted earlier, due to limitations in the modelling surrounding the existing infrastructure inside the Waikerie Lifestyle Village.

Meanwhile, Damage Area 3 shows no damage until the 0.2% AEP event.

4.3.3.3. Total tangible damage estimates for Scenario A (Existing Conditions)

Indirect tangible damage estimates were calculated using the recommendations in the INFFEWS tool, which are:

- 15% of direct tangible damages for Residential buildings
- 55% of direct tangible damages for Commercial and Industrial buildings.

Combining both the direct and indirect tangible damage estimates, total tangible damage estimates are provided in Table 25, below.

Table 25. Total tangible damages under Existing Conditions.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	\$1.8m	\$3.7m	\$6.5m	\$11.3m	\$15.5m	\$26.6m
Commercial	\$2.3m	\$2.9m	\$3.6m	\$4.2m	\$4.6m	\$5.5m
Industrial	\$0.1m	\$0.1m	\$0.1m	\$0.1m	\$0.1m	\$0.3m
Total	\$4.2m	\$6.8m	\$10.2m	\$15.7m	\$20.2m	\$32.4m

4.3.4. Scenario B (Ultimate Development) damages

4.3.4.1. Affected properties

The total number of buildings impacted under Ultimate Development are shown in Table 26, summarised into depth categories. Table 27 shows the breakdown per building type.

Table 26. Inundated buildings by depth under Ultimate Development.

Flood depth range* (m)	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
0-0.1	74	96	119	163	192	262
0.1-0.15	0	1	7	4	10	14
0.15-0.25	2	1	2	4	3	18
0.25-0.5	0	2	1	6	9	12
0.5-1.0	0	0	2	3	3	10
1.0-1.5	0	0	0	0	2	3
1.5-2.5	0	0	0	0	0	0
2.5-5.0	0	0	0	0	0	0
Total	76	100	131	180	219	319
<i>Change from Scenario A</i>	6 +8.6%	5 +5.3%	4 +3.1%	7 +4.0%	9 +4.3%	8 +2.6%

Results show little difference between existing and future conditions, largely due to the expected changes being mostly in newly developed areas, rather than within the existing town centre. These areas would require their own stormwater systems to be set up, which based on location, are unlikely to be combined with the existing networks.

Results for this scenario cannot be anticipated, however, until these new stormwater networks, and building locations, are known.

Table 27. Inundated buildings by land use under Ultimate Development.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	27	48	75	120	155	249
Commercial	40	43	45	49	53	59
Industrial	9	9	11	11	11	11
Total	76	100	131	180	219	319
<i>Change from Scenario A</i>	<i>6</i> <i>+8.6%</i>	<i>5</i> <i>+5.3%</i>	<i>4</i> <i>+3.1%</i>	<i>7</i> <i>+4.0%</i>	<i>9</i> <i>+4.3%</i>	<i>8</i> <i>+2.6%</i>

4.3.4.2. Direct tangible damage estimates for Scenario B (Ultimate Development)

Using the determined stage-damage curves, the damages under Scenario B are shown by land use (Table 28) and sub-catchment (Table 29) for each modelled event.

Table 28. Direct tangible damages under Ultimate Development.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	\$1.9m	\$3.5m	\$5.9m	\$10.1m	\$13.7m	\$23.8m
Commercial	\$1.5m	\$1.9m	\$2.3m	\$2.7m	\$3.0m	\$3.7m
Industrial	\$0.1m	\$0.1m	\$0.1m	\$0.1m	\$0.2m	\$0.4m
Total	\$3.5m	\$5.5m	\$8.3m	\$13.0m	\$16.9m	\$27.9m
<i>Change from Scenario A</i>	<i>\$0.4m</i> <i>+11.4%</i>	<i>\$0.3m</i> <i>+5.5%</i>	<i>\$0.3m</i> <i>+3.6%</i>	<i>\$0.4m</i> <i>+3.1%</i>	<i>\$0.4m</i> <i>+2.4%</i>	<i>\$1.1m</i> <i>+3.9%</i>

Table 29. Direct tangible damages per damage area under Ultimate Development.

Damage Area	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
1	\$0.3m	\$1.0m	\$1.9m	\$3.4m	\$4.0m	\$6.3m
2	\$0.4m	\$0.6m	\$0.9m	\$1.2m	\$1.6m	\$2.8m
3	\$0.0m	\$0.0m	\$0.0m	\$0.0m	\$0.0m	\$0.1m
4	\$0.9m	\$1.4m	\$1.9m	\$2.5m	\$2.8m	\$4.2m
5	\$0.2m	\$0.2m	\$0.3m	\$0.3m	\$0.3m	\$0.3m
6	\$0.6m	\$0.7m	\$1.1m	\$1.5m	\$2.0m	\$3.4m
7	\$1.0m	\$1.3m	\$1.8m	\$2.8m	\$4.2m	\$6.1m
8	\$0.1m	\$0.3m	\$0.3m	\$0.7m	\$1.4m	\$3.4m
Outside of these areas	\$0.0m	\$0.0m	\$0.1m	\$0.5m	\$0.6m	\$1.2m
Total	\$3.5m	\$5.5m	\$8.3m	\$13.0m	\$16.9m	\$27.9m
<i>Change from Scenario A</i>	<i>\$0.4m</i> <i>+11.4%</i>	<i>\$0.3m</i> <i>+5.5%</i>	<i>\$0.3m</i> <i>+3.6%</i>	<i>\$0.4m</i> <i>+3.1%</i>	<i>\$0.4m</i> <i>+2.4%</i>	<i>\$1.1m</i> <i>+3.9%</i>

The most notable difference between existing and ultimate development conditions are in areas outside the defined damage areas during the 0.2% AEP. This is likely due to the addition of two additional catchments in the south of the model that affect the buildings at 12831-12833 Sturt Hwy.

4.3.4.3. Total tangible damage estimates for Scenario B (Ultimate Development)

Using the same methodology described previously, total tangible damage estimates for Ultimate Development are provided in Table 30, below.

Table 30. Total tangible damages under Ultimate Development.

Land use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	\$2.2m	\$4.1m	\$6.8m	\$11.7m	\$15.8m	\$27.4m
Commercial	\$2.3m	\$2.9m	\$3.5m	\$4.2m	\$4.7m	\$5.7m
Industrial	\$0.1m	\$0.1m	\$0.2m	\$0.2m	\$0.3m	\$0.6m
Total	\$4.6m	\$7.1m	\$10.4m	\$16.0m	\$20.7m	\$33.7m
<i>Change from Scenario A</i>	<i>\$0.4m</i> <i>+8.7%</i>	<i>\$0.3m</i> <i>+4.2%</i>	<i>\$0.2m</i> <i>+1.9%</i>	<i>\$0.3m</i> <i>+1.9%</i>	<i>\$0.5m</i> <i>+2.4%</i>	<i>\$1.3m</i> <i>+3.9%</i>

5. Water Quality Modelling

A water quality modelling was developed for the town of Waikerie to assess how stormwater runoff from the town affects the River Murray and identify opportunities to improve water management. The modelling process follows current best practice guidelines according to the South Australian MUSIC Guidelines.

5.1. Water Quality Modelling Approach

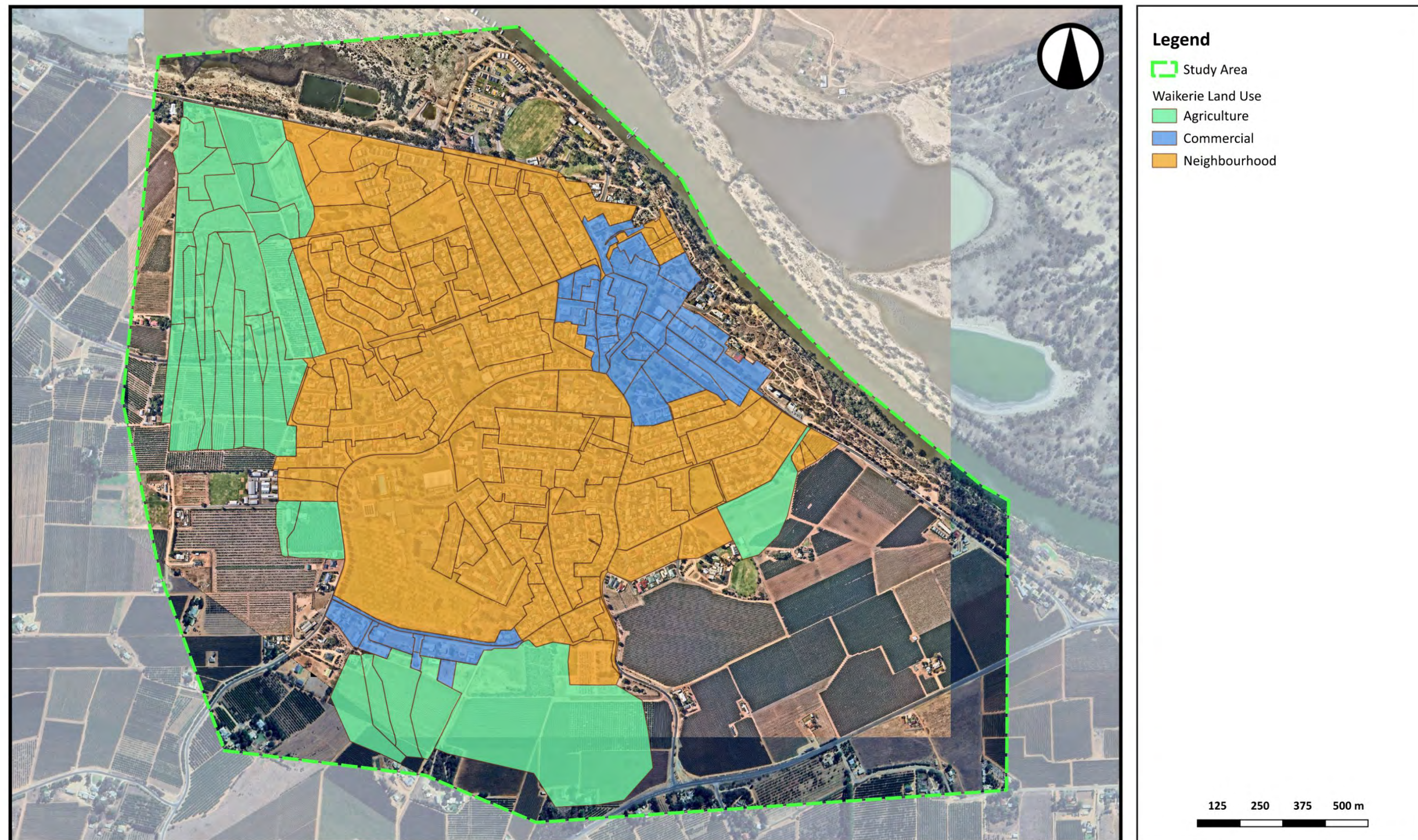
Stormwater from Waikerie flows through a drainage network into the River Murray, carrying pollutants that harm water quality and damage sensitive river ecosystems. Runoff from urban areas is particularly affected by residential and commercial activities, introducing:

- Gross pollutants
- Sediments
- Nutrients (nitrogen and phosphorous)
- Other dissolved pollutants (hydrocarbons, organic matter and chemicals)
- Metals

Pollutant loads in Waikerie's stormwater were estimated using MUSIC software, which simulates stormwater quantity, quality, and treatment performance. By combining catchment data with weather inputs, MUSIC predicts pollutants such as sediment, nutrients, and contaminants, and evaluates the effectiveness of different management strategies to reduce impacts on waterways.

Rainfall and evapotranspiration data from the Loxton Research Centre (1976–2010), recorded at six-minute intervals, were used in the model. A 1 mm rainfall threshold was applied to impervious surfaces, with 139 mm soil storage and 69 mm field capacity used for pervious areas, based on Loxton's Loamy Sand soils. These settings follow MUSIC guidelines and have little effect on runoff volumes except where impervious coverage is low.

The catchment was divided into three land-use sub-catchments: agricultural, commercial and residential with the remaining unshaded 203ha study area included as 10% impervious Agricultural land-use. Imperviousness was estimated using Directly Connected Impervious Area (DCIA) values, a key factor in runoff predictions, derived from satellite imagery and the 2022 Land Use dataset. The digitised catchment is shown in Figure 25.



WAIKERIE STORMWATER MANAGEMENT PLAN

EXISTING WAIKERIE SUB-CATCHMENTS BASED ON LANDUSE

Project: 24024 - Waikerie SMP

Revision: 1

Date: 05/09/2025

Coordinate System: GDA2020 / MGA zone 54

Drawn: B. Hennekam

Background Imagery: Nearmap (13 March 2023), Google Satellite



Figure 25. Existing Waikerie sub-catchments based on land use

MUSIC's default pollutant concentrations for TSS, TN, and TP were used, consistent with South Australian MUSIC Modelling Guidelines. Default values for gross pollutant removal efficiency were also applied, ensuring consistency and regulatory compliance where site-specific data is unavailable.

Two distinct scenarios have been developed to assess potential improvements in water quality and the overall performance of stormwater management strategies for the township of Waikerie.

Scenario 1 – Existing conditions (baseline conditions)

Scenario 2 – Existing conditions with existing Water Sensitive Urban-Design (WSUD)

The modelling used digitised sub-catchments as Source nodes to estimate pollutant loads (Scenario 1) and added Treatment nodes (Scenario 2) to assess pollutant reductions at treatment points and across the system. Existing WSUD infrastructure, including the Hart Lagoon wetland, was incorporated, while swale collection and water reuse were excluded to focus on pollutant loads from the catchment.

MUSIC outputs include:

- Source loads: Runoff and pollutants without treatment.
- Residual loads: Runoff and pollutants after treatment.
- Percent reduction: Pollutant reduction from treatment.

The following sections summarise the water quality performance of the specified requirements two modelled scenarios.

5.2. MUSIC modelling and results

5.2.1. Model parameters

A MUSIC model was created to simulate Waikerie's current stormwater conditions, estimating baseline (source) pollutant loads without any water quality treatment.

5.2.1.1. Catchments

MUSIC estimated the pollutant loads generated in each sub-catchment based on the specific land use types present (shown in Table 31). These individual estimates were then aggregated to calculate the total pollutant load for each catchment, ultimately providing an overall value for the entire study area.

Table 31. MUSIC modelling for pollutant loads

Parameter	Pollutant Load		
	Agricultural	Commercial	Residential
Total Suspended Solids (kg/yr)	1,514.93	3,725.62	17,780.91
Total Phosphorus (kg/yr)	1.64	10.51	26.93
Total Nitrogen (kg/yr)	10.14	60.53	204.30

5.2.1.2. Pollutant Concentrations

The Riverland reach of the Murray River, located in South Australia's south-central, low-rainfall region, has the following water quality characteristics: TN is measured at 1.0 mg/L (1000 µg N/L), TP at 0.10 mg/L (100 µg P/L), and TSS are not directly measured using Australian and New Zealand

Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) default values.

Pollutant concentrations at each catchment and the cumulative are shown in Table 32. It is important to note that these concentrations were modelled using the full range of rainfall data, encompassing both dry and wet periods.

Table 32. Scenario 1 pollutant concentrations

Catchment	Pollutant Load		
	Total Nitrogen P ₅₀ /P ₉₀ (mg/L)	Total Phosphorous P ₅₀ /P ₉₀ (mg/L)	Total Suspended Solids P ₅₀ /P ₉₀ (mg/L)
Agricultural	0/0.699	0/0.699	0/0.041
Commercial	0/2.089	0/0.251	0/6.025
Residential	0/3.311	0/0.288	0/3.388
Total Catchment	0/2.128	0/0.058	0/0.635

5.2.2. Scenario 1

Baseline Water Quality Modelling

The results for the baseline scenario for the entire 453ha study area is summarised in Table 33 below. The "Reduction Target" column outlines the South Australian water quality performance targets for WSUD (South Australian MUSIC Guidelines, 2021), as defined by the Department of Environment, Water, and Natural Resources.

Table 33. MUSIC modelling results for baseline scenario

Parameter	Pollutant Load	Reduction Target
Flow (ML/yr)	203.92	-
Total Suspended Solids (kg/yr)	41,455.16	80%
Total Phosphorus (kg/yr)	61.26	60%
Total Nitrogen (kg/yr)	422.85	45%
Gross Pollutants (kg/yr)	9,395.79	-

5.2.3. Scenario 2

5.2.3.1. Hart Lagoon

Hart Lagoon constructed wetland and stormwater harvesting and reuse system was constructed in 2023 to intercept and treatment 136.7ha of Waikerie's urban areas before flowing into the natural Hart Lagoon NIWA wetland downstream. The Hart Lagoon catchment includes six urban-residential sub-catchments, which were delineated based on topography and the locations of existing stormwater system inlets and outlets.

The system is comprised of a sediment basin, prior to flowing into the wetland and then entering the 4.5ML storage pond. The stored water is then used to irrigate the surrounding seven hectares of parkland, including the Waikerie AFL Oval.

- The sedimentation basin is effective at trapping large solids and gross pollutants but demonstrates limited performance in removing nutrients.
- The wetland pond provides a more balanced treatment, showing good effectiveness in reducing suspended solids, nutrients, and gross pollutants through macrophyte adsorption in the shallow planted zones and extended detention time in the deep zones.
- At the wetland outlet, the pond achieves additional high pollutant reductions. This is attributed to the extended retention time, which enhances settling and supports biological processing.

5.2.3.2. Hart Lagoon Constructed Wetland Water Quality Performance

Scenario 2 modelling assessed the effect of existing treatment measures, incorporating the Hart Lagoon wetland as a WSUD feature. Results, shown in Table 34, compare pollutant reductions against South Australian WSUD performance targets (South Australian MUSIC Guidelines, 2021).

Table 34. MUSIC modelling results for Hart Lagoon Constructed Wetland

Parameter	Source	Residual	% Reduction	Reduction Target
Flow (ML/yr)	129.58	50.51	61.02	-
Total Suspended Solids (kg/yr)	23,021.46	3,053.84	86.73	80%
Total Phosphorus (kg/yr)	39.08	8.32	78.72	60%
Total Nitrogen (kg/yr)	274.97	86.21	68.65	45%
Gross Pollutants (kg/yr)	6,513.85	0.00	100.00	-

Results show pollutant reduction targets have been exceeded for the catchment due to the construction of Hart Lagoon wetland and will provide approximately 40ML of reuse water per annum while still providing adequate environmental flows into the downstream Lagoon.

5.2.3.3. Scenario 2 Water Quality Performance

Of the total 453 hectares across the study area, 135.7 hectares drain into the Hart Lagoon wetland. Pollutant reduction outcomes for Waikerie are presented in Table 35.

Table 35. Pollutant reductions at Hart Lagoon wetland

Parameter	Source	Residual	% Reduction
Flow (ML/yr)	203.92	125.79	38.32
Total Suspended Solids (kg/yr)	41455.16	21325.86	48.56

Parameter	Source	Residual	% Reduction
Total Phosphorus (kg/yr)	61.26	33.97	44.55
Total Nitrogen (kg/yr)	422.85	241.19	42.96
Gross Pollutants (kg/yr)	9395.79	3302.52	64.85

Across the entire study area , the pollutant load targets are not met, however show a vast improvement on the baseline figures.

5.3. Pollutant information

Table 36 shows the sources and impacts of the pollutants determined in MUSIC and other residual pollutants. Refer to 2.8.1 for more detailed pollutant information.

Table 36. Pollutants, sources and impacts

Types of Pollutants	Sources	Impacts
Suspended Sediments and Solids	Eroded and washed soil from construction sites Sediment-laden agricultural runoff Sediments from natural erosion during heavy rainfall Logging, deforestation, and exposed land Mismanaged waste disposal and landfills	Reduces light penetration, disrupting aquatic plants and ecosystems Increases turbidity in rivers (e.g., River Murray) - Sediment deposits clog stormwater drains and pipes, leading to blockages, corrosion, and maintenance issues - Weakens infrastructure, escalating damage and costs - Accelerates soil degradation and loss of fertility
Nutrients (Nitrogen and Phosphorus)	Farmlands rich in fertilisers and animal manure Urban landscapes with fertilisers on lawns Poorly maintained septic system Industrial discharge Atmospheric deposition (vehicle exhaust, industrial emissions)	Eutrophication and algal blooms (e.g., cyanobacteria/blue-green algae) Oxygen depletion in water bodies, suffocating fish and aquatic life Acidification of groundwater Disturbance of soil microbial activity and increased surface runoff Imbalances in natural life cycles and food chains

Types of Pollutants	Sources	Impacts
Gross Pollutants	Litter and trash from public spaces and roads Waste from commercial and industrial sites Roads and highways (plastic bags, debris) Construction debris Poor waste and wastewater management	Visual pollution and harm to aquatic ecosystems Blocks drains, causing flooding and reduced efficiency Health risks from untreated waste Degrades riverbanks and aquatic habitats Reduces recreational and aesthetic values of waterways
Other incidental pollutants		
Metals	Industrial activities, construction sites, automotive industry Atmospheric deposition Stormwater runoff	Bind to sediments, degrading ecosystems Accumulate in soil and groundwater Toxicity affecting aquatic life and human health Can enter the food chain and pose health risks
Hydrocarbons	Petroleum-based products (fuel spills, industrial discharge, urban runoff, vehicle emissions)	Indicate petroleum contamination Pollute rivers, impair water quality Harm aquatic ecosystems Toxic accumulation in soil and groundwater Health hazards if they enter food chains
Emerging Organic Contaminants (EOCs)	Pharmaceuticals, personal care products, industrial materials, pesticides, herbicides, synthetic compounds	Disrupt natural processes and ecological functions Cause toxicity and resistance in aquatic organisms Affect reproduction, growth, and survival rates of aquatic fauna Accumulate in soil and groundwater Enter the food chain, creating long-term health risks

5.4. Water demand and supply

Waikerie's potable water comes from the River Murray, managed under the Water Allocation Plan and treated at the local TRILITY Water Treatment Plant (4 ML/day capacity). The Central Irrigation Trust supplies large volumes for horticulture, while wastewater is treated for irrigation reuse at the TRILITY Wastewater Treatment Plant. The Hart Lagoon wetland supports the Stormwater Reuse Project, providing irrigation for Waikerie Oval and serving as a firefighting water reserve.

Table 37 shows the water supply sources at Waikerie and their details.

Table 37. Water supply sources

Sources / Scheme	Facility	Design Capacity and Volume
Water Allocation Plan	Waikerie Water Treatment Plant (TRILITY)	4 ML/day design capacity; serves approximately 2,000 people
Recycled water	Waikerie Wastewater Treatment Plant	Approximately 200 ML/year planned reuse
Stormwater	Hart Lagoon Stormwater Harvesting & Reuse Project	Approximately 55 ML/year demand, SWHR supplied ~40ML/year
Water for irrigation	Central Irrigation Trust	Approximately 150 GL/year across region wide districts

Currently, no publicly available data details Waikerie's specific water demand. However, water use across Riverland towns typically peaks during the summer months due to the region's climate and increased outdoor use.

Table 38 shows the estimated stormwater harvesting capacity for each sub-catchment, as determined using the MUSIC model.

Table 38. Harvesting capacity at each sub-catchment

Sub-catchment	Flow (ML/yr)
Agricultural	5.49
Commercial	25.83
Residential	98.26

6. Risk Assessment

Flood risk assessment is a critical process for identifying, evaluating, and managing the potential impacts of flooding on communities, infrastructure, and the environment.

Four scenarios were analysed during this risk assessment to evaluate the current and future risks for the town of Waikerie:

- Scenario 1a showing existing conditions at 18% AEP

- Scenario 1b showing future development conditions at 18% AEP
- Scenario 5a showing existing conditions at 1% AEP
- Scenario 5b showing future development conditions at 1% AEP

The risks were classified under safety, strategic, operational, regulatory, and reputational categories and prioritised using a consequence-likelihood matrix. Risk categories with descriptions are outlined as in Table 39. The risk assessment matrix and description of each classification is shown in Figure 26.

Results show that without improvements, the number of high and severe flood risk areas is likely to increase as the town grows.

Table 39. Risk categories

Risk category	Description
Safety (Including public health and well-being)	Includes contaminated water exposure, drowning possibility and injuries, electrocution, traffic and evacuation and emergency locations accessibility
Strategic risks	Includes changes in land uses, Water-Sensitive Urban Design (WSUD) strategy and future development potential
Operational risks	Includes blockages or debris, overflows, asset recovery and capacity outfall
Regulatory risks	Includes land-use controls, waste and hazardous material management, water quality, safety obligations, emergency protocol, cultural heritage and biodiversity approvals and public health standards
Reputational and political risks	Includes prioritisation disputes, transparency gaps, cost increases, environmental harm and malformation

				Consequence				
				Negligible impact on cost, safety, schedule, or environment. Easily managed.	Small financial or schedule impact; minor inconvenience or minor maintenance response.	Measurable cost or delay; localised flooding; moderate maintenance or public impact.	Significant cost increase or construction delay; failure of asset function; safety risk; possible media attention.	Catastrophic failure; serious injury or fatality; major flood or legal action; reputational damage.
				Insignificant	Minor	Moderate	Major	Severe
				1	2	3	4	5
Likelihood	May occur only in exceptional circumstances	Rare	1	Low	Low	Low	Low	Moderate
	Could occur at some time, but not expected under normal conditions	Unlikely	2	Low	Low	Moderate	Moderate	High
	Might occur; reasonable chance within planning period	Possible	3	Low	Moderate	Moderate	High	High
	Will probably occur in most years	Likely	4	Low	Moderate	High	High	Severe
	Expected to occur in most circumstances or multiple times per year	Almost Certain	5	Moderate	Moderate	High	Severe	Severe

Figure 26. Risk assessment matrix and description of each classification

6.1. Risk Assessment

The risk assessments for scenarios 1a, 1b, 5a and 5b are shown in Table 40, Table 41, Table 42 and Table 43, respectively.

Table 40. Risk assessment for Scenario 1a – 18% AEP Existing Conditions

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 74-75)	Ponding over road and between houses	Safety	2	2	Low
2-1	Apex Park (North-eastern end)	Ponding in low point of park along fenceline	Strategic	2	3	Moderate
2-2	2 West Rd	Ponding in backyard	Safety	2	2	Low
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Safety	2	2	Low
3-1	17 West Rd	Significant gutter flows	Operational	2	4	Moderate
3-2	5A West Rd	Significant gutter flows	Operational	2	4	Moderate
3-3	Bottom of Stanley St	Significant gutter flows (full street width)	Operational	2	4	Moderate
4-1	Top of Cates Ave	Significant gutter flows	Operational	2	4	Moderate
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Operational/ Safety	2	3	Moderate
4-3	Community Sports complex	Ponding between oval and tennis court areas	Strategic/ Reputational	4	3	High
5-1	Machinery Museum	Ponding on grassed area	Operational	1	4	Low
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Operational	2	3	Moderate
7-1	Civic Centre grounds	Ponding in low point of park	Strategic	2	3	Moderate
7-2	Ambulance station	Ponding in driveway	Safety/ Reputational	5	2	Moderate
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park (not a Council-owned asset)	Safety/ Reputational	5	4	Severe
7-4	Wohling St / Ifould Park	Ponding over road and some of park	Strategic/ Operational	3	3	Moderate
8-1	Ian Oliver Drive	Ponding adjacent to road	Strategic	2	2	Low

Table 41. Risk assessment for Scenario 1b – 18% AEP Ultimate Development

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Minor ponding between houses	Safety	2	2	Low
2-1	Apex Park (North-eastern end)	Ponding in low point of park along fenceline	Strategic	3	4	High
2-2	2 West Rd	Ponding in backyard	Safety	3	2	Moderate
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Safety	3	2	Moderate
2-4	31 Mary Starr Drive	Minor ponding in backyard	Operational/ Strategic	3	2	Moderate
3-1	17 West Rd	Significant gutter flows	Operational	2	4	Moderate
3-2	5A West Rd	Significant gutter flows	Operational	2	4	Moderate
3-3	Bottom of Stanley St	Significant gutter flows (full street width)	Operational	2	4	Moderate
4-1	Top of Cates Ave	Significant gutter flows	Operational	2	4	Moderate
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Operational/ Safety	2	3	Moderate
4-3	Community Sports complex	Ponding between oval and tennis court areas	Strategic/ Reputational	4	3	High
4-4	Bowling club	Ponding on green	Strategic	2	2	Low
5-1	Machinery Museum	Ponding on grassed area	Operational	3	4	High
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Operational	3	3	Moderate
6-2	Bottom of Kirby St (41 Peake Terrace)	Significant gutter flows (not on road)	Operational	1	3	Low
7-1	Civic Centre grounds	Ponding in low point of park	Strategic	2	4	Moderate
7-2	Ambulance station	Ponding in driveway	Safety/ Reputational	5	3	High
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park (not a Council-owned asset)	Safety/ Reputational	5	5	Severe
7-4	Wohling St / Ifould Park	Ponding over road and some of park	Strategic/ Operational	3	4	High
8-1	Ian Oliver Drive	Ponding adjacent to road	Strategic	3	3	Moderate
8-2	41 Strangman Rd	Ponding in vineyard (away from structures)	Strategic	3	3	Moderate

Table 42. Risk assessment for Scenario 5a – 1% AEP Existing Conditions

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Ponding over road and between houses	Safety/ Operational	4	2	Moderate
1-2	Lifestyle Village (Central, village hub)	Ponding over road and onto paths	Operational/ Safety	3	4	High
1-3	Lifestyle Village (North-eastern end, residences 40 and 41)	Ponding over road and between houses	Safety/ Operational	4	3	High
1-4	Lifestyle Village (North-western end, residences 48-52)	Ponding over road	Safety/ Operational	4	3	High
1-5	Lifestyle Village (Western end, residences 61-63)	Ponding over road	Safety/ Operational	4	3	High
1-6	Peake Tce (adj. Lifestyle Village)	Ponding in swale adjacent road	Operational	1	2	Low
1-7	Lifestyle Village (Residence 88)	Ponding around house	Strategic/ Regulatory	3	2	Moderate
2-1	Apex Park (Northern end)	Ponding in low point of park along fenceline	Strategic	4	3	High
2-2	2 West Rd	Ponding in backyard	Safety	2	2	Low
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Safety	3	2	Moderate
2-4	31 Mary Starr Drive	Minor ponding in backyard (pool)	Operational/ Strategic	2	2	Low
2-5	Bottom of Mary Starr Drive	Significant ponding along gutter	Safety/ Operational	4	3	High
2-6	Mary Starr Basin & swale	Both overtop	Operation/ Regulatory	2	2	Low
3-1	17 West Rd	Significant gutter flows	Operational	3	4	High
3-2	5A West Rd	Significant gutter flows	Operational	3	4	High
3-3	Bottom of Stanley St	Significant gutter flows (full street width)	Operational	2	4	Moderate
4-1	Top of Cates Ave	Significant gutter flows and ponding in Lutheran Church	Operational/ Reputational	3	4	High
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Safety/ Operational	2	4	Moderate
4-3	Community Sports complex	Ponding between oval and tennis court areas. Flowing into Warrawee Lodge (Rotary Drive).	Strategic/ Reputational	5	4	Severe

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
4-4	Bowling club	Ponding on green	Strategic	2	2	Low
4-5	Traffic lights on Lawrie Tce	Ponding adjacent to road	Operational	3	3	Moderate
4-6	Warrawee Lodge (Eastern end)	Ponding against the eastern fenceline	Strategic	3	3	Moderate
4-7	Elders Way	Ponding at the carpark at the end of the street	Operational	2	3	Moderate
5-1	Machinery Museum	Ponding on grassed area	Operational	4	4	High
5-2	Football oval	Minor ponding on oval	Operational	1	3	Low
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Operational/ Safety	4	3	High
6-2	Bottom of Kirby St (West of 41 Peake Terrace)	Significant gutter flows (not on road)	Operational	2	3	Moderate
6-3	41 Peake Tce	Ponding in depression between Peake Terrace and service road	Operational	2	3	Moderate
7-1	Civic Centre grounds	Ponding over grassed area	Strategic	3	3	Moderate
7-2	Ambulance station	Ponding in driveway	Safety/ Reputational	5	3	High
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park (not a Council-owned asset)	Safety/ Reputational	5	4	Severe
7-4	Wohling St / Ifould Park	Significant ponding over entire park and adjacent roads	Strategic/ Operational/ Safety	5	4	Severe
7-5	Medical Centre (1 Strangman Rd)	Significant gutter flows	Operational	2	3	Moderate
7-6	10 Dowling St	Significant gutter flows	Operational/ Safety	4	3	High
7-7	9 Miller St	Ponding in backyard and into laneway	Safety	5	4	Severe
7-8	16 Miller St	Significant gutter flows	Operational	1	3	Low
7-9	Civic Ave near RV dump point	Significant gutter flows	Operational	2	3	Moderate
8-1	Ian Oliver Drive	Ponding adjacent to road	Strategic	4	2	Moderate
8-2	Bottom of Burns St	Significant gutter flows on both sides of road	Operational	2	3	Moderate
8-3	Tiller Crescent	Ponding on the northern end of the cul-de-sac	Operational	1	3	Low
8-4	Cates St (bottom of cul-de-sac)	Significant gutter flows	Operational	1	3	Low

Table 43. Risk assessment for Scenario 5b – 1% AEP Ultimate Development

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Ponding over road and between houses	Safety/ Operational	4	2	Moderate
1-2	Lifestyle Village (Central, village hub)	Ponding over road and onto paths	Operational/ Safety	3	4	High
1-3	Lifestyle Village (North-eastern end, residences 40 and 41)	Ponding over road and between houses	Safety/ Operational	4	3	High
1-4	Lifestyle Village (North-western end, residences 48-52)	Ponding over road	Safety/ Operational	4	3	High
1-5	Lifestyle Village (Western end, residences 61-63)	Ponding over road	Safety/ Operational	4	3	High
1-6	Peake Tce (adj. Lifestyle Village)	Ponding in swale adjacent road	Operational	1	3	Low
1-7	Lifestyle Village (Residence 88)	Ponding around house	Strategic/ Regulatory	3	2	Moderate
1-8	Lifestyle Village Men's Shed	Ponding around shed	Strategic	2	1	Low
1-9	Lifestyle Village (NW intersection)	Ponding at pits 2-1 & 3-1	Operational/ Regulatory	3	2	Moderate
2-1	Apex Park (Northern end)	Ponding in low point of park along fenceline	Strategic	4	3	High
2-2	2 West Rd	Ponding in backyard	Safety	2	2	Low
2-3	West Rd (Walking track)	Ponding along fenceline north of walking track	Safety	3	2	Moderate
2-4	31 Mary Starr Drive	Minor ponding in backyard (pool)	Operational/ Strategic	2	2	Low
2-5	Bottom of Mary Starr Drive	Significant ponding along gutter	Safety/ Operational	4	3	High
2-6	Mary Starr Basin & swale	Both overtop	Operation/ Regulatory	2	2	Low
3-1	17 West Rd	Significant gutter flows	Operational	3	4	High
3-2	5A West Rd	Significant gutter flows	Operational	3	4	High
3-3	Bottom of Stanley St	Significant gutter flows (full street width)	Operational	2	4	Moderate
4-1	Top of Cates Ave	Significant gutter flows and ponding in Lutheran Church	Operational/ Reputational	3	4	High

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
4-2	Laneway between Jemison St and Heming St	Ponding over laneway	Safety/ Operational	2	4	Moderate
4-3	Community Sports complex	Ponding between oval and tennis court areas. Flowing into Warrawee Lodge (Rotary Drive).	Strategic/ Reputational	5	4	Severe
4-4	Bowling club	Ponding on green	Strategic	2	2	Low
4-5	Traffic lights on Lawrie Tce	Ponding adjacent to road	Operational	3	3	Moderate
4-6	Warrawee Lodge (Eastern end)	Ponding against the eastern fenceline	Strategic	3	3	Moderate
4-7	Elders Way	Ponding at the carpark at the end of the street	Operational	2	3	Moderate
5-1	Machinery Museum	Ponding on grassed area	Operational	4	4	High
5-2	Football oval	Minor ponding on oval	Operational	1	3	Low
6-1	45-47 Peake Terrace	Ponding in depression between Peake Terrace and service road	Operational/ Safety	4	3	High
6-2	Bottom of Kirby St (West of 41 Peake Terrace)	Significant gutter flows (not on road)	Operational	2	3	Moderate
6-3	41 Peake Tce	Ponding in depression between Peake Terrace and service road	Operational	2	3	Moderate
7-1	Civic Centre grounds	Ponding over grassed area	Strategic	3	3	Moderate
7-2	Ambulance station	Ponding in driveway	Safety/ Reputational	5	3	High
7-3	Medical Centre (2 Strangman Rd)	Ponding next to building and in car park (not a Council-owned asset)	Safety/ Reputational	5	4	Severe
7-4	Wohling St / Ifould Park	Significant ponding over entire park and adjacent roads	Strategic/ Operational/ Safety	5	4	Severe
7-5	Medical Centre (1 Strangman Rd)	Significant gutter flows	Operational	2	3	Moderate
7-6	10 Dowling St	Significant gutter flows	Operational/ Safety	4	3	High
7-7	9 Miller St	Ponding in backyard and into laneway	Safety	5	4	Severe
7-8	16 Miller St	Significant gutter flows	Operational	1	3	Low
7-9	Civic Ave near RV dump point	Significant gutter flows	Operational	2	3	Moderate
7-10	Civic Ave near Nippy's/Mitre 10	Significant gutter flows	Operational	2	3	Moderate

ID	Location	Description	Risk Category	Consequence	Likelihood	Risk Rating
8-1	Ian Oliver Drive	Ponding adjacent to road	Strategic	4	2	Moderate
8-2	Bottom of Burns St	Significant gutter flows on both sides of road	Operational	2	3	Moderate
8-3	Tiller Crescent	Ponding on the northern end of the cul-de-sac	Operational	1	3	Low
8-4	Cates St (bottom of cul-de-sac)	Significant gutter flows	Operational	1	3	Low
8-5	41 Strangman Rd	Ponding in vineyard (away from structures)	Safety	3	2	Moderate

6.2. Distribution of Risk Ratings

Table 44 summarises identified risk ratings for all scenarios.

Table 44. Risk ratings distribution

	Low	Moderate	High	Severe
Scenario 1a – 18% AEP Existing Conditions	5	10	1	1
Scenario 1b - 18% AEP Ultimate Development	3	12	5	1
Scenario 5a – 1% AEP Existing Conditions	9	15	13	4
Scenario 5b – 1% AEP Ultimate Development	10	18	13	4

7. Stormwater Management Objectives and Targets

This section establishes the objectives and performance targets that will guide stormwater management across the Waikerie township and the catchment area. These objectives provide a framework for future decision-making and support the broader goal of delivering sustainable stormwater outcomes that reduce flood risk, protect the community, improve environmental values, and align with regional and State planning requirements.

7.1. Guidelines and Policies

The Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007) instructs that:

“As a minimum, objectives are to set goals for:

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

Further guidance is provided in Water Sensitive Urban Design – Creating More Liveable and Water Sensitive Cities in South Australia (Department of Environment, Water and Natural Resources, 2013), which defines the following indicative stormwater quality improvement targets:

- 80% reduction in Total Suspended Solids (TSS)
- 60% reduction in Total Phosphorus (TP)
- 45% reduction in Total Nitrogen (TN)
- 90% reduction in Gross Pollutants (GP)

These targets are consistent with the performance targets recommended in the Water Sensitive SA – South Australian MUSIC Modelling Guidelines (Water Sensitive SA, 2021), and represent current best practice for achieving sustainable, catchment-based stormwater outcomes in South Australia.

These benchmarks have been adopted as ‘Aspirational’ targets for the water quality improvement objectives within this Stormwater Management Plan (SMP) to support a more sustainable and liveable environment for the community, however in reality all water quality improvements will be beneficial to the receiving waterways.

7.2. Overall Goal

The overall goal of this SMP is to establish a comprehensive and sustainable stormwater management system for the town of Waikerie that:

- Minimises flood risks to people, property, and infrastructure;
- Improves the quality of stormwater discharging to the River Murray;

- Minimises adverse impacts on receiving environments;
- Supports urban growth consistent with sustainable land use and water-sensitive design principles;
- Enhances the amenity and resilience of the Waikerie community; and
- Delivers cost-effective, climate-resilient outcomes for the Waikerie community.

7.3. Objectives and Targets

Objectives and targets set for achieving the overall goals are shown in Table 45.

Table 45 Stormwater Management Objectives and Targets

No.	Objectives	Targets	Absolute (Abs) or Aspirational (Asp)
1	Provide an acceptable level of flood protection for public and private assets.	a. Ensure all developments have habitable floor levels protected from a 5% AEP (1 in 20 years) or more frequent flood event, including the required freeboard allowance.	Abs
		b. Ensure all new developments have habitable floor levels protected from a 1% AEP (1 in 100 year) or less frequent flood event.	Asp
		c. Ensure no private property is subject to high or extreme hazard (H3 hazard and above) in a 1% AEP flood event or less.	Abs
		d. Ensure no residential roadways or properties are exposed to H3 or higher hazard during a 18% AEP flood event.	Abs
		e. Ensure no commercial or industrial roadways or properties experience H3 or higher hazard during a 18% AEP flood event, or higher.	Abs
		f. Maintain safe vehicle access (H1 hazard) along state and local arterial roads during a 1% AEP event.	Abs
		g. Council provide flood risk information to the community and provide assistance to community for creating flood plans.	Asp
2	Planning for new developments	a. A stormwater management plan must be developed for new developments and submitted to Council for approval.	Abs

No.	Objectives	Targets	Absolute (Abs) or Aspirational (Asp)
		b. Maximise opportunities for on-site stormwater reuse and storage in all new developments.	Asp
		c. For developments connecting to existing underground networks, restrict post-development peak flow to pre-development levels for 5% AEP and 1% AEP events through on-site detention.	Abs
		d. Ensure all new developments do not increase downstream flood risk and include a major overland flow path for the 1% AEP critical storm.	Abs
		e. All new developments will consider their impact on the downstream network, including swales and basins, and will provide adequate mitigation where the downstream network is subsequently over capacity considering both peak flow and runoff volume.	Asp
		f. Incorporate WSUD measures to achieve water-quality improvement targets consistent with WSUD Guidelines, including: • 80% reduction in TSS • 60% reduction in TP • 45% reduction in TN	Abs
3	Provide an acceptable level of performance in underground stormwater system and pits	a. Design minor drainage systems for a 18%AEP capacity with no overflows where practical. Lower standards may be acceptable where physical or economic constraints exist, and a safe overflow route is available. higher standards should apply where no overflow route exists.	Abs
		b. Protect existing development from inundation in a 1% AEP event, where practical and economically viable.	Abs
4	Improve water quality discharging to the River	a. Achieve an 80% reduction in TSS compared to the 'untreated' case	Abs

No.	Objectives	Targets	Absolute (Abs) or Aspirational (Asp)
	Murray and protect aquatic ecosystem health	b. Achieve a 60% reduction in TP compared to the 'untreated' case	Abs
		c. Achieve a 45% reduction in TN compared to the 'untreated' case	Abs
		d. Achieve a 90% reduction in litter/gross pollutants compared to the 'untreated' case	Abs
5	Increase the beneficial use of stormwater	a. Opportunities for stormwater harvesting for non-potable uses including irrigation of parks, sporting fields, and streetscapes are to be assessed.	Abs
		b. Promote reuse within commercial and industrial developments through planning incentives.	Abs
		c. Council are to require developments to utilise stormwater reuse where authority allows.	Asp
6	Protect and enhance ecological and biodiversity values associated with stormwater infrastructure.	a. Maintain or enhance riparian and floodplain vegetation along drainage lines	Abs
		b. All new and upgraded stormwater outlets, discharging to the river are to be designed to control silt deposits, discharging velocities and mitigate any adverse effects to the physical conditions of the receiving environment.	Abs
		c. Prevent untreated stormwater discharge into sensitive environmental areas.	Abs
		d. Design and manage detention basins and wetlands as multi-functional ecological assets.	Asp
		e. Integrate biodiversity corridors within stormwater reserves through targeted revegetation and landscaping.	Asp
7	Incorporate open space, recreation, and amenity outcomes in planning.	a. Develop and implement planning and design policies that minimise the impact of flooding on new and existing developments.	Abs

No.	Objectives	Targets	Absolute (Abs) or Aspirational (Asp)
		b. Adopt integrated design principles to achieve multiple outcomes (water management, amenity, biodiversity) in new development, retrofits, stormwater, road and streetscape upgrades.	Asp
		c. Promote design approaches that protect and enhance natural systems, increase biodiversity, and enable passive stormwater treatment and reuse.	Asp
8	Asset Management and Governance	a. Council to maintain up to date information on the location, size, age and condition of stormwater infrastructure.	Abs
		b. Ensure all WSUD assets have an operation and maintenance plan in place.	Abs
9	Climate Resilience and Adaptation	a. Design new stormwater infrastructure with consideration of 2090 climate-change rainfall projections.	Asp
10	Communication and engagement with stakeholders, businesses, and the community	a. Effectively engage with the community on stormwater management issues and proposed strategies including WSUD and stormwater reuse opportunities where possible.	Asp
		b. Increase community and business awareness to enable effective response to extreme-weather and flood warnings.	Asp
		c. Identify opportunities for partnerships with the community and agencies in the development and implementation of strategies.	Asp

8. Stormwater Management Responses

A range of stormwater management solutions was developed to address the key flooding, water quality, and drainage challenges identified throughout the study. These solutions were assessed against the project's objectives and reviewed with Council and the SMP Steering Committee to identify the most effective and achievable management responses.

The preferred management responses were evaluated for their ability to reduce flood risk, improve water quality, support future growth, and deliver environmental and community benefits. The resulting strategy provides a balanced and practical framework for enhancing the resilience, performance, and long-term sustainability of the stormwater system across the town of Waikerie.

8.1. Summary of strategies

Waikerie has two distinct stormwater networks: the Hart Lagoon network, which drains approximately two-thirds of the township to Hart Lagoon, and the River Murray network, which drains the remaining areas towards the River Murray.

Flood modelling and flood risk assessment identified a number of problem areas, grouped as Damage Areas (DAs) based on catchment characteristics, drainage behaviour, and the performance of the existing stormwater network. To address these issues, the proposed stormwater management responses have been organised into solution sets, each targeting one or more Damage Areas.

The proposed management responses combine conventional stormwater infrastructure upgrades with Water Sensitive Urban Design (WSUD) measures to achieve the flood management and water quality objectives established in Section 8. Conventional measures include stormwater pipe upgrades, network extensions, detention basins, and drainage improvements, while WSUD measures provide complementary benefits by reducing runoff volumes, improving water quality, and enhancing urban amenity.

A fundamental principle of this Stormwater Management Plan is to manage stormwater as close to its source as practicable. Treating, retaining, and slowing runoff before it enters the drainage network reduces peak flows, improves water quality, promotes infiltration, and reduces pressure on downstream infrastructure and receiving environments. This source-control approach complements conventional drainage upgrades by reducing demand on the existing network, improving system resilience, and supporting more sustainable stormwater management outcomes.

Where conventional engineering solutions are constrained or impractical, additional WSUD measures have been incorporated to improve overall system performance. These include:

- Infiltration system, such as leaky wells, tree inlets;
- Series of biofilters and vegetated swales;
- Permeable paving/porous asphalt;
- Constructed wetlands;
- Underground detention systems; and,
- Stormwater harvesting and reuse opportunities.

Several of the proposed management responses also incorporate whole-of-catchment or end-of-pipe treatment systems. These should be designed using a treatment train approach that combines natural treatment systems with proprietary devices, such as gross pollutant traps (GPTs) and trash

racks, to maximise the removal of litter, sediments, nutrients, and other pollutants before discharge to receiving waters.

In addition to improving water quality, centralised treatment systems can reduce long-term maintenance requirements while delivering broader environmental and community benefits, including enhanced visual amenity, wetlands, walking trails, and recreational spaces. Early planning and integration of these systems into future projects will help maximise these environmental, social, and operational outcomes.

8.1.1. Increasing inlet capacity [S1]

A significant number of single side entry pits are present across the study areas. It is recommended that, where feasible, these be upgraded to double side entry pits as part of repair and renewal works on the existing stormwater network. This approach would improve inlet capacity and overall system performance during storm events. Upgrade works may include retrofitting existing pits or full replacement, depending on asset condition and site constraints.

8.1.2. Increasing onsite storage [S2]

This is not limited to larger-scale basins such as detention, retention, or bioretention basins, nor to the specific solutions identified in this SMP.

It is recommended to incorporate Water Sensitive Urban Design (WSUD) measures and increase minor on-site storage (retention) as part of road infrastructure upgrades, including streetscape improvements, traffic channelisation works, and kerb extension redesign. Integrating these measures can help reduce runoff volumes, improve water quality, and enhance the overall performance of the stormwater network.

8.1.3. Review of existing stormwater and WSUD assets and programming [S3]

A staged condition assessment of the stormwater drainage network is recommended to identify blockages and pipes that are in poor or very poor condition and require repair or replacement. Undertaking the assessment in stages will enable defects to be prioritised and addressed efficiently, reducing the risk of damage to trench reinstatement works and adjacent assets while minimising further deterioration of the drainage network.

An associated asset renewal program should be reviewed, reinstated where necessary, and progressively updated based on the findings of the condition assessments, together with the outcomes of completed maintenance and renewal works. This will support a targeted, risk-based approach to asset management and help ensure the ongoing performance, reliability, and service life of the stormwater network.

All existing Water Sensitive Urban Design (WSUD) assets should be incorporated into Council's asset management system, together with any new WSUD assets constructed following adoption of this SMP. This will enable the development of a coordinated maintenance and renewal program based on the expected service life, condition, and performance of each asset. Integrating WSUD assets into the broader asset management framework will support proactive maintenance, optimise lifecycle costs, and ensure the long-term effectiveness of these stormwater management measures.

8.1.4. Coordination with other infrastructure programs

Following endorsement of this SMP, implementation of the proposed solutions should be coordinated with relevant road and infrastructure programs to maximise efficiency and minimise rework. This includes:

- Ensuring planned stormwater upgrades are aligned with road reseal and reconstruction programs to avoid conflicts and duplication of works.
- Prioritising stormwater infrastructure installation ahead of new road construction to prevent retrofitting and associated costs.
- Coordinating stormwater upgrade works with kerb and water-table construction or renewal to achieve integrated delivery and improved drainage outcomes.

This coordinated approach will support cost-effective implementation, reduce disruption, and optimise the performance of both stormwater and transport infrastructure.

8.2. Structural strategies

The proposed stormwater management solutions are shown in Figure 27, with their descriptions and expected outcomes summarised in Table 46.



Figure 27. Proposed remediation measures

Table 46. Stormwater Management Responses

Solution Set	ID	Brief Description	Benefit Provided				Cost		Reduction in Flood Damages
			Flood protection	Water quality	Stormwater Reuse	Improved amenities	Capital Cost	Operating Cost	
A	A2	New detention basin in Growth Area 3 (to the west of the Lifestyle Village).	✓	✓			\$ 718,500	\$ 10,500/yr	18% AEP: \$299k 1% AEP: \$2.02m
	A8	Surcharge grate from the main trunk line with swale to Mary Starr Basin.	✓	✓			\$ 66,600	\$ 188/yr	
	A10	Extend existing network to intersection of Blight and Matthews Streets.	✓	✓			\$ 382,600	\$ 1,247/yr	
	A11	Upgrade trunk from Stanley St to outlet.	✓				\$ 2,629,600	\$ 2,621/yr	
	A13	Outlet pipe upgrade on Mary Starr Dve.	✓				\$ 129,200	\$ 182/yr	
B	B1	Reducing levels in the underground network around the intersection of Cates St and Lawrie Terrace	✓				\$ 1,008,500	\$ 1,608/yr	18% AEP: \$64.7k 1% AEP: \$87.1k
	B4	Options for the Community Sports Complex:							
		a) Wetland option	✓	✓	✓	✓	\$ 705,300	\$ 12,950/yr	
C	C1	b) Detention basin option	✓	✓	✓				18% AEP: \$0k 1% AEP: \$257k
		Review and optimisation of the underground stormwater network at:							
		o Peake Terrace	✓	✓			\$ 816,100	\$ 984/yr	
D		o Henderson St							18% AEP: \$727k 1% AEP: \$2.92m
		o Kirby St							
	C2	Replace aging section of Peake Terrace underground network (Leonard Norman Drive to Hart Lagoon Wetland Complex)	✓	✓			\$ 889,100	\$ 951/yr	
	D1	A detention basin on civic reserve.		✓		✓	\$ 348,100	\$ 3,830/yr	
	D2	Increased inlet capacity and upgraded pipes on Strangman Rd and between Dowling St and Miller St	✓				\$ 771,800	\$ 1,348/yr	
	D3	Closing off the pipe through the resident's yard at 14 Miller St	✓				\$ 4,500	-	
	D4	Detention basin and swale at Ifould Park	✓	✓			\$ 2,958,000	\$ 12,998/yr	
	D5	Formalising the inlets on the western side of Ian Oliver Dve	✓				\$ 143,200	\$ 314/yr	
	D6	Upgraded outlet to the river	✓				\$ 157,800	\$ 240/yr	
	D8	Raising kerbs along Cates St and Strangman Rd	✓				\$ 156,800	\$ 365/yr	

8.2.1. Solution Set A

Solution Set A addresses flooding within Damage Areas 1, 2 and 3, covering residential areas between Lawrie Terrace and West Road, the Mary Starr Basin and Apex Park, and the Waikerie Lifestyle Village. Damage Area 4 has been excluded because it functions as a separate hydraulic area and should be assessed in conjunction with downstream overflows.

Flooding within these areas is primarily caused by capacity constraints in the trunk drainage network, particularly along West Road and at Junction A, as well as backwater effects from the Hart Lagoon Constructed Wetland outlet during larger storm events. Uncertainty remains regarding the size and grade of sections of the existing trunk pipeline, which may influence the extent of upstream flooding. In addition, limited information on the as-constructed stormwater system for the Waikerie Lifestyle Village introduces uncertainty in the predicted flood behaviour. A review of the developer's stormwater design and as-constructed infrastructure is recommended to confirm the flood risk and refine future management responses.

8.2.1.1. Proposed options

The suite of solutions comprising Set A include:

- A2. New detention basin in Growth Area 3 (to the west of the Lifestyle Village).
- A8. Surcharge grate from the main trunk line with swale to Mary Starr Basin.
- A10. Extend existing network to intersection of Blight and Matthews Streets.
- A11. Upgrade trunk from Stanley St to outlet.
- A13. Outlet pipe upgrade on Mary Starr Dve.

8.2.1.2. New detention basin in Growth Area 3 [A2]

The proposed design includes the following measures:

- Construction of a new detention basin to the west of the Lifestyle Village.
- Optimisation of the swale connecting the Mary Starr Basin overflow (including spill level) to the new basin.
- The design also includes a new bund to the north of the Mary Starr Basin to prevent overtopping and spilling into the Lifestyle Village.
- Note that the new basin was not modelled with an outflow pipe, as outflows during a storm event were considered negligible, and this creates a conservative approach to design. However an outflow pipe should be included in detailed design, which is envisioned as running directly north and underneath Peake Terrace, to the natural Hart Lagoon floodplain. The final basin design should also consider the potential to receive runoff from any future development of Growth Area 3.

The flood extent under the ultimate development scenario is shown in Figure 28. The proposed design, together with the flood extent after mitigation, are shown in Figure 29.

8.2.1.3. Surcharge grate from the main trunk line [A8]

By adding a surcharge grate to the main trunk line, water will be able to surcharge in a controlled manner from this grate and be directed to the Mary Starr and proposed basins, rather than upwelling from pits within the Lifestyle Village.

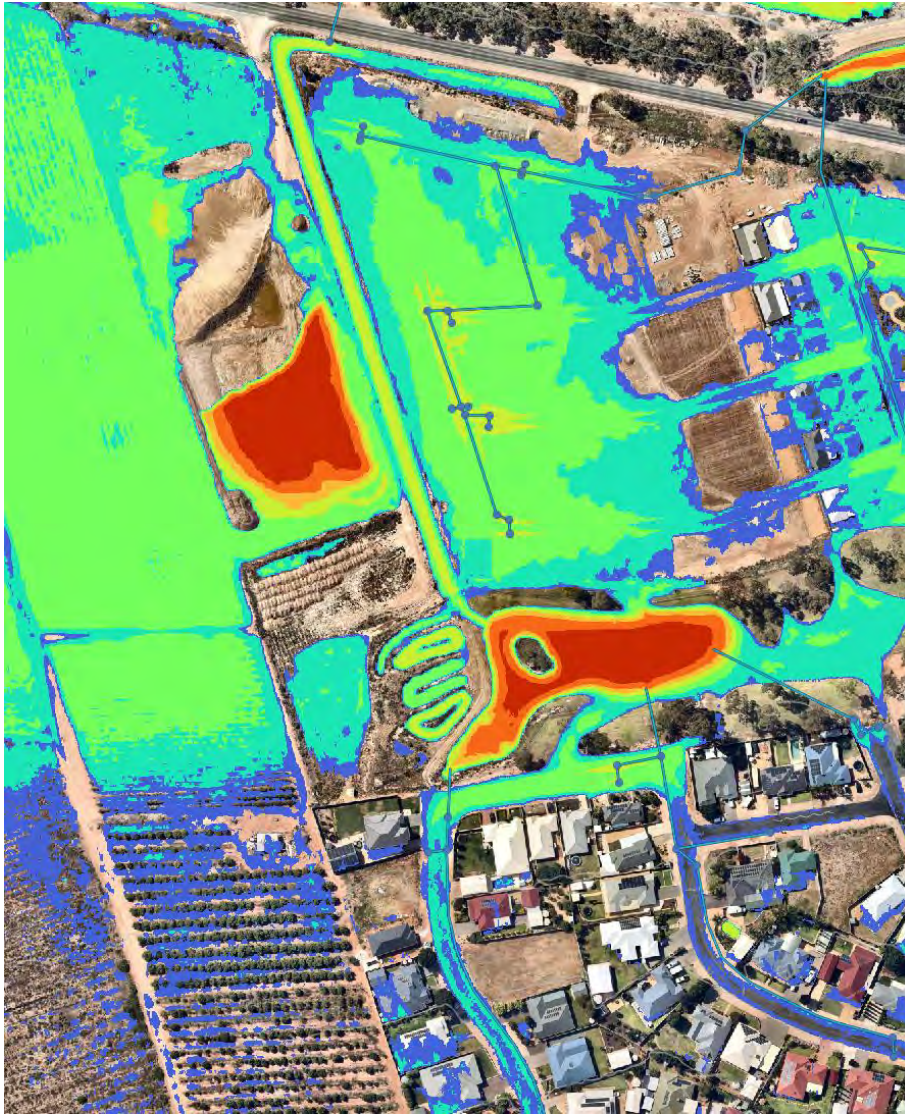


Figure 28. Modelled flood extent at location of Option A2 under Scenario 5b.

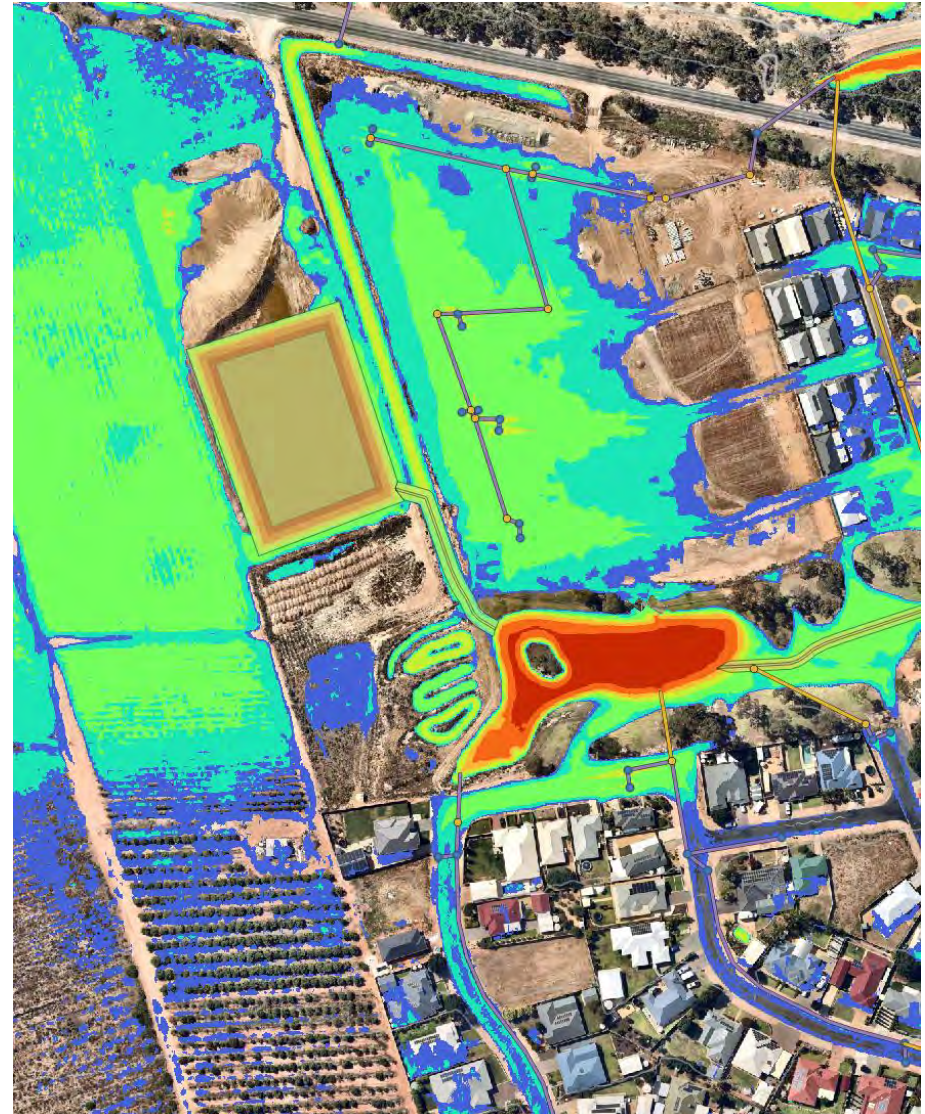


Figure 29. Modelled flood extent for remediation Option A2 (Scenario 5c).

The proposed design includes the following measures:

- Installation of a 1500 mm square surcharge grate onto the main trunk line running from the Stanley St junction to the outlet.
- A new swale to direct water from the surcharge grate to the Mary Starr Basin.
- Realignment, including a new outlet, for the existing outlet pipe from Marks Terrace.

Levels should be confirmed during detailed design.

Note that if this option is progressed *without* Option A2 being progressed it will likely just shift flooding issues from one location (the Lifestyle Village) to another (Mary Starr Dve).

The flood extent under the ultimate development scenario is shown in Figure 30. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 31.

8.2.1.4. Extend existing network to intersection of Blight and Matthews Streets [A10]

The proposed design includes the following measures:

- Three new double SEPs at the intersection of Blight and Matthews streets.
- Extending the 375 mm line up Mary Starr Dve (east branch) to connect the new pits.
- Raising the kerb along Matthews St to add further protection during large events.

The flood extent under the ultimate development scenario is shown in Figure 32. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 33.

8.2.1.5. Upgrade trunk from Stanley St to outlet [A11]

The exact details of the trunk drain from Stanley street to the outlet are unknown, due to recent upgrades at both the Stanley St junction, and within the Lifestyle Village. These should be confirmed prior to detailed design of any remediation works. That said, modelling suggests this line needs to be larger than it is anticipated the current line is. This trunk can be a choke point for the entire network if undersized, affecting flooding and overflows along West Rd, down the laneways, plus within Apex Park and the Lifestyle Village. Further, works undertaken on the top of Cates St, particularly in the vicinity of the Lutheran Church, may be less effective if this line is not adequately sized.

The proposed design includes the following measures:

- Increasing the trunk drain to 1200 mm pipes.

It is recommended that if undertaken, a review of levels of the West Rd branch be undertaken to optimise outcomes across the whole network.

The flood extent under the ultimate development scenario is shown in Figure 34. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 35.

8.2.1.6. Outlet pipe upgrade on Mary Starr Dve [A13]

The proposed design includes the following measures:

- Upgrade pipe from 600 mm to 900 x 600 mm box culvert.
- Optimise invert levels.

The flood extent under the ultimate development scenario is shown in Figure 36. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 37.

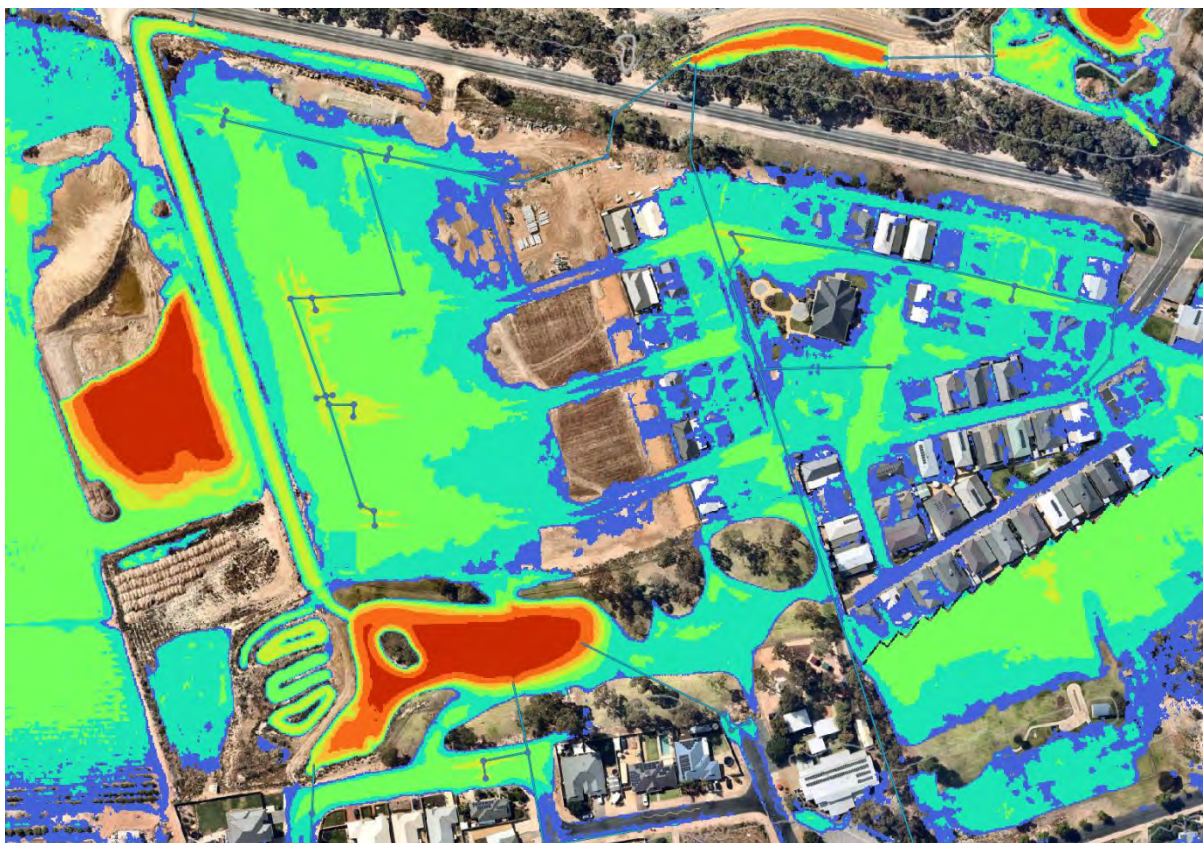


Figure 30. Modelled flood extent at location of Option A8 under Scenario 5b.

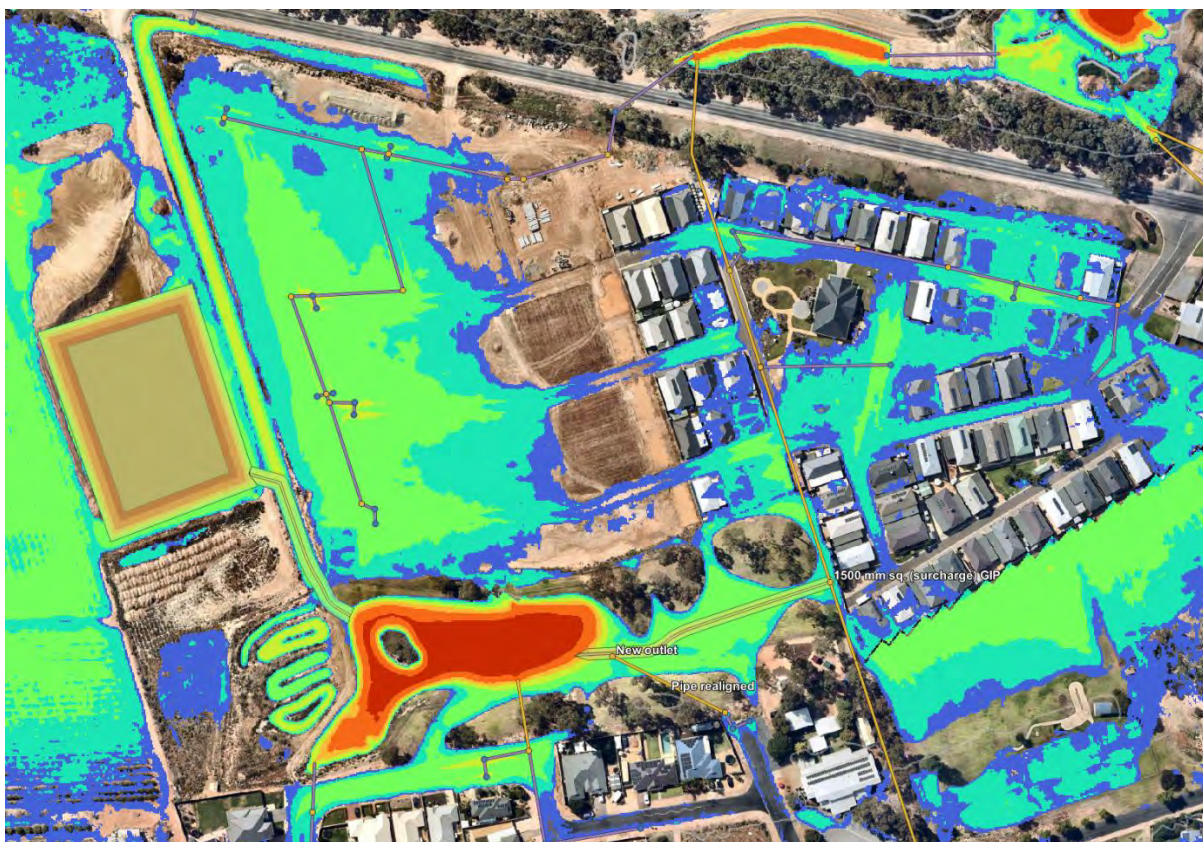


Figure 31. Modelled flood extent for remediation Option A8 (Scenario 5c).

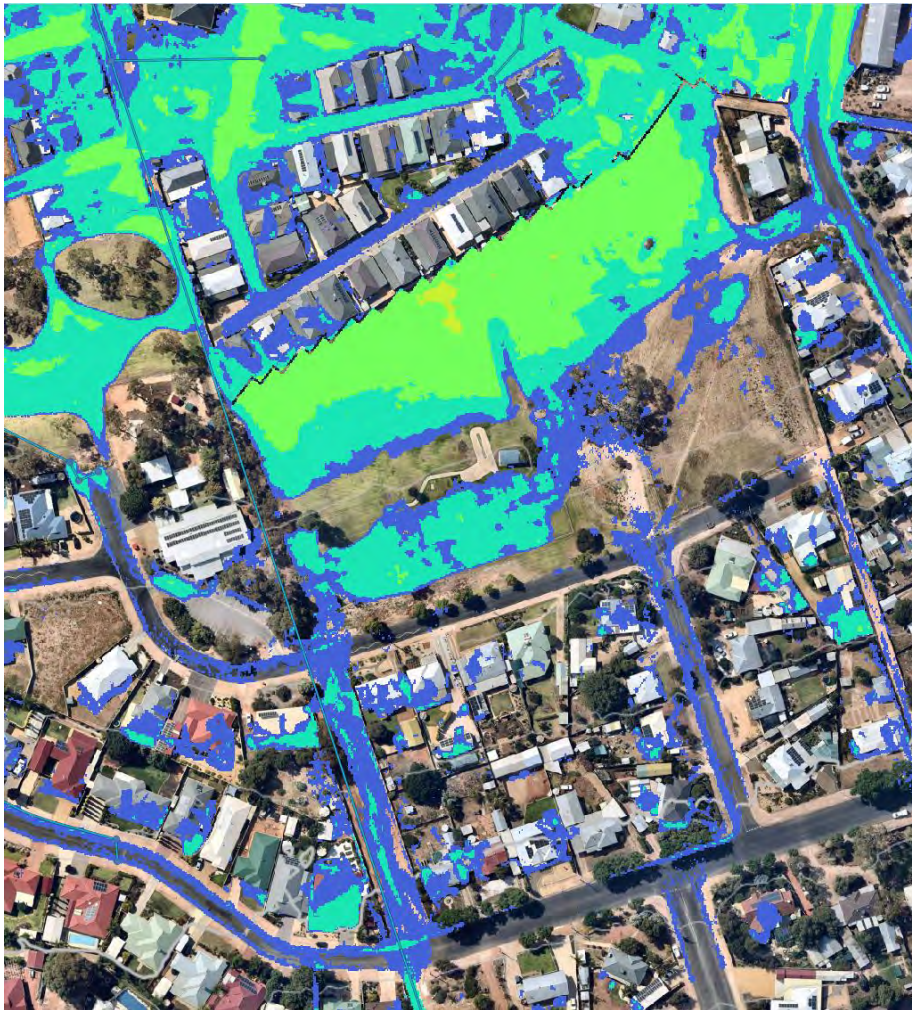


Figure 32. Modelled flood extent at location of Option A10 under Scenario 5b.

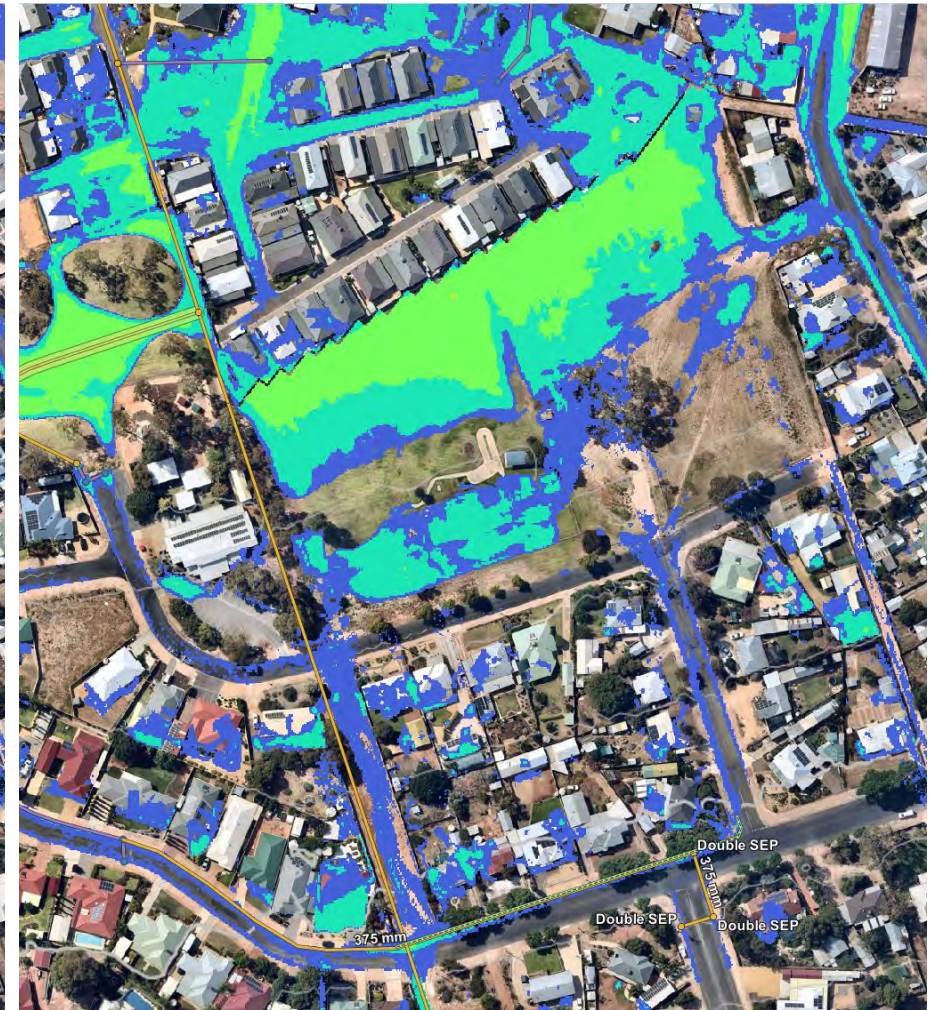


Figure 33. Modelled flood extent for remediation Option A10 (Scenario 5c).



Figure 34. Modelled flood extent at location of Option A11 under Scenario 5b.

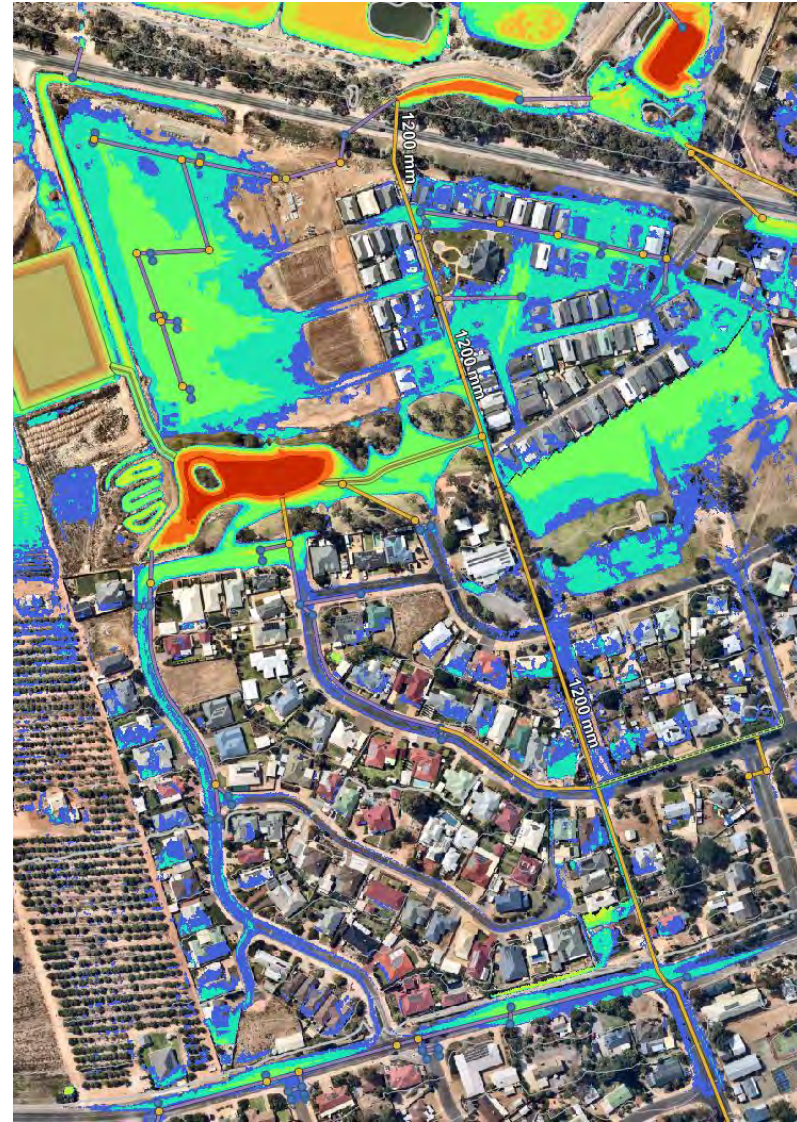


Figure 35. Modelled flood extent for remediation Option A11 (Scenario 5c).

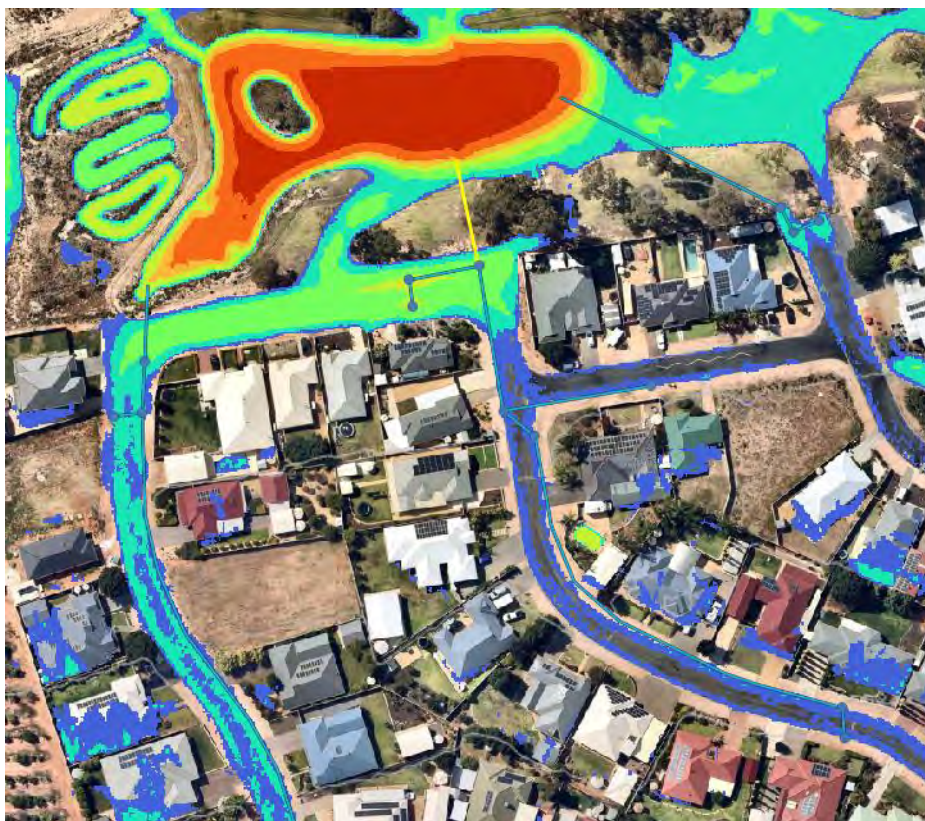


Figure 36. Modelled flood extent at location of Option A13 under Scenario 5b.

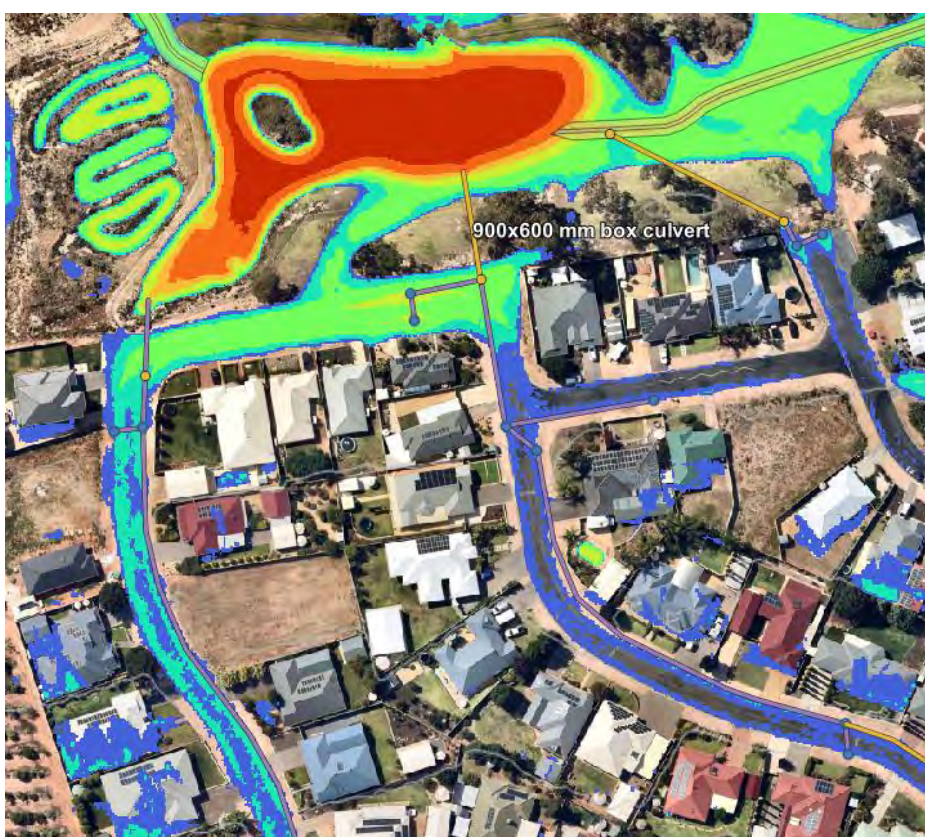


Figure 37. Modelled flood extent for remediation Option A13 (Scenario 5c).

8.2.2. Solution Set B

Solution Set B targets Damage Area 4, where multiple drainage issues converge at the Community Sports Complex, a significant local depression that functions as a major flooding hotspot. Stormwater is currently pumped from this area into the trunk drainage network; however, modelling indicates that the existing pump has limited effectiveness during large storm events.

Additional flooding occurs near the Lutheran Church, likely due to constraints within the underground drainage network, although the configuration of key junctions could not be confirmed during the condition assessment. Other localised flooding issues are generally associated with these primary constraints or with buried or restricted drainage outlets.

8.2.2.1. Proposed options

The suite of solutions comprising Set B include:

B1. Reducing levels in the underground network around the intersection of Cates St and Lawrie Terrace to address ponding at the Lutheran church.

B4. Options for the Community Sports Complex:

- c) Wetland option
- d) Detention basin option

8.2.2.2. Reducing flooding at the Lutheran church [B1]

The proposed design includes the following measures:

- Reduced levels of three junction boxes to improve gravity flows.
- Removing pipe constriction by upgrading 375 mm pipe to 450 mm pipe (to match connecting pipes).
- Increasing pipe size from Lutheran church to Stanley St junction to 900 mm.

The flood extent under the ultimate development scenario is shown in Figure 38. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 39.

8.2.2.3. Detention basin or wetland at the Community Sports Complex [B4]

The proposed design includes the following measures:

- Installation of new detention basin.
- Consideration of adjoining wetland, to be designed during detailed design.
- Removal of pump to Cates St, to reduce pressure at Lutheran church.

The flood extent under the ultimate development scenario is shown in Figure 40. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 41.



Figure 38. Modelled flood extent at location of Option B1 under Scenario 5b.



Figure 39. Modelled flood extent for remediation Option B1 (Scenario 5c).

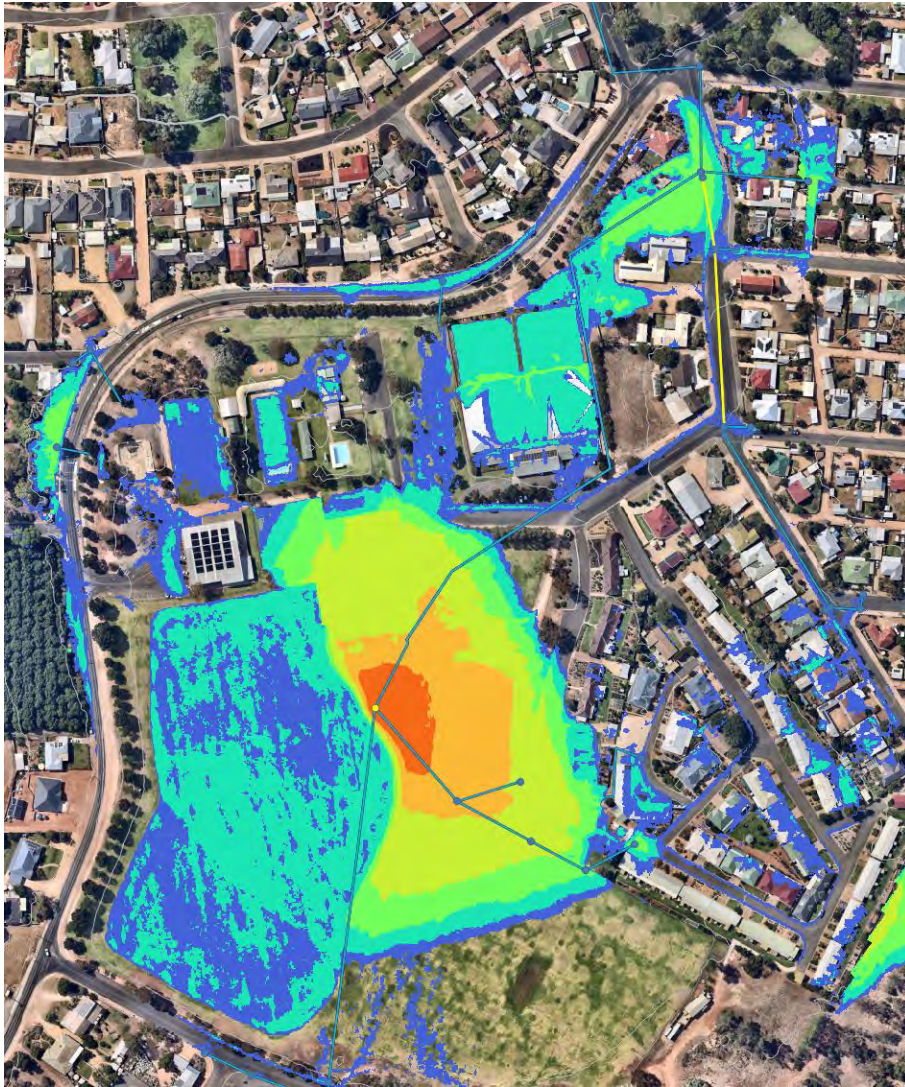


Figure 40. Modelled flood extent at location of Option B4 under Scenario 5b.

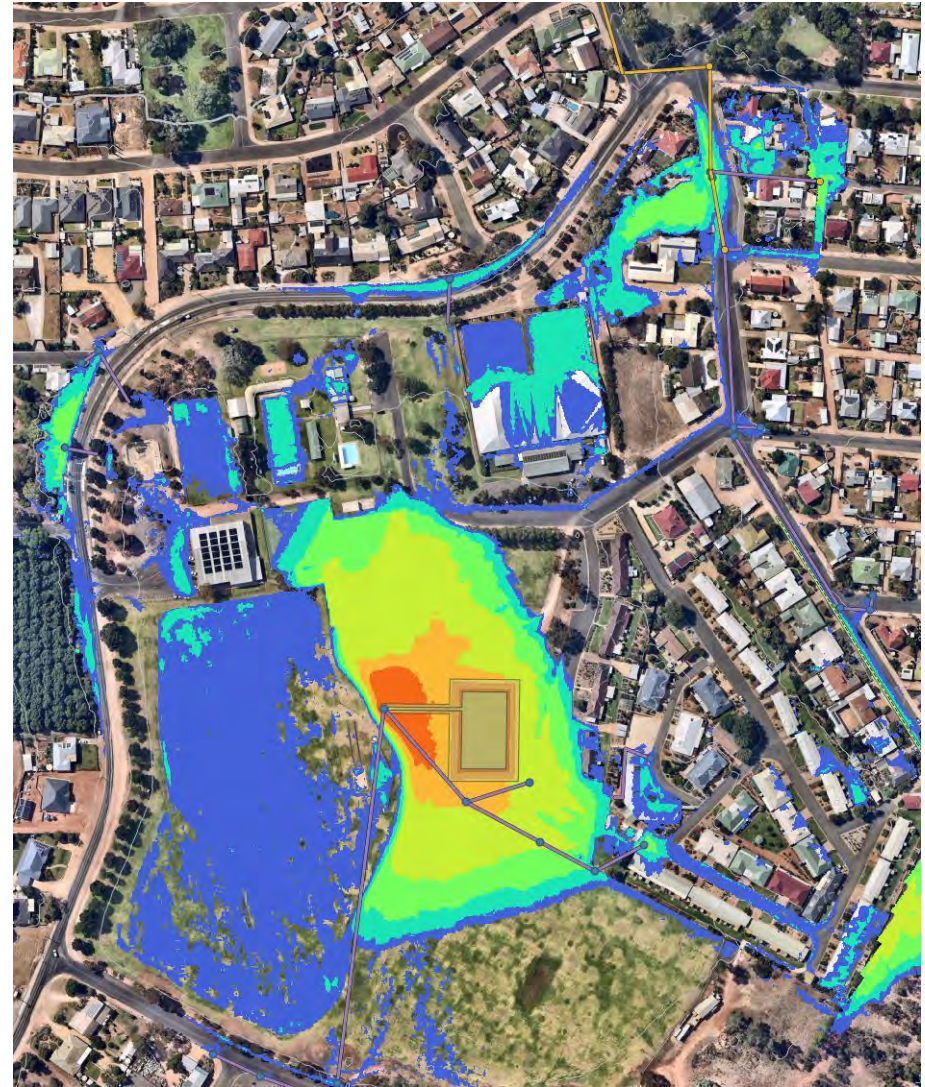


Figure 41. Modelled flood extent for remediation Option B4 (Scenario 5c).

8.2.3. Solution Set C

Solution Set C targets Damage Areas 5 and 6, which include the football oval, Leonard Norman Drive, and the lower sections of Henderson Street, Kirby Street, and Peake Terrace. Damage Area 5 was only partially represented in the hydraulic model because stormwater infrastructure information was unavailable during model development. Subsequent site investigations identified additional culverts that should be incorporated into future model updates.

Flooding within these areas is primarily caused by disconnected drainage systems, uncontrolled road runoff, and ponding in low-lying areas where Peake Terrace restricts overland flows towards the River Murray. The preferred management responses focus on optimising the pit and pipe network to improve drainage capacity, reduce overland flow, and alleviate localised flooding.

8.2.3.1. Proposed options

The suite of solutions comprising Set C include:

C1. Review and optimisation of the underground stormwater network at:

- Peake Terrace
- Henderson St
- Kirby St
- Pflaum Terrace / Coombe Terrace intersection

C2. Replace aging section of Peake Terrace underground network (Leonard Norman Drive to Hart Lagoon Wetland Complex).

8.2.3.2. Optimisation of stormwater network along and adjoining Peake Terrace [C1]

The proposed design includes the following measures:

- Continuation of 1200 x 450 mm box culvert on Kirby St through to main trunk drain.
- Upgrading final section of pipes (from Kirby St to outlet) of trunk drain to 1200 mm, to remove flow constriction and increase capacity.
- Remove existing pipe from service road (43-45 Peake Tce) and construct isolated drainage directly to Hart Lagoon inlet swale (600 mm pipe).

The flood extent under the ultimate development scenario is shown in **Figure 42**. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in **Figure 43**.

8.2.3.3. Replace aging section of Peake Terrace underground network [C2]

Council noted that one large event recently caused blowouts, dislodged pavers and popped lids all the way up from Leonard Norman Drive to the roundabout. Their suspicion is that it is due to the age and condition of pipes between the bend and the HLCW.

Modelling did not suggest that any changes to pipe sizing (other than as noted in Option C1) is required, however it is recommended that the condition of this section is reviewed using CCTV – preferably before undertaking Option C1 – so that works can be implemented in the most efficient and cost-effective manner.

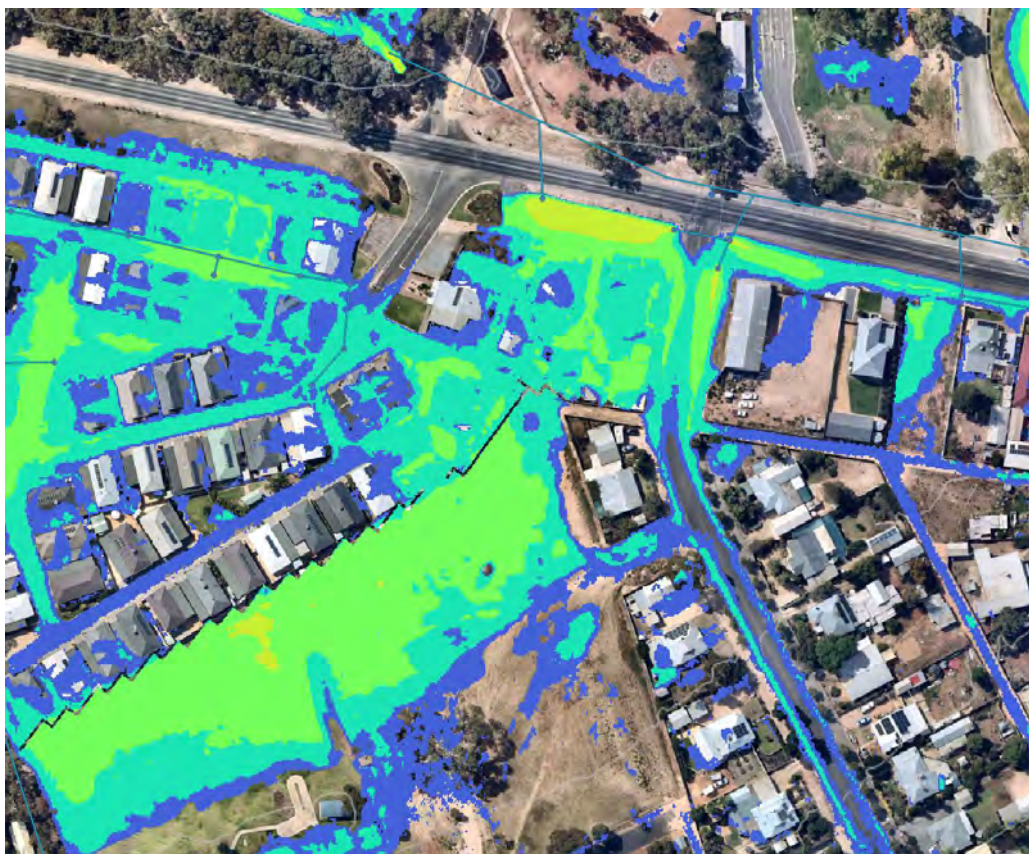


Figure 42. Modelled flood extent at location of Option C1 under Scenario 5b.

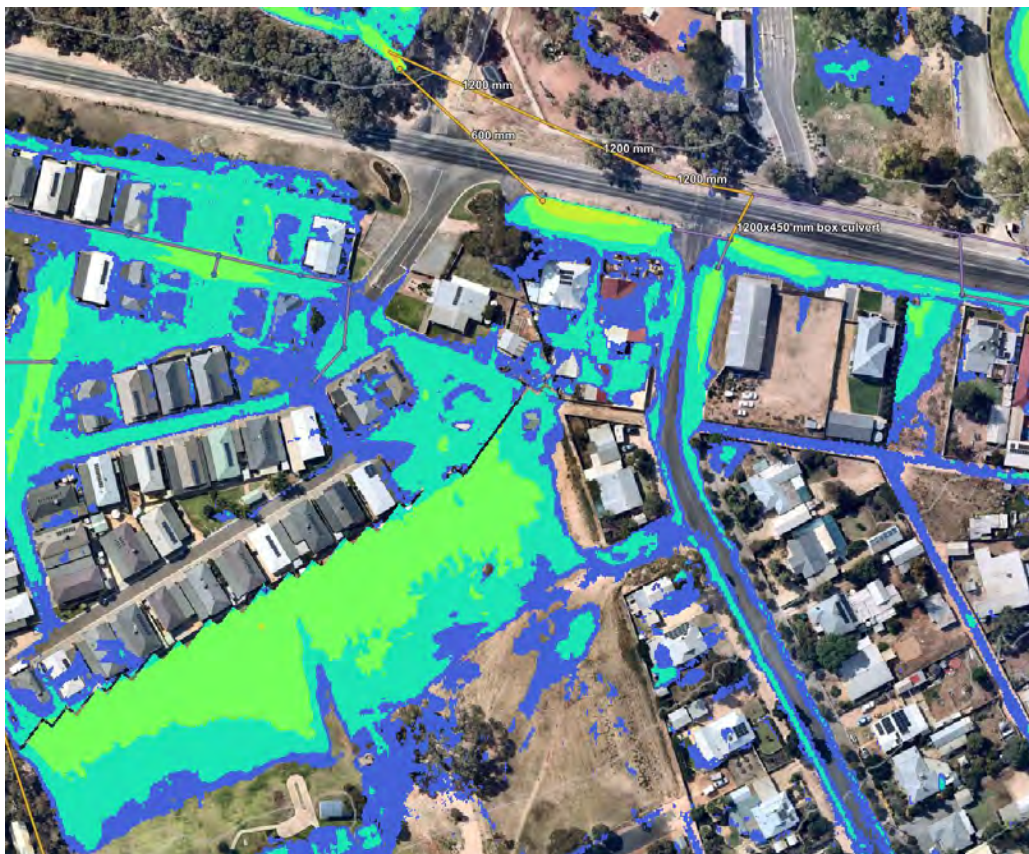


Figure 43. Modelled flood extent for remediation Option C1 (Scenario 5c).

8.2.4. Solution Set D

Solution Set D targets Damage Areas 7 and 8, which drain the southern and eastern portions of Waikerie towards the River Murray. These areas are located on the upper plateau, where local depressions, including Ifould Park, have limited natural drainage.

Flooding is primarily caused by a major bottleneck at the downstream outlet, where a 900 mm trunk pipe discharges into a 450 mm outlet pipe, significantly restricting system capacity. Additional flooding occurs at Ifould Park, the civic grounds opposite Nippy's, and other localised low points where undersized pipes, inlet constraints, and drainage depressions reduce network performance.

8.2.4.1. Proposed options

The suite of solutions comprising Set D include:

D1. A detention basin on civic reserve.

D2. Increased inlet capacity and upgraded pipes on Strangman Rd and between Dowling St and Miller St.

D3. Closing off the pipe through the resident's yard at 14 Miller St (not modelled).

D4. Detention basin and swale at Ifould Park.

D5. Formalising the inlets on the western side of Ian Oliver Dve.

D6. Upgraded outlet to the river.

D8. Raising kerbs along Cates St and Strangman Rd.

8.2.4.2. A detention basin on civic reserve [D1]

The proposed management response comprises the construction of a detention basin within the Civic Reserve to improve stormwater quality and provide detention for runoff generated from the surrounding commercial and industrial catchment. Due to the complexity of the site topography and dense vegetation, the detention basin was not incorporated into the flood model; however, its water quality performance was assessed using MUSIC.

The contributing catchment drains the industrial and commercial areas surrounding Nippy's Factory and is classified as Commercial and Industrial land use. Existing stormwater pipes collect runoff from the catchment and convey flows towards a low-lying area along Civic Avenue, between the Waikerie RV Dump Point and the St John Ambulance facility, before continuing downstream to Ifould Park.

The proposed detention basin is located within this existing grassed depression and is designed to intercept and treat runoff prior to discharge. . The key characteristics of the design are:

- The detention basin has a surface area of 2,500m².
- The existing pipe network will collect runoff from the catchment and convey it to the detention basin.
- An exfiltration rate of 3.6mm/h has been adopted, and the outlet pipe has been sized at 225mm in diameter.

The catchment characteristics adopted in the MUSIC model are summarised in Table 48, while the predicted water quality performance of the proposed detention basin is presented in Table 49.

Table 47. Solution D1 catchment details.

Area (ha)	Land use	Current catchment imperviousness (%)	Projected catchment imperviousness (%)
5.869	Commercial and Industrial	76	76

Table 48. Scenario 4 MUSIC results for existing conditions and ultimate development.

Parameter	Source	Residual	Reduction %
Flow (ML/yr)	7.60	6.01	20.97
Total Suspended Solids (kg/yr)	1,097.40	133.46	87.84
Total Phosphorus (kg/yr)	3.10	0.83	73.33
Total Nitrogen (kg/yr)	17.82	10.21	42.69
Gross Pollutants (kg/yr)	344.74	-	100.00

As no changes in land use or impervious area are assumed between the existing and ultimate development scenarios, the model predicts no change in catchment runoff or pollutant generation. Consequently, the water quality benefits achieved by the detention basin are expected to remain consistent under both scenarios.

Additional Recommendation

Given the industrial nature of the catchment, stormwater runoff may contain elevated concentrations of hydrocarbons, sediments, nutrients, and trace metals associated with commercial and industrial activities. It is recommended that the detailed design investigate opportunities to enhance treatment performance through the incorporation of appropriate pre-treatment measures, such as gross pollutant traps (GPTs) or sediment forebays, upstream of the detention basin.

Routine inspection, maintenance, and water quality monitoring should also be incorporated into the asset management program to ensure the ongoing performance of the basin and compliance with relevant water quality objectives.

8.2.4.3. Pipe upgrades in Strangman Rd and Dowling St [D2]

The proposed design includes the following measures:

- Removal of existing box culvert from southern side of Strangman to Dowling St, and conversion of existing outlet to single SEP.
- Replacement of the above with new 375 mm pipe from northern SEP (existing northern box culvert to remain) to existing SEP at 8 Dowling St.
- Upgrade existing 300 mm pipe from SEP (8 Dowling St) to junction box with 450 mm pipe.
- Upgrade existing pipes from junction box in front of 10 Dowling St to junction box in front of 14 Miller St with 750 mm pipe.

The flood extent under the ultimate development scenario is shown in **Figure 44**. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 45.

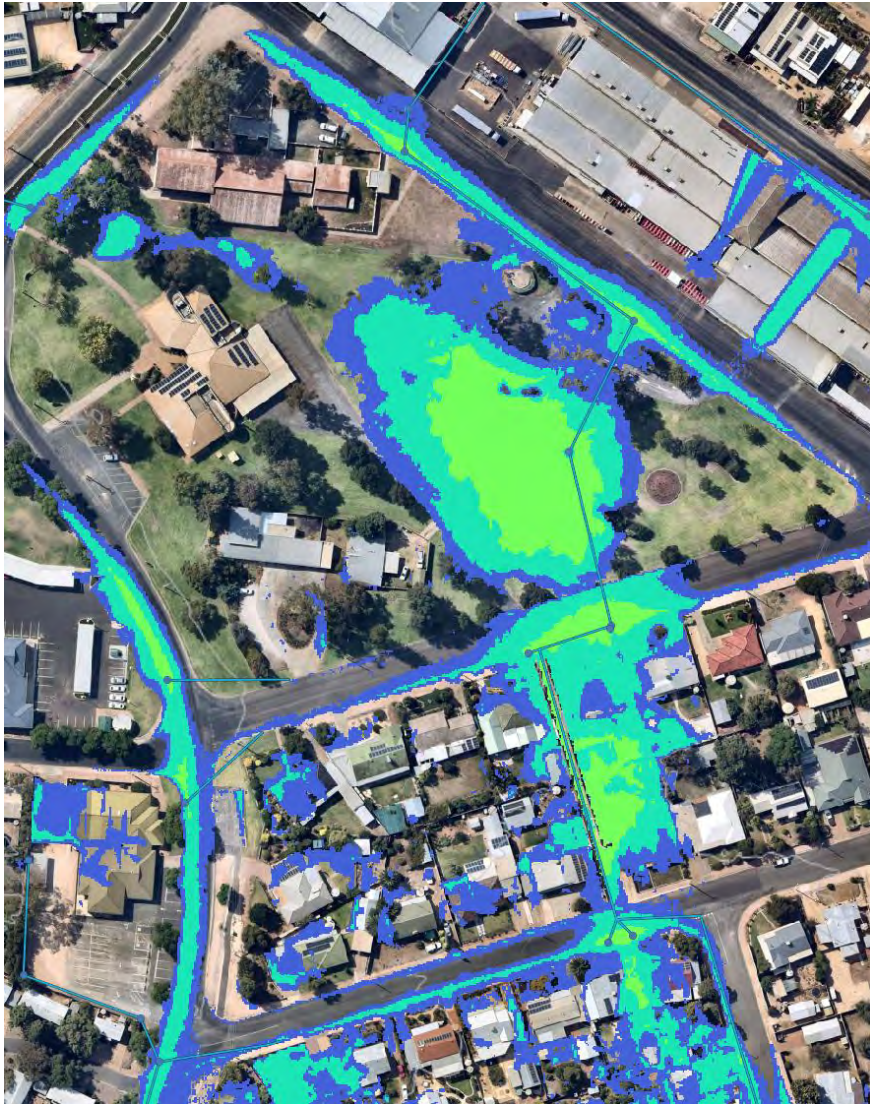


Figure 44. Modelled flood extent at location of Option D2 under Scenario 5b.

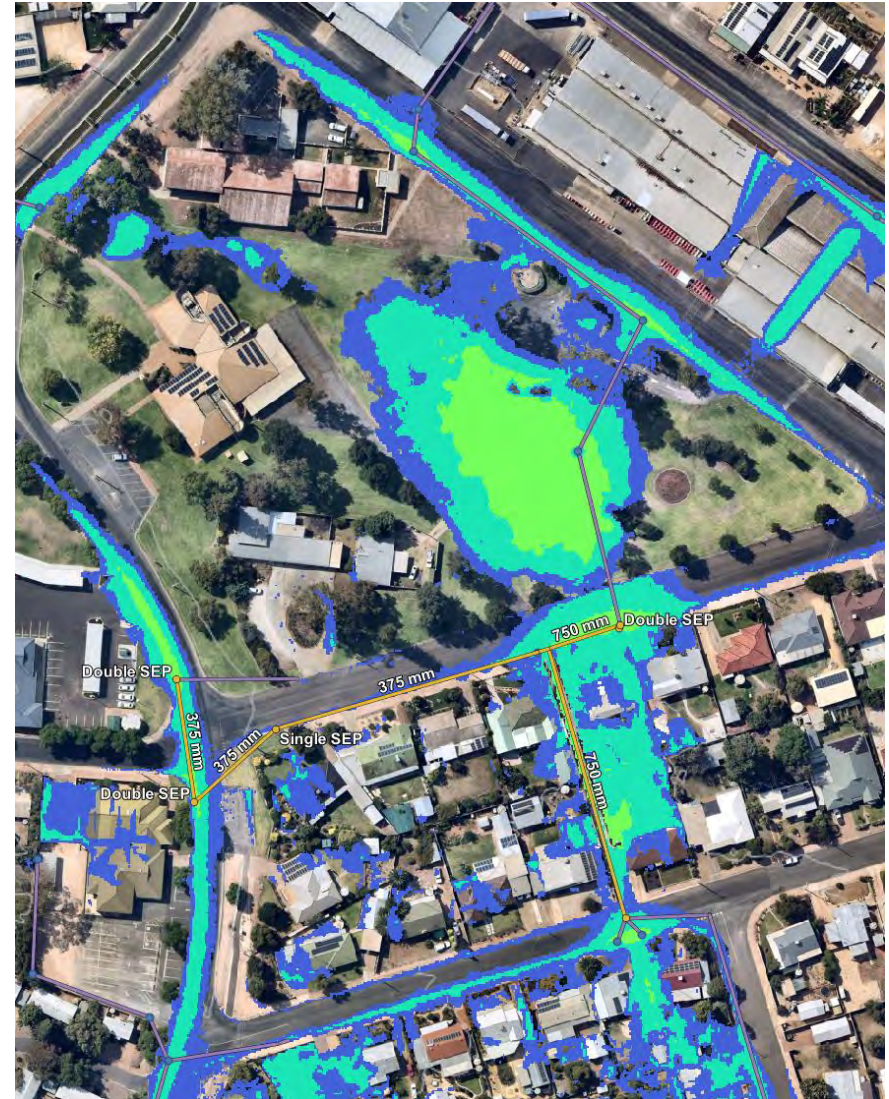


Figure 45. Modelled flood extent for remediation Option D2 (Scenario 5c).

8.2.4.4. Detention basin and swale at Ifould Park [D4]

The proposed design includes the following measures:

- Construction of a detention basin within Ifould Park.
- Adaptation of existing SEPs and pipes to direct flows into the basin.
- New 900 x 450 mm box culvert to divert high flows (IL set 300mm above JB floor) into basin from Jacobs St.
- Small swale outlet into new headwall, plus pipe to existing junction box.
- New 900 mm outlet along McCutcheon St and easement towards existing junction box on Ian Oliver Drive. Modelling shows it is best if this can remain isolated and outlet adjacent to existing pipes (to be upgraded under Options D5 and D6).

The flood extent under the ultimate development scenario is shown in **Figure 46**. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in **Figure 47**. *(Note that the final section of the proposed new outlet is shown in **Figure 49** together with the Options D5 and D6).*

8.2.4.5. Formalising the inlets on the western side of Ian Oliver Dve [D5]

There is currently a small opening allowing runoff to drop into an unsafe, makeshift pit on the western side of Ian Oliver Dve, and then cross underneath Ian Oliver Dve into the large junction box. A secondary pipe runs from an unknown location to the north.

It is proposed that this inlet is replaced with a safe, 600 mm square grated inlet pit. The existing 600 mm should be removed and the alignment used for the new, isolated outlet from Option D4.

The flood extent under the ultimate development scenario is shown in **Figure 48**. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in **Figure 49**, together with Option D6.

8.2.4.6. Upgraded outlet to the river [D6]

The final outlet from this whole stormwater network is a 450 mm pipe, after earlier pipe sections are as large as 900 mm. This constricts outflows and contributes to flooding through this entire network, which drains approximately one-third of the town.

The proposed design includes the following measures:

- Upgrading this pipe section from 450 mm to 900 mm pipe.

It is possible to further increase the size of this pipe, instead of installing the new outlet pipe proposed in Option D4, however modelling suggests that the large junction box would also then require upgrading, and that outflows would still not be as good as running a secondary pipe. This could be reviewed during detailed design. This also keeps treated water from the detention basin separate from the untreated water flowing through the existing pipes.

Also note that the cliffs beneath the outlet appear that they may have eroded due to this outlet in the past. It is therefore strongly recommended that a formalised rock chute be designed and installed when upgrading these outlets, to protect this cliff into the future.

The flood extent under the ultimate development scenario is shown in **Figure 48**. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in **Figure 49**, together with Option D5.

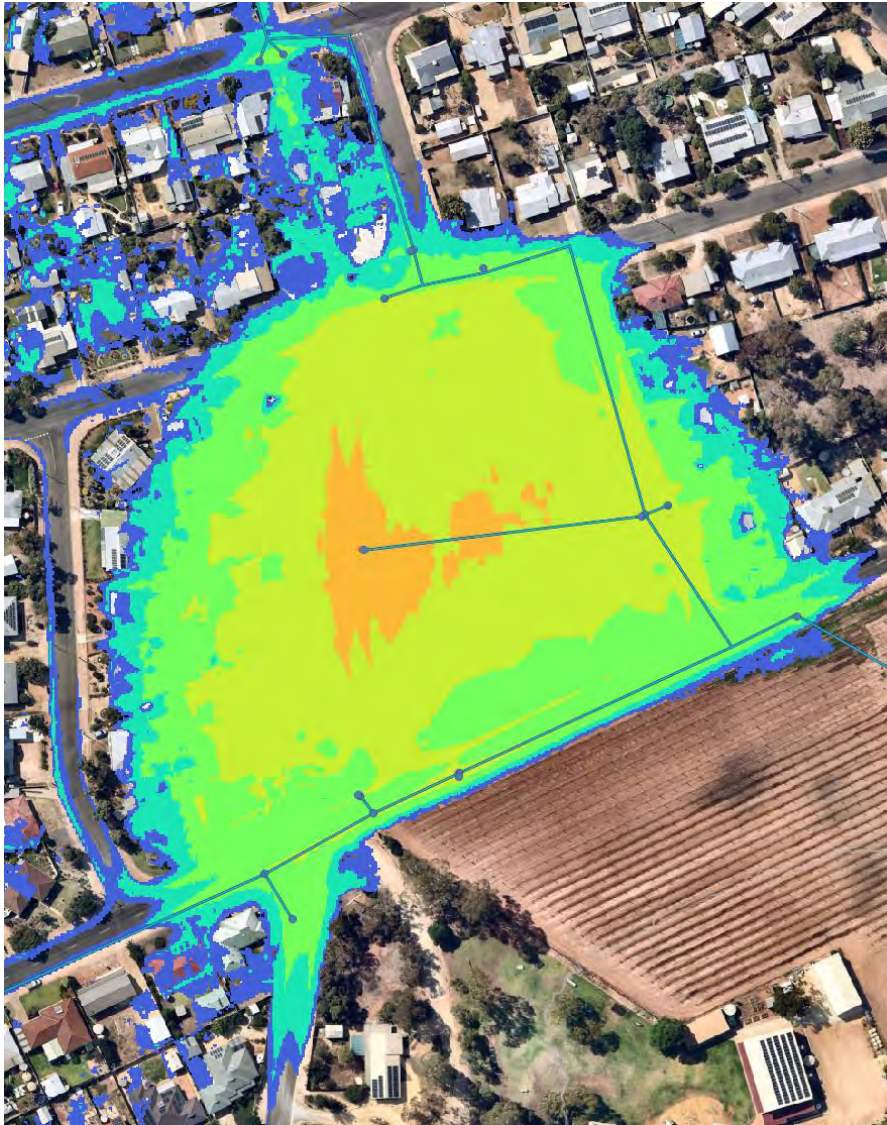


Figure 46. Modelled flood extent at location of Option D4 under Scenario 5b.

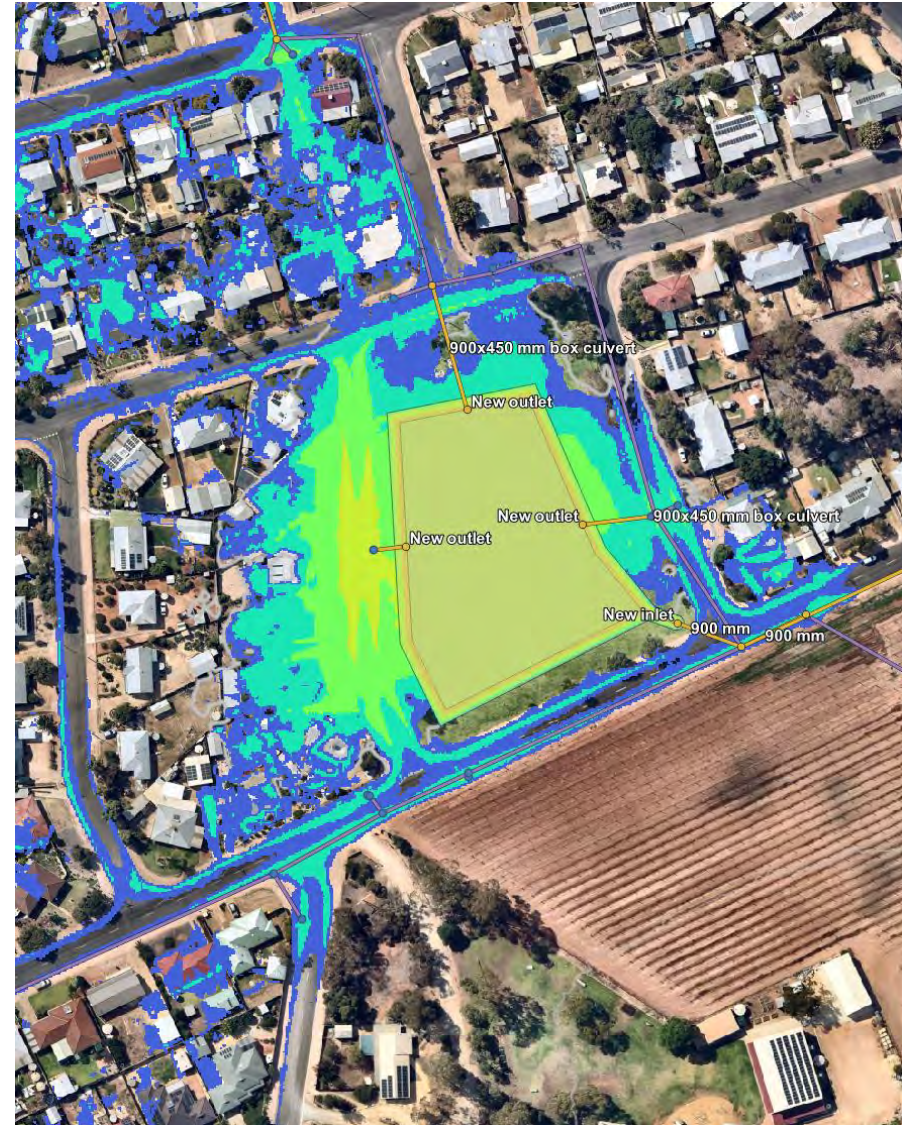


Figure 47. Modelled flood extent for remediation Option D4 (Scenario 5c).

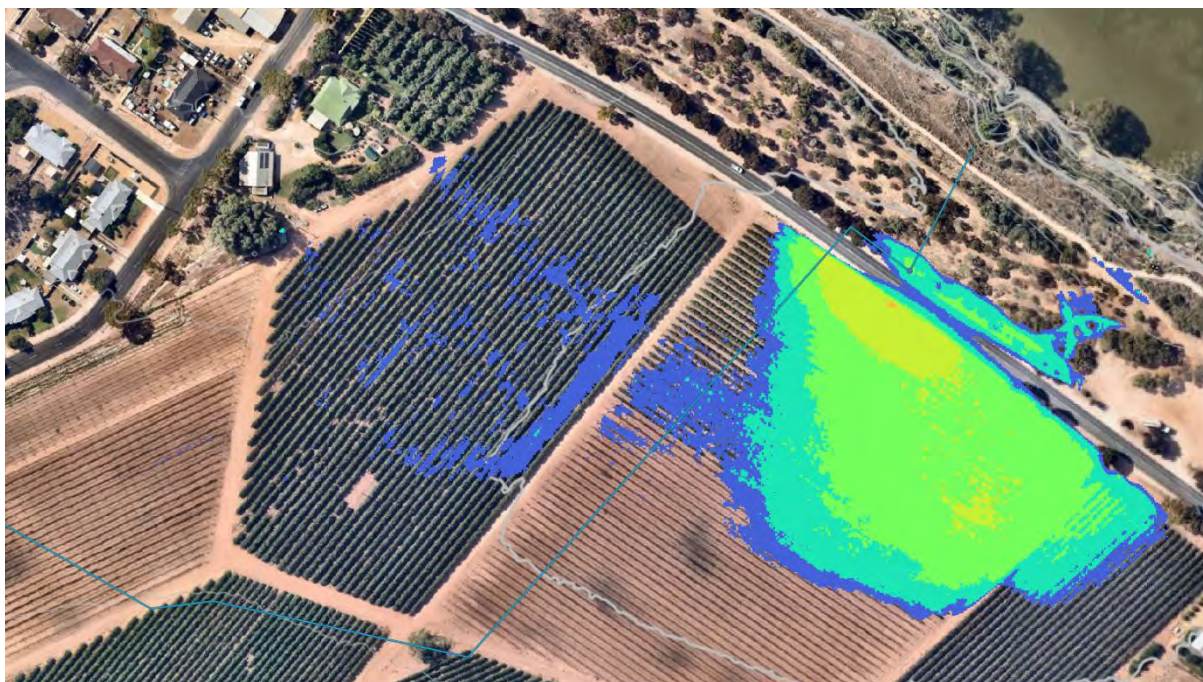


Figure 48. Modelled flood extent at location of Option D5 & D6 under Scenario 5b.

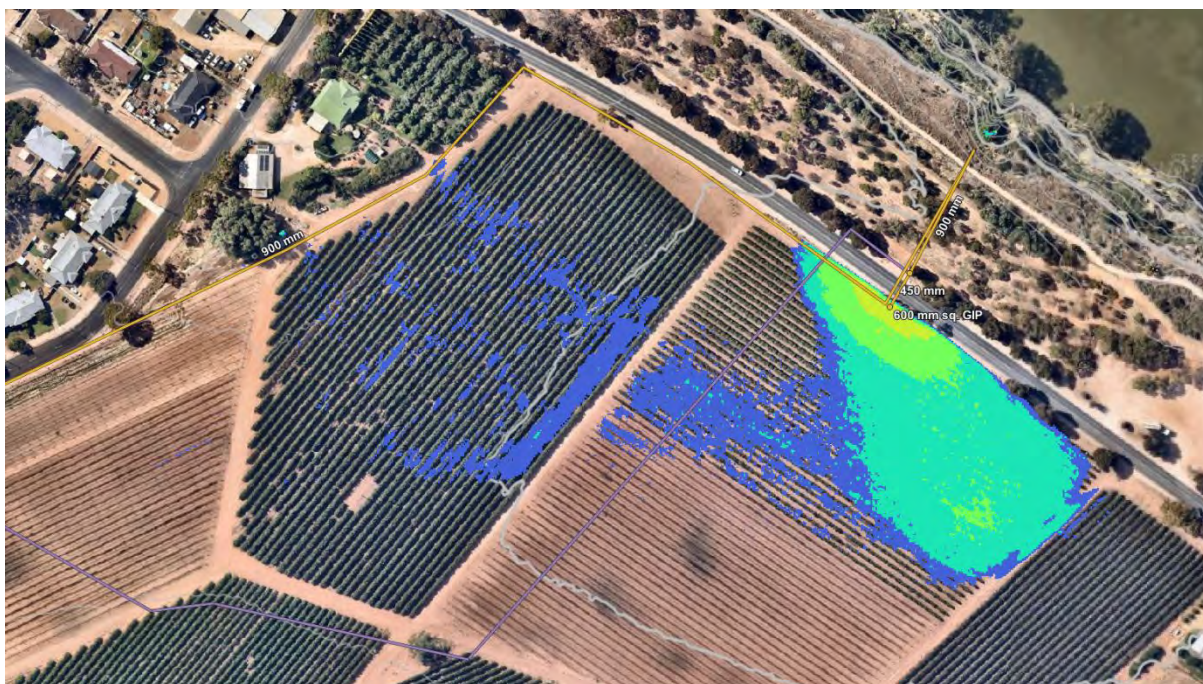


Figure 49. Modelled flood extent for remediation Option D5 & D6 (Scenario 5c).

8.2.4.7. Raising kerbs along Cates St and Strangman Rd [D8]

To prevent overland flows crossing into adjacent properties, it is recommended to increase kerb heights at the following locations. The proposed kerb increases should be designed in conjunction with modifications to the roadway crossfall and road profile so that runoff is retained within the road corridor and directed towards the drainage system, rather than overtopping the kerb and entering private land:

- Along the eastern side of Strangman Rd, from De Vito Dr to the cemetery.
*Note that a solution at the bottom of De Vito Drive will also be required to fully prevent runoff entering the adjacent vineyards. This may involve modification of the roadway crossfall and road profile, local drainage improvements, or other hydraulic controls, and a collaborative approach between Council and the landholder may be required.
- Along the western side of Cates St, from the lane between Andrew and Kleeman streets to the bottom of the cul-de-sac.
*Note that consideration should be given to diverting runoff from this catchment towards the proposed detention basin or wetland at the Community Sports Complex (B4), as this may provide improved flood protection and greater water quality benefits.

The flood extent under the ultimate development scenario is shown in Figure 50. The proposed pipe upgrades, together with the flood extent after mitigation, are shown in Figure 51, together with Option D6.

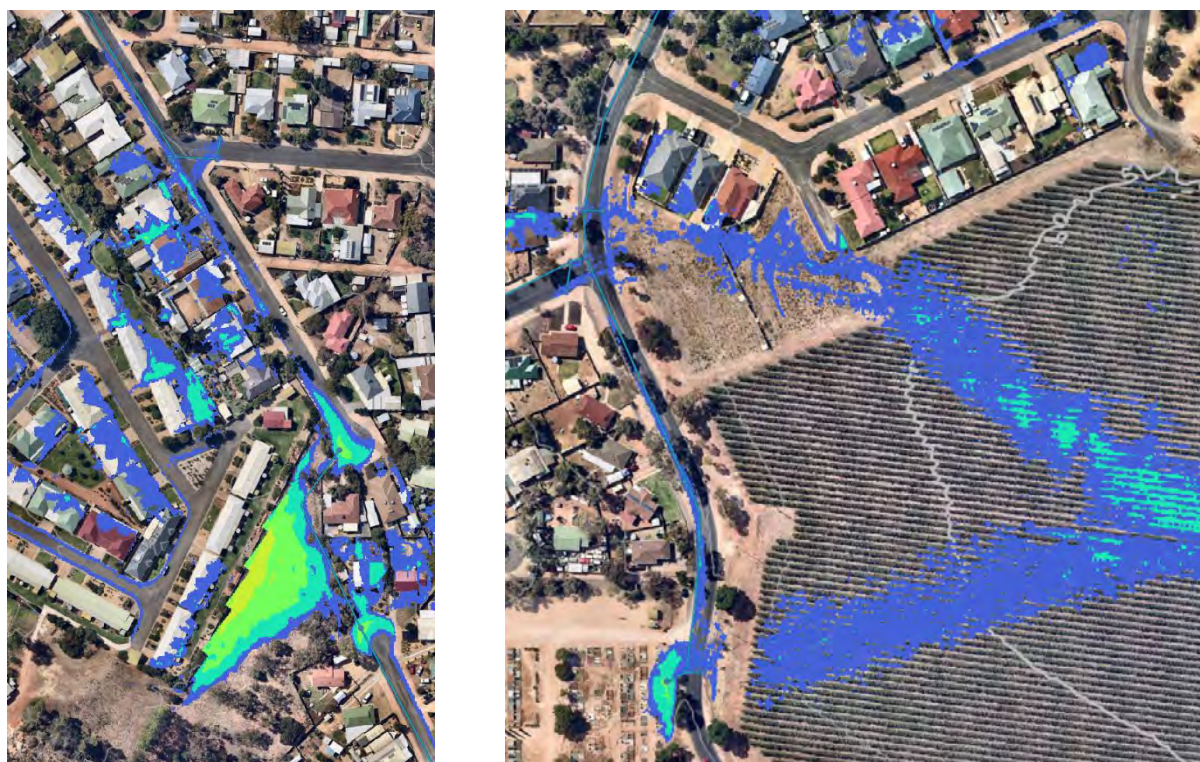


Figure 50. Modelled flood extent at Cates St (LHS) and Strangman Rd (RHS) [Option D8] under Scenario 5b.

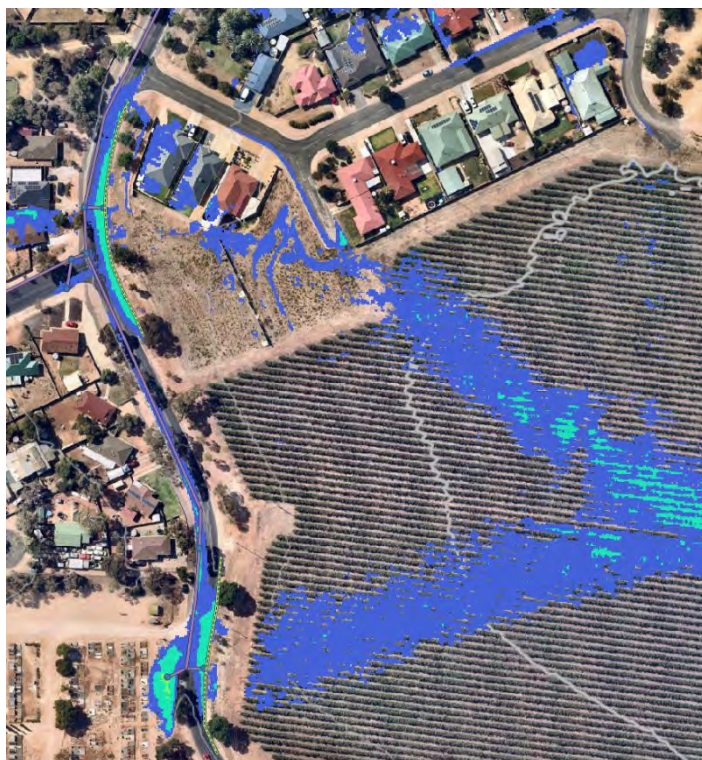
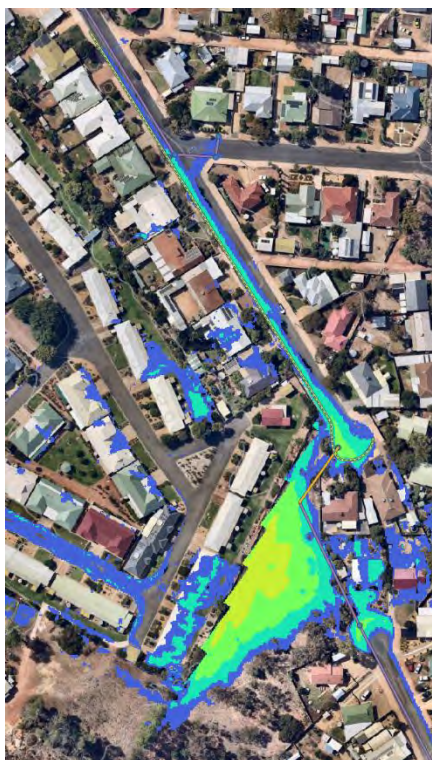


Figure 51. Modelled flood extent at Cates St (LHS) and Strangman Rd (RHS) for remediation design [Option D8] under Scenario 5c.

9. Implementation Plan

A cost estimate was prepared for each proposed management response. These responses were then evaluated using a Multi-Criteria Analysis (MCA), which considered factors including flood risk reduction, environmental and ecological benefits, stormwater harvesting and reuse potential, social and community outcomes, and economic performance.

The results of the MCA, together with the cost estimates, were used to prioritise the proposed management responses and inform the development of the implementation plan.

When implementing the proposed management responses, consideration should be given to the legislative and policy requirements outlined in Table 49, as these may influence the design, approval, construction, and ongoing operation of the proposed works.

Table 49. Legislations and requirements

Legislation or Body	Description	Project Relevance
Landscape South Australia Act 2019, Murraylands and Riverland Water Affecting Activities Control Policy	The <i>Landscape South Australia Act 2019</i> provides for the development of Water Affecting Activities (WAA) Control Policies. The Murraylands and Riverland Water Affecting Activities Control Policy identifies activities that may require a WAA permit, the principles for assessment, and the relevant authority responsible for approvals.	Some proposed mitigation measures, such as detention basins and other works affecting watercourses or overland flow paths, may require assessment and approval under the WAA Control Policy.
Basin Plan 2012, SA River Murray Water Resource Plan (SA RM WRP)	Under the <i>Water Act 2007</i> (Commonwealth) and the <i>Basin Plan 2012</i> , a Water Resource Plan is required for the River Murray. The South Australia River Murray Water Resource Plan establishes objectives for surface water management and water quality, including water quality targets within the River Murray. The Plan is administered by the Department for Environment and Water (DEW).	The proposed mitigation measures should improve the quality of stormwater discharged to the River Murray and support the objectives of the SA River Murray Water Resource Plan.
Planning Development and Infrastructure (General) Regulations 2017, Planning and	Under the <i>Planning, Development and Infrastructure (General) Regulations 2017</i> , many routine stormwater works undertaken by Council are excluded from the definition of development. However, some works may require	Certain mitigation measures, such as detention basins or works within regulated overlays, may require Development Approval and referral to the relevant authorities for assessment.

Legislation or Body	Description	Project Relevance
Design Code, River Murray Act	Development Approval and referral in accordance with the Planning and Design Code and the <i>River Murray Act 2003</i> .	
Environment Protection Act 1993 Section 25 (General Environmental Duty)	Section 25 of the <i>Environment Protection Act 1993</i> establishes a general environmental duty requiring all reasonable and practicable measures to be taken to prevent or minimise environmental harm. Compliance is regulated by the Environment Protection Authority (EPA).	Construction and maintenance of the proposed mitigation measures should be undertaken in accordance with the General Environmental Duty to minimise environmental impacts.
Environment Protection (Water Quality) Policy 2015	The <i>Environment Protection (Water Quality) Policy 2015</i> is subordinate legislation under the <i>Environment Protection Act 1993</i> . It establishes the framework for protecting surface water and groundwater quality and outlines environmental values and water quality objectives. Although the Policy excludes diffuse stormwater discharges from public stormwater systems, its objectives remain relevant to stormwater management.	The proposed mitigation measures should improve stormwater quality before discharge to the River Murray, supporting the intent and objectives of the Policy.
SA Water	SA Water is responsible for the management and delivery of potable water throughout the state, drawing supply via offtakes along the River Murray.	Offtakes are located within the town along the River Murray (see Figure 52). Council may wish to notify the relevant bodies of any proposed management actions being implemented which may impact runoff quality during construction or operation and provide them an opportunity to comment on plans and designs as appropriate.
Central Irrigation Trust (CIT)	CIT manages and delivers irrigation water for agriculture throughout the Riverland, drawing supply via offtakes along the River Murray.	

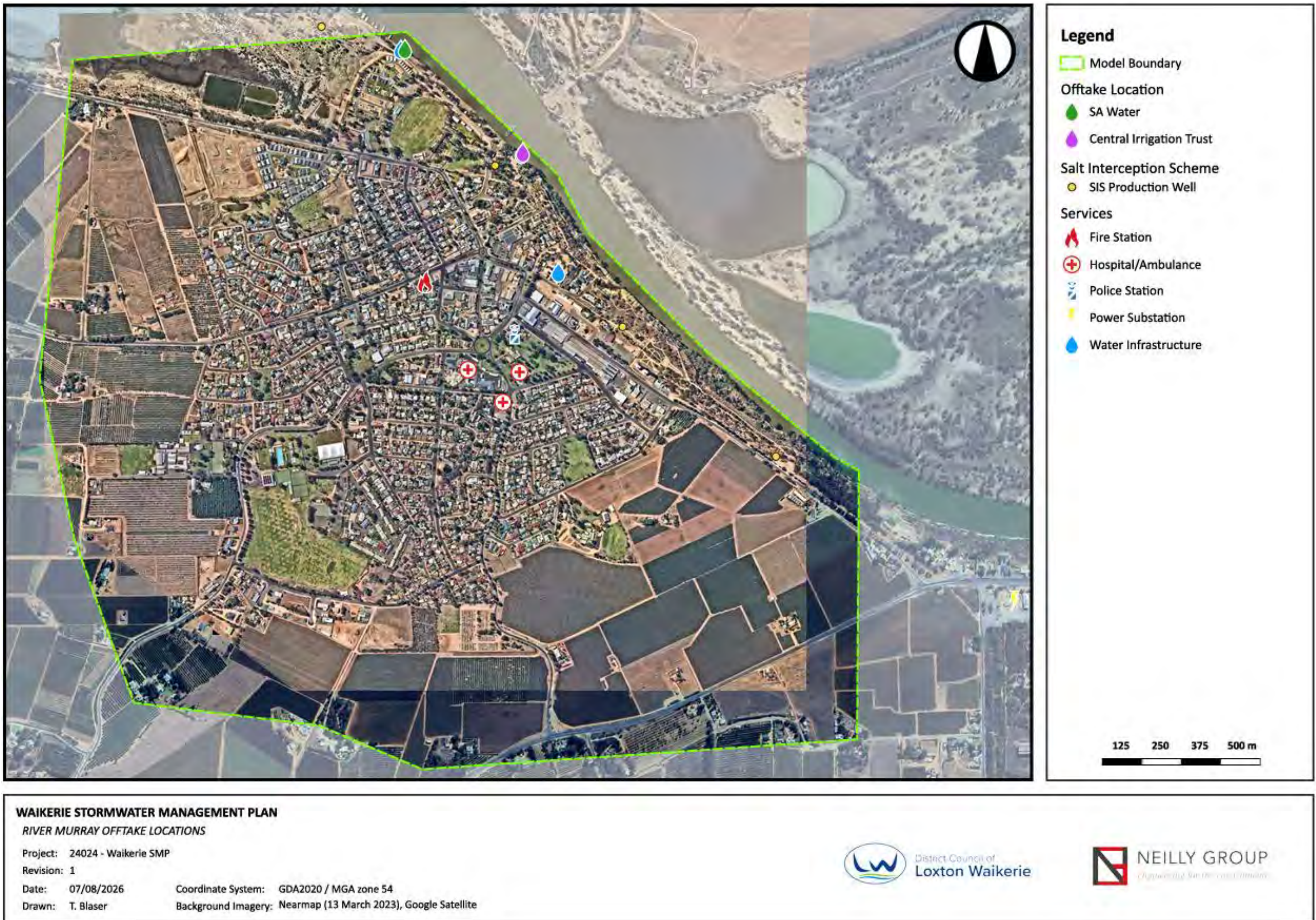


Figure 52. River Murray Offtake Locations

9.1. Prioritisation list

The Multi-Criteria Analysis (MCA) framework used to evaluate the proposed management responses is presented in Table 50. The MCA considered a range of factors, including flood risk reduction, environmental and ecological benefits, stormwater harvesting and reuse potential, social and community outcomes, and economic performance.

Weightings were assigned to each criterion based on its relative importance, with the greatest emphasis placed on outcomes that reduce risk and potential damages, such as improving public safety and protecting property and critical infrastructure. Criteria associated with broader community enhancements, such as amenity improvements, were assigned lower weightings.

Table 50. Multi-Criteria Analysis (MCA) Framework

Criterion	Weighting	Factors	
Flood Protection	30	Flood impacts, flood risk reduction, reduction in flood damages	30
Environmental and Ecological Benefits	25	Water quality improvement, including reductions in GP, TSS, TP, TN	6.25
		Watercourse protection, including erosion & sedimentation, create greater protection of watercourses improves environmental outcomes; less protection risks degradation of aquatic ecosystems.	8.75
		Biodiversity enhancement	5
		Habitat creation and ecological connectivity- create greater contribution to ecosystem protection enhances sustainability; less conservation effort risks ecological decline.	5
Stormwater Harvesting and Reuses	10	Increased infiltration capacity, including greater infiltration area, increased infiltration rates	2
		Stormwater harvesting and retention, increased retention volume and creating potential for stormwater reuse	4
		Stormwater reuse and community benefit	4
Social Amenities	10	Visual amenity enhancement	2
		Additional open space and recreational opportunities	2
		Improved public safety	2
		Increased Injury risk (post-mitigation), including increased chances of slips, falls, structural collapse	2
		Disruption during construction	2

Criterion	Weighting	Factors	
Economics	25	Capital costs	12.5
		Maintenance Costs (recurring costs)	5
		Economic viability, available funds	5
		Number of directly involved, impacted stakeholders	2.5
Total	100		100

9.1.1.1. Flood protection

Flood protection was assigned the highest weighting in the Multi-Criteria Analysis (MCA) to reflect the primary objective of reducing flood risk to the community. Management responses were assessed based on their ability to reduce flood extents, depths, velocities, and associated damages to residential, commercial, and public assets. Particular emphasis was placed on improving public safety, reducing property damage, maintaining access to critical infrastructure and emergency services, and increasing the capacity and resilience of the stormwater drainage network during storm events.

Higher scores were assigned to management responses that deliver the greatest reduction in flood risk and associated damages, particularly those that improve flooding conditions across larger catchment areas or provide benefits to a greater number of properties, critical assets, and community infrastructure.

9.1.1.2. Environmental and Ecological Benefits

Environmental and ecological benefits were assessed based on the ability of each management response to improve stormwater quality and protect the receiving environment. Consideration was given to reductions in gross pollutants (GP), total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN), together with improvements to waterway health through reduced erosion and sedimentation. Additional benefits, including biodiversity enhancement and habitat creation, were also considered to encourage sustainable stormwater management and improve the ecological values of the River Murray and surrounding environments.

9.1.1.3. Stormwater Harvesting and Reuse

Management responses were assessed for their potential to increase stormwater infiltration, detention, harvesting, and reuse. Preference was given to solutions that maximise infiltration opportunities, increase retention volumes, and provide opportunities for beneficial reuse of stormwater where practical. These measures improve water security, reduce potable water demand, and contribute to more sustainable management of urban water resources.

9.1.1.4. Social and Community Outcomes

Social and community outcomes considered the broader benefits of each management response beyond flood mitigation. Assessment criteria included improvements to visual amenity, creation or enhancement of public open space, and improvements to public safety following implementation. Potential adverse impacts, including disruption during construction and any residual public safety

risks associated with the completed works, were also considered to ensure that proposed solutions provide a positive overall outcome for the community.

9.1.1.5. Economic Performance

Economic performance assessed the financial viability and long-term affordability of each management response. Consideration was given to capital costs, ongoing maintenance and operational costs, funding availability, and the number of stakeholders directly affected by implementation. Preference was given to solutions that deliver the greatest overall benefit while representing a cost-effective and sustainable investment for Council and the community.

9.2. Implementation Plan

The resulting prioritisation of management responses is presented in Table 51 and forms the basis of the implementation plan.

Council have identified several priority locations for stormwater improvements based on known flooding issues, community feedback, and strategic importance. This has been reflected in the implementation plan through higher scores assigned under the social and community outcomes and economic performance criteria, recognising their greater strategic value and increased potential to attract funding. The assessment of flood risk reduction, environmental and ecological benefits, and stormwater harvesting and reuse potential remained based solely on the technical performance of each management response and was not influenced by Council's identified priorities.

Table 51. Implementation Plan

Solution ID	Brief Description	Score	Priority	Nominated Timeframe	Further Investigations Required?	Land Acquisition Required?	Planning or Policy Changes Required?
Structural Strategies							
D8	Raising kerbs along Cates St and Strangman Rd	5.86	Very High	0-2yrs			
	<i>Note: A Very-High priority was assigned in recognition of the identified flood risk to private properties.</i>						
C1	Optimisation of the underground stormwater network at: - Peake Terrace - Henderson St - Kirby St	5.48	Very High	0-2yrs	√		
	<i>Note: A Very-High priority was assigned in recognition of the identified flood risk to private properties.</i>						
B4	Constructed wetland at the Community Sports Complex	6.39	High	2-5yrs	√	√	
D4	Detention basin and swale at Ifould Park	5.91	High	2-5yrs	√		
D3	Pipe outlet disconnection at Property # 14 Miller St	5.12	Medium	5-10yrs			
C2	Replace aging section of Peake Terrace underground network (Leonard Norman Drive to Hart Lagoon Wetland Complex)	5.08	Medium	5-10yrs	√		
D6	Upgraded outlet to the river	5.05	Medium	5-10yrs	√		
A8	Surcharge grate from the main trunk line with swale to Mary Starr Basin	5.01	Medium	5-10yrs	√		
A10	Extend existing network to intersection of Blight and Matthews Streets.	4.98	Medium	5-10yrs	√		
A11	Upgrade trunk from Stanley St to outlet.	4.75	Medium	5-10yrs	√		
D5	Formalising the inlets on the western side of Ian Oliver Dve	4.74	Medium	5-10yrs	√		
A13	Outlet pipe upgrade on Mary Starr Dve.	4.71	Medium	5-10yrs	√		
D1	A detention basin on civic reserve.	4.57	Medium	5-10yrs	√		
B1	Reducing levels in the underground network around the intersection of Cates St and Lawrie Terrace	4.54	Medium	5-10yrs	√		
D2	Increased inlet capacity and upgraded pipes on Strangman Rd and between Dowling St and Miller St	4.14	Medium	5-10yrs	√		
A2	New detention basin in Growth Area 3 (to the west of the Lifestyle Village).	3.98	Low	10-15yrs	√	√	
Long-Term Strategies							
S1	Increasing inlet capacity		Medium	0-15yrs			
S2	Increasing on-site storage		Medium	0-15yrs	√		
S3	Review of existing stormwater and WSUD assets and programming		High	0-3yrs			√
	Education and Promotion of WSUD Measures		Medium	0-5yrs			√
	Ongoing Maintenance and Monitoring of Council Assets		Low	10-30yrs			√

10. Risk Reduction Assessment and Discussion

10.1. Residual flood risks

Using the methodology outlined in Section 7, a residual risk assessment was undertaken to evaluate the effectiveness of the proposed management responses and identify any remaining flood risks following implementation.

The assessment focused on future development post mitigation scenarios, including:

- Scenario 1c - future development conditions post mitigation during 18% AEP events, and;
- Scenario 5c - future development conditions post mitigation during 1% AEP events.

The residual risk assessment results Scenarios 1c and 5c are presented in Table 52 and Table 53, respectively.

Table 52. Post mitigation risk assessment for Scenario 1c – 18% AEP Future

ID	Location	Risk Category	Existing Stormwater Infrastructure (Scenario 1b)			Post Mitigation (Scenario 1c)		
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Safety	2	2	Low	REMEDIED		
2-1	Apex Park (North-eastern end)	Strategic	3	4	High	3	3	Moderate
2-2	2 West Rd	Safety	3	2	Moderate	REMEDIED		
2-3	West Rd (Walking track)	Safety	3	2	Moderate	1	2	Low
2-4	31 Mary Starr Drive	Operational/ Strategic	3	2	Moderate	REMEDIED		
3-1	17 West Rd	Operational	2	4	Moderate	2	4	Moderate
3-2	5A West Rd	Operational	2	4	Moderate	2	3	Moderate
3-3	Bottom of Stanley St	Operational	2	4	Moderate	REMEDIED		
4-1	Top of Cates Ave	Operational	2	4	Moderate	REMEDIED		
4-2	Laneway between Jemison St and Heming St	Operational/ Safety	2	3	Moderate	2	3	Moderate
4-3	Community Sports complex	Strategic/ Reputational	4	3	High	4	3	High
4-4	Bowling club	Strategic	2	2	Low	REMEDIED		
5-1	Machinery Museum	Operational	3	4	High	3	4	High
6-1	45-47 Peake Terrace	Operational	3	3	Moderate	REMEDIED		
6-2	Bottom of Kirby St (41 Peake Terrace)	Operational	1	3	Low	1	3	Low
7-1	Civic Centre grounds	Strategic	2	4	Moderate	REMEDIED		

ID	Location	Risk Category	Existing Stormwater Infrastructure (Scenario 1b)			Post Mitigation (Scenario 1c)		
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating
7-2	Ambulance station	Safety/ Reputational	5	3	High	REMEDIED		
7-3	Medical Centre (2 Strangman Rd)	Safety/ Reputational	5	5	Severe	REMEDIED		
7-4	Wohling St / Ifould Park	Strategic/ Operational	3	4	High	2	2	Low
8-1	Ian Oliver Drive	Strategic	3	3	Moderate	2	1	Low
8-2	41 Strangman Rd	Strategic	3	3	Moderate	REMEDIED		

Table 53. Post mitigation risk assessment for Scenario 5c – 1% AEP Future

ID	Location	Risk Category	Existing Stormwater Infrastructure (Scenario 1b)			Post Mitigation (Scenario 1c)		
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating
1-1	Lifestyle Village (South-western end, residences 73-74)	Safety/Operational	4	2	Moderate	3	2	Moderate
1-2	Lifestyle Village (Central, village hub)	Operational/Safety	3	4	High	2	4	Moderate
1-3	Lifestyle Village (North-eastern end, residences 40 and 41)	Safety/Operational	4	3	High	4	3	High
1-4	Lifestyle Village (North-western end, residences 48-52)	Safety/Operational	4	3	High	2	2	Low
1-5	Lifestyle Village (Western end, residences 61-63)	Safety/Operational	4	3	High	REMEDIED		
1-6	Peake Tce (adj. Lifestyle Village)	Operational	1	3	Low	1	3	Low
1-7	Lifestyle Village (Residence 88)	Strategic/Regulatory	3	2	Moderate	3	2	Moderate
1-8	Lifestyle Village Men's Shed	Strategic	2	1	Low	REMEDIED		
1-9	Lifestyle Village (NW intersection)	Operational/Regulatory	3	2	Moderate	REMEDIED		
2-1	Apex Park (Northern End)	Strategic	4	3	High	3	3	Moderate
2-2	2 West Rd	Safety	2	2	Low	2	2	Low
2-3	West Rd (Walking track)	Safety	3	2	Moderate	3	2	Moderate
2-4	31 Mary Starr Drive	Operational/Strategic	2	2	Low	2	2	Low
2-5	Bottom of Mary Starr Drive	Safety/Operational	4	3	High	4	3	High
2-6	Mary Starr Basin & swale	Operation/Regulatory	2	2	Low	4	2	Moderate
3-1	17 West Rd	Operational	3	4	High	3	4	High

ID	Location	Risk Category	Existing Stormwater Infrastructure (Scenario 1b)			Post Mitigation (Scenario 1c)		
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating
3-2	5A West Rd	Operational	3	4	High	3	4	High
3-3	Bottom of Stanley St	Operational	2	4	Moderate	2	4	Moderate
4-1	Top of Cates Ave	Operational/ Reputational	3	4	High	2	3	Moderate
4-2	Laneway between Jemison St and Heming St	Safety/ Operational	2	4	Moderate	2	4	Moderate
4-3	Community Sports complex	Strategic/ Reputational	5	4	Severe	4	4	High
4-4	Bowling club	Strategic	2	2	Low	2	2	Low
4-5	Traffic lights on Lawrie Tce	Operational	3	3	Moderate	3	3	Moderate
4-6	Warrawee Lodge (Eastern end)	Strategic	3	3	Moderate	3	3	Moderate
4-7	Elders Way	Operational	2	3	Moderate	REMEDIED		
5-1	Machinery Museum	Operational	4	4	High	4	4	High
5-2	Football oval	Operational	1	3	Low	1	3	Low
6-1	45-47 Peake Terrace	Operational/ Safety	4	3	High	3	3	Moderate
6-2	Bottom of Kirby St (West of 41 Peake Terrace)	Operational	2	3	Moderate	1	3	Low
6-3	41 Peake Tce	Operational	2	3	Moderate	2	3	Moderate
7-1	Civic Centre grounds	Strategic	3	3	Moderate	REMEDIED		
7-2	Ambulance station	Safety/ Reputational	5	3	High	REMEDIED		
7-3	Medical Centre (2 Strangman Rd)	Safety/ Reputational	5	4	Severe	REMEDIED		

ID	Location	Risk Category	Existing Stormwater Infrastructure (Scenario 1b)			Post Mitigation (Scenario 1c)		
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating
7-4	Wohling St / Ifould Park	Strategic/ Operational/ Safety	5	4	Severe	3	2	Moderate
7-5	Medical Centre (1 Strangman Rd)	Operational	2	3	Moderate	2	3	Moderate
7-6	10 Dowling St	Operational/ Safety	4	3	High	3	3	Moderate
7-7	9 Miller St	Safety	5	4	Severe	2	3	Moderate
7-8	16 Miller St	Operational	1	3	Low	1	3	Low
7-9	Civic Ave near RV dump point	Operational	2	3	Moderate	2	3	Moderate
7-10	Civic Ave near Nippy's/Mitre 10	Operational	2	3	Moderate	2	3	Moderate
8-1	Ian Oliver Drive	Strategic	4	2	Moderate	2	2	Low
8-2	Bottom of Burns St	Operational	2	3	Moderate	2	3	Moderate
8-3	Tiller Crescent	Operational	1	3	Low	1	3	Low
8-4	Cates St (bottom of cul-de-sac)	Operational	1	3	Low	1	2	Low
8-5	41 Strangman Rd	Safety	3	2	Moderate	3	2	Moderate

10.1.1. Distribution of Risk Ratings - Post Mitigation

Table 54 summarises identified risk ratings for all scenarios.

Table 54. Risk ratings distribution – post mitigation

		18% AEP Future	1% AEP Future
Low	Existing Stormwater Infrastructure	3	10
	Post mitigation	4	11
	Change	+1	+1
Moderate	Existing Stormwater Infrastructure	12	18
	Post mitigation	4	21
	Change	-8	+3
High	Existing Stormwater Infrastructure	5	13
	Post mitigation	2	6
	Change	-3	-7
Severe	Existing Stormwater Infrastructure	1	4
	Post mitigation	0	0
	Change	-1	-4

Implementation of the recommended stormwater management measures is anticipated to substantially lower flood risk throughout Waikerie during both minor (18% AEP) and major (1% AEP) storm events. The assessment indicates that the measures not only reduce the total number of identified flood risks, but also result in the redistribution of residual risks from higher consequence ratings to lower-risk categories, as presented in Table 54.

For the 18% AEP (minor) event, the number of identified flood risks decreases from 21 to 10, equating to a 52% reduction. High-risk locations are reduced from five to two, while moderate-risk locations decrease from twelve to four. The one severe risk identified in this event was remediated by the proposed mitigation strategies.

For the 1% AEP (major) event, the total number of identified flood risks decreases from 45 to 38, representing an overall reduction of approximately 15%. Although the reduction in total risk numbers is comparatively smaller, the severity of the residual risks is considerably reduced. High-risk locations decrease from 13 to 6, and the four severe risks identified under existing conditions are fully removed, leaving no severe residual risks following implementation of the recommended management responses.

The increase in low and moderate risk locations demonstrates that the proposed measures effectively reduce the likelihood and consequence of flooding, with many residual risks shifting from the Severe and High categories into the Moderate and Low categories. Overall, the recommended management responses provide improvement to community safety, reduce the potential for flood-related damage to property and infrastructure, and strengthen the long-term resilience and functionality of the Waikerie stormwater network.

10.2. Water Quality Improvements and residual pollutants

The estimated reductions in pollutant loads resulting from the implementation of the proposed WSUD measures, in combination with the existing treatment provided by Hart Lagoon, are summarised in Table 55.

Table 55. Water quality results

Parameter	Source	Residual Load	Reduction	Reduction %	Target	Achieved?
Flow (ML/yr)	203.92	108.83	95.09	46.63		
Total Suspended Solids (kg/yr)	41,455.16	12,872.18	28,582.98	68.95	80%	N
Total Phosphorus (kg/yr)	61.26	17.70	43.56	71.11	60%	Y
Total Nitrogen (kg/yr)	422.85	178.47	244.38	57.79	45%	Y
Gross Pollutants (kg/yr)	9,395.79	43.73	9,352.06	99.53	90%	Y

The proposed strategy significantly improves stormwater quality across the Waikerie catchment by reducing runoff volumes and removing key pollutants before discharge to the River Murray. MUSIC modelling indicates that the recommended WSUD measures, including detention basins, constructed wetlands, and other treatment systems, will reduce annual stormwater runoff by approximately 47% while achieving substantial reductions in pollutant loads.

Overall, the proposed management responses are predicted to achieve reductions of approximately 69% for Total Suspended Solids (TSS), 71% for Total Phosphorus (TP), 58% for Total Nitrogen (TN), and 99.5% for Gross Pollutants (GP). The proposed strategy exceeds the adopted water quality targets for Total Phosphorus, Total Nitrogen, and Gross Pollutants, while achieving a substantial improvement in Total Suspended Solids, although the 80% reduction target is not fully met.

These results demonstrate that integrating distributed WSUD measures with the existing Hart Lagoon treatment system and the other measures proposed in this SMP provides a highly effective treatment train for stormwater management. In addition to improving water quality, the measures reduce runoff volumes, enhance the protection of the River Murray, and contribute to more sustainable management of the township's stormwater system.

Further improvements could also be achieved by encouraging the incorporation of WSUD measures and on-site detention or storage systems where feasible, as recommended in Strategy 2 (S2) – Increase On-site Storage. Implementing these measures as part of future development, redevelopment and infrastructure upgrade projects would help manage stormwater closer to its source, further reducing runoff volumes and pollutant loads before they enter the broader drainage network. This would complement the proposed catchment-scale management responses and further strengthen the overall water quality and resilience outcomes of the SMP.

11. Conclusion and Discussion

This Stormwater Management Plan provides the District Council of Loxton Waikerie with a comprehensive, evidence-based framework for managing stormwater across the township of Waikerie over the long term. Through detailed catchment investigations, hydrological and hydraulic modelling, water quality assessment, flood risk analysis, and evaluation of management responses, the SMP has identified the key challenges affecting the existing stormwater network and established a prioritised program of works to improve its performance, resilience, and sustainability.

The investigations confirmed that much of Waikerie's stormwater network is approaching the end of its service life and no longer provides sufficient capacity to accommodate current and future rainfall conditions. Existing constraints, including undersized pipes, disconnected drainage systems, localised depressions, and limited natural drainage pathways, contribute to recurring flooding throughout the township. Climate change is expected to further increase the frequency and intensity of short-duration storm events, reinforcing the need for a proactive and integrated approach to stormwater management.

The recommended management responses combine conventional drainage upgrades with Water Sensitive Urban Design (WSUD), source-control measures, stormwater quality treatment, detention, and stormwater harvesting opportunities. Rather than relying solely on increasing pipe capacity, the strategy promotes a balanced approach that manages stormwater throughout the catchment by reducing runoff at its source, improving water quality, and reducing demand on the existing drainage network.

The investigations also highlight the importance of protecting the River Murray through improved stormwater quality management. While Hart Lagoon currently provides an important level of treatment, additional WSUD measures distributed throughout the catchment will further reduce sediment, nutrient, and gross pollutant loads before discharge to receiving waters. These measures will also provide broader environmental and community benefits, including improved urban amenity, enhanced biodiversity, and opportunities for stormwater harvesting and reuse.

The prioritised implementation plan provides Council with a practical framework for directing future capital investment, infrastructure renewal, maintenance programs, and external funding applications. As projects are progressively implemented, the proposed management responses will reduce flood risk, improve stormwater quality, protect property and infrastructure, enhance community safety, and support sustainable urban growth. Ongoing monitoring, periodic review of the hydraulic model, and integration of future development information will ensure the SMP remains relevant and responsive to changing conditions.

Ultimately, the successful implementation of this Stormwater Management Plan will depend on continued collaboration between Council, developers, government agencies, and the local community. By integrating stormwater management with broader land use planning and asset management, the recommended strategy provides a clear pathway towards a more resilient, efficient, and sustainable stormwater system that supports the long-term liveability, prosperity, and environmental health of Waikerie.

12. References

12.1. Reference texts

Australian Bureau of Statistics (ABS) 2021, '2021 Waikerie, Census All persons QuickStats', Australian Bureau of Statistics, Government of Australia, viewed 9 January 2025,

<<https://www.abs.gov.au/census/find-census-data/quickstats/2021/UCL415021>>.

Australian Institute for Disaster Resilience (AIDR) 2017, Guideline 7.3 Flood Hazard, from the Australian Disaster Resilience handbook collection, Australian Institute for Disaster Resilience, Commonwealth of Australia, viewed 26 July 2025, <<https://knowledge.aidr.org.au/media/3518/adr-guideline-7-3.pdf>>.

Hennekam B 2023, *Review of Waikerie Stormwater network using DRAINS*, Neilly Group, Australia, viewed 25 February 2025.

Bureau of Meteorology (BOM) 2025, 'Climate statistics for Australian locations', Bureau of Meteorology, Australian Government, viewed 9 January 2025,

<http://www.bom.gov.au/climate/averages/tables/cw_020028.shtml>.

CSIRO and Bureau of Meteorology 2015, *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology, Australia, viewed 8 January 2025,

<https://www.climatechangeinaustralia.gov.au/media/ccia/2.2/cms_page_media/168/CCIA_2015_NRM_TechnicalReport_WEB.pdf>.

Department of Environment, Water and Natural Resources, 2013, *Water Sensitive Urban Design – Creating More Liveable and Water Sensitive Cities in South Australia*, Department of Environment, Water and Natural Resources, August 2013.

<<water-sensitive-urban-design-policy-gen.pdf>>

Department for Environment and Water (DEW) 2024, 'Traditional Owners', Government of Australia, viewed 6 January 2025, <<https://www.environment.sa.gov.au/topics/river-murray/about/traditional-owners>>.

District Council of Loxton Waikerie and URPS 2024, *Loxton Waikerie Growth Strategy*, District Council of Loxton Waikerie, Loxton, SA, viewed 9 January 2025,

<https://www.loxtonwaikerie.sa.gov.au/_data/assets/pdf_file/0019/1551412/Final-DCLW-Growth-Strategy-February-2024-Excluding-Engagement-Summary-Compressed.pdf>.

District Council of Loxton Waikerie (DCLW) and URPS 2024, *Loxton Waikerie Growth Strategy*, District Council of Loxton Waikerie, Loxton, SA, viewed 20 June 2025,

<https://www.loxtonwaikerie.sa.gov.au/_data/assets/pdf_file/0019/1551412/Final-DCLW-Growth-Strategy-February-2024-Excluding-Engagement-Summary-Compressed.pdf>.

Hou B & Petts A 2021, 'Delamerian National Drilling Initiative: stratigraphy of Murray Basin cover sediments', *MESA Journal*, vol. 95, no. 1, viewed 13 January 2025, pp. 48-65,

<<https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MESAJ094048-065.pdf>>.

Macumber P 2023, 'Hydraulically Disconnected Rivers in the Highlands and Southern Riverine Plain of S.E Australia', *Sustainability*, vol. 15, no. 865, viewed 13 January 2025, pp. 1-35,

<https://www.researchgate.net/publication/366889896_Hydraulically_Disconnected_Rivers_in_the_Highlands_and_Southern_Riverine_Plain_of_SE_Australia>.

Marsden Z 2006, *Chowilla Floodplain Groundwater Monitoring Network Expansion*, Department of Water, Land and Biodiversity Conservation, Government of South Australia, Adelaide, viewed 13 January 2025,

<https://www.waterconnect.sa.gov.au/Content/Publications/DEW/ki_dwlbc_report_2004_52.pdf>.

Marsland K & Nicol J 2007, *2006 River Murray Wetlands Baseline Survey, Vegetation Component*, South Australian Research and Development Institute, Adelaide, viewed 20 December 2024,

<https://pir.sa.gov.au/data/assets/pdf_file/0016/231640/No_193_2006_River_Murray_Wetland_baseline_final_report_160207_alias.pdf>.

Mosely L, Priestley M, Brookes J, Dittmann S, Farkas J, Farrell M, Ferguson A, Gibbs M, Hipsey M, Huang J, Lam-Gordillo O, Simpson S, Tyler J, Waycott M, & Welsh D 2023, 'Extreme eutrophication and salinisation in the Coorong estuarine-lagoon ecosystem of Australia's largest river basin (Murray-Darling)', *Marine Pollution Bulletin*, vol. 188, viewed 10 January 2025, pp. 1-16,

<<https://www.sciencedirect.com/science/article/pii/S0025326X23000796#>>.

Murray-Darling Basin Authority (MDBA) 2021. 'Water Allocation Plan for the River Murray Prescribed Watercourse', Government of South Australia, viewed 28 February 2025,

<https://cdn.environment.sa.gov.au/landscape/docs/mr/rmwap_final_web_ready.pdf> .

Murray-Darling Basin Authority (MDBA) 2021. 'Water Affecting Activities Control Policy', Government of South Australia, viewed 03 March 2025,

<https://cdn.environment.sa.gov.au/landscape/docs/mr/murraylands_and_riverland_water_affecting_activities_control_policy_fina.pdf>.

Murray-Darling Basin Authority (MDBA) 2023, 'Fish', Government of Australia, viewed 19 December 2024,

<<https://www.mdba.gov.au/basin/plants-and-wildlife/fish>>.

Neilly Group 2023, *23053 SA_LWDC_DRAIN_Stormwater_Culvert_Review_v2b*, Neilly Group Pty Ltd, Memo for LWDC reporting on findings of a DRAINS review and update for the town of Waikerie.

Neilly Group 2023, *Waikerie Rotary Cliff Top Walk Concept Report*, prepared by Neilly Group for District Council of Loxton Waikerie.

PlanSA 2023, *Population Projections for South Australia and Regions – 2021 to 2051*, PlanSA, Department for Trade and Investment, Government of South Australia,

<https://plan.sa.gov.au/data/assets/pdf_file/0019/1235431/Population-Projections-for-South-Australia-and-Regions-2021-to-2051.pdf>.

Rawlinsons 2025, *Construction cost guide 2025*, Rawlinsons Publishing, Perth, WA, Edition 33.

Rutherford I, Kenyon C, Thoms M, Grove J, Turnbull J, Davies P, & Lawrence S 2019, 'Human impacts on suspended sediment in the River Murray, South Eastern Australia: Multiple lines of evidence', *River Research and Applications*, vol. 36, no. 4, viewed 20 December 2024, pp. 522-541,

<https://onlinelibrary.wiley.com/doi/epdf/10.1002/rra.3566?saml_referrer>.

Shiel R, Walker K, & Williams W 1982, 'Plankton of the Lower River Murray, South Australia', *Marine and Freshwater Research*, vol. 33, no. 2, viewed 20 December 2024, pp. 302-327,

<https://www.researchgate.net/publication/235337531_Plankton_of_the_Lower_River_Murray_South_Australia>.

State of Queensland 2018, Brisbane River Strategic Floodplain Management Plan, prepared by BMT for the State of Queensland, viewed 21 July 2025, <https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/8f5de849-673e-4ec1-9143-1332a37f1f2b/r.b22374.007.05.ter_main_report.pdf?ETag=5f8b7ecc052ae620c9020c64fff1a29e>.

Stormwater Management Authority 2007, *Stormwater Management Planning Guidelines*, Stormwater Management Authority, July 2007.

Verhoeven J, Kahn S, & Evans M 2024, *Challenges and adaptation needs for water quality in the Murray-Darling Basin in response to climate change*, Australian Academy of Technological Sciences & Engineering, Canberra, viewed 20 December 2024, <<https://www.atse.org.au/media/yzrlqqcm/mdb-essay-2-verhoeven.pdf>>.

Water Sensitive SA 2021, *South Australian MUSIC Guidelines*, Water Sensitive SA, March 2021.

Winnall E 2019, *District Council of Loxton Waikerie Economic Development Report and Project Plan*, District Council of Loxton Waikerie, Loxton, SA, viewed 6 January 2025, <https://www.lwdc.sa.gov.au/_data/assets/pdf_file/0016/349000/DCLW-Economic-Development-Report-2019-2023.pdf>.

12.2. Websites used as data sources

ARR Datahub – <https://data.arr-software.org/>

Bureau of Meteorology – Climate Data Online: <http://www.bom.gov.au/climate/data/index.shtml>

IFD data: <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>

ELVIS – <https://elevation.fsd.org.au/>

Google Earth Engine – https://developers.google.com/earth-engine/datasets/catalog/GOOGLE_Research_open-buildings_v3_polygons

SAPPA – <https://sappa.plan.sa.gov.au/>

12.3. Tools for modelling and data manipulation

Climate Change Rainfall Modifier (CCRM) –

<https://watercom.com.au/resources/climate-change-rainfall-modifier/>

DRAINS – Version: 2025.01.9147.24925 (64 bit)
Supplier: Watercom

INFFEWS Value Tool – Version: 2022-12
Supplier: CRC for Water Sensitive Cities

TUFLOW – Build: 2023-03-AD-iSP-w64
Solution Scheme: HPC
Supplier: BMT Commercial Australia Pty Ltd