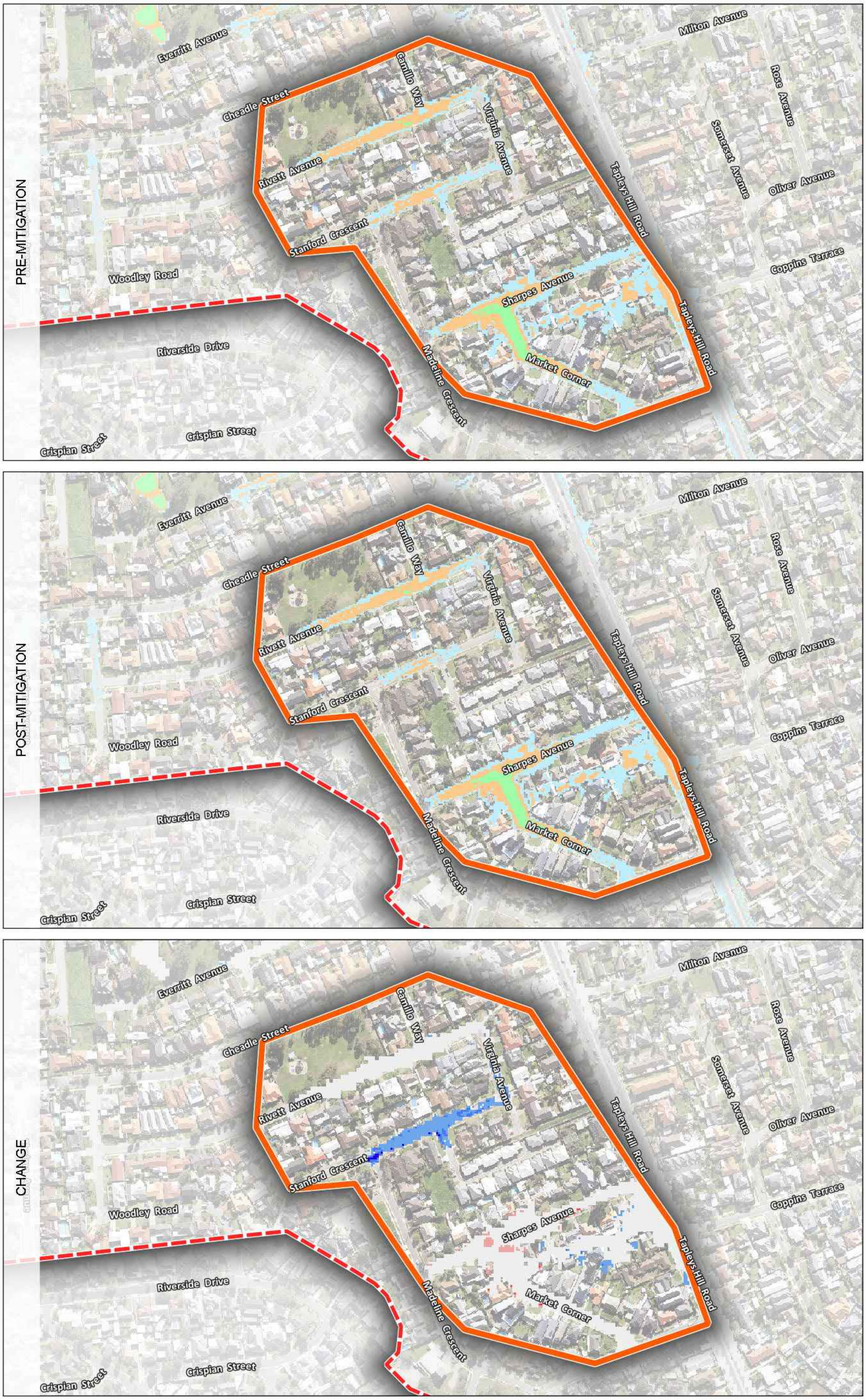

Legend

- Flood zone
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 100 200 300 m

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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2019

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
MARKET CORNER PIPE UPGRADES
20% AEP CHANGE MAP

Figure 6.29

6.3 Non-structural mitigation strategies

In addition to the structural flood mitigation strategies described in the preceding sections, there are a number of non-structural strategies that should be considered for reducing the impacts of flooding within the West Lakes catchment. Non-structural strategies generally require low capital investments (compared to the structural strategies) and hence can be cost effective measures for reducing flood damages.

6.3.1 Education and awareness

Detailed floodplain mapping of the catchment has been developed as part of this SMP. This information should be made widely available to the community so that they are informed about where flooding is likely to occur. Being aware of the flood risk can allow the community to better manage the risk, likely resulting in a reduction in flood damages. The information could be provided through mail-outs to flood affected property owners, accessible via the internet or made available at public places such as libraries and Council's office. Businesses and residents can be encouraged to develop flood action plans to reduce damages in the event of a flood and change the way in which valuable items are stored.

The State Emergency Service (SES) flood website provides information about flood preparedness and recommends measures to be taken before, during and after a flood. An informed community is likely to be more resilient to flooding. Simple actions such as relocating valuable items can significantly reduce the long-term impacts of a flood event.

Education and awareness addresses Goal F3 of this SMP.

6.3.2 Use of flood mapping outputs

The results of the catchment flood mapping should be utilised in the planning of new developments to ensure that they are designed such that they have adequate flood protection (Goal RA1). It is recommended that the flood maps developed as part of this SMP should be incorporated into the Planning and Design Code flood overlay such that planning decisions can be made on the basis of the most up-to-date information.

Flood mapping outputs can also be uploaded onto the DEW Flood Awareness website.

6.3.3 Flood warning

Typically, if the community is given sufficient warning of the potential for flooding, the magnitude of the social and economic damages can be reduced significantly. Given some warning, the community and emergency services would have additional time to sandbag flood prone areas and remove valuable portable property from areas that may have otherwise suffered flood damages. The potential reduction in flood damages when more than 12 hours of warning is provided, as opposed to less than two hours, can range from 20% up to 50%, depending on the relative experience of the community in dealing with flooding (DNRE, 2000).

Council currently has a flood preparation process which is implemented when the forecast rain exceeds 15 mm. The current process involves:

- Contacting residents on known flood affected parcels advising of the availability of sandbags.
- Checking net type GPTs at critical locations to ensure that they are empty and that the release mechanisms are functional.
- Notify Jet Vac crew of forecast rain, and checking of SEPs at known flooding hot spots.
- Liaising with DIT to understand if the lake level can be lowered.
- Proactive checking of SEPs in known flooding areas during the rainfall event.

In more severe events Council also liaises with SES.

Flood warning is useful in large riverine catchments where a significant warning time could be provided. Given the relatively short response time for the local catchments (typically less than one hour), it is considered that Council's current approach is sufficient.

On this basis, it is recommended that Council retain their current approach of warning in advance of forecast heavy rainfall events and focus on increasing education and awareness to improve the flood resilience of the community.

6.4 Reduction in damages

Comparison of the pre- and post-mitigation flood mapping confirms that implementation of the proposed structural flood management strategies will result in a reduced number of inundated properties for any given storm event. A summary of the modelled number of flood-affected properties for the post-mitigation scenario (assuming implementation of all of the works) is provided in Table 6.1. Residential properties with above floor flooding are summarised in Table 6.2.

Table 6.1 Number of flood-affected properties (post-mitigation)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	27	34	43	61	94	169	244	575
2 West Lakes Central	0	0	0	0	0	1	2	4
3 West Lakes North East	3	4	4	4	4	9	13	49
4 West Lakes East	16	33	59	95	147	280	415	707
5 West Lakes South	3	4	8	9	11	14	24	63
6 Trimmer Parade	16	29	76	147	300	629	919	1642
7 Meakin	36	53	106	172	298	511	714	1144
8 Henley Grange	13	15	43	96	222	480	730	1324
Total	**114**	**172**	**339**	**584**	**1076**	**2093**	**3061**	**5508**

Table 6.2 Number of residential properties with above-floor flooding (post-mitigation)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0	0	0	3	8	30	50	141
2 West Lakes Central	0	0	0	0	0	0	0	0
3 West Lakes North East	0	0	0	0	0	0	0	0
4 West Lakes East	0	1	1	3	9	28	60	130
5 West Lakes South	0	0	0	0	0	0	5	12
6 Trimmer Parade	0	0	2	7	21	94	187	497
7 Meakin	0	0	3	6	25	66	116	339
8 Henley Grange	0	0	0	2	21	76	163	466
Total	**0**	**1**	**6**	**21**	**84**	**294**	**581**	**1585**

It can be seen that implementation of the proposed flood mitigation strategies results in 6 residential properties being subject to over-floor inundation in a 20% AEP event, a significant reduction on the 43 identified at risk of flood damage pre-mitigation measures. In a 1% AEP event, the modelling indicates that the number of residential properties subject to over floor inundation would decrease from 896 to 581.

The flood damages for the post-mitigation flooding were estimated using the same approach as detailed in Section 5, and are shown in Table 6.3. The AADs, including the reduction in AAD between the pre- and post-mitigation scenarios, are summarised in Table 6.4. The results demonstrate an average reduction in damages of $2.1 million per year.

Table 6.3 Post-mitigation flood damages ($ million)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0.07	0.09	0.14	0.34	0.78	2.14	3.48	9.14
2 West Lakes Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
3 West Lakes North East	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.11
4 West Lakes East	0.08	0.19	0.29	0.59	1.45	3.29	6.10	12.40
5 West Lakes South	0.24	0.34	0.49	0.66	0.90	1.20	1.82	3.78
6 Trimmer Parade	0.04	0.06	0.26	0.73	1.73	7.51	13.81	32.38
7 Meakin	0.09	0.17	0.49	0.99	2.46	6.08	10.39	24.39
8 Henley Grange	0.06	0.12	0.26	0.95	2.58	6.63	12.30	30.98
Total	**0.59**	**0.98**	**1.94**	**4.26**	**9.91**	**26.52**	**47.94**	**113.28**

Table 6.4 Change in annual average damages

Zone	Annual average damage ($)		
	Pre-mitigation	Post-mitigation	Reduction
1 West Lakes West	$340,000	$229,000	$111,000
2 West Lakes Central	$0	$0	$0
3 West Lakes North East	$8,000	$8,000	$0
4 West Lakes East	$381,000	$380,000	$1,000
5 West Lakes South	$359,000	$359,000	$0
6 Trimmer Parade	$1,231,000	$583,000	$648,000
7 Meakin	$1,833,000	$619,000	$1,214,000

Zone	Annual average damage ($)		
	Pre-mitigation	Post-mitigation	Reduction
8 Henley Grange	$718,000	$624,000	$94,000
Total	**$4,870,000**	**$2,803,000**	**$2,068,000**

6.5 Economic analysis

Cost estimates have been prepared for each of the structural flood mitigation strategies (provided in Appendix E). To assist in understanding the relative economic benefits of offsetting flood damages via structural mitigation strategies, a benefit-cost ratio (BCR) has been determined for each of the damage assessment zones. This provides an indication of which projects in the catchment are most beneficial in terms of cost.

The reduction in AAD associated with each strategy was converted to a net present value using a discount rate of 4% across a 50-year horizon (Commonwealth of Australia, 2018). The BCRs were calculated using the ratio of the net present value of reduced damages to the cost of the works. The BCRs within each zone are summarised in Table 6.5.

Table 6.5 Benefit-cost ratios (by damage zone)

Zone	BCR	Flood mitigation strategies
1 West Lakes West	0.23	Sansom Road pipe upgrades; Recreation Parade detention basin
6 Trimmer Parade	0.51	Frank Mitchell Reserve underground tank; Golfers Avenue pipe and pump upgrades; Beatrice Avenue and Trimmer Parade
7 Meakin	0.57	Gleneagles Reserve underground tank; Crittenden Road to Grange Lakes pipe upgrades; Matheson Reserve underground tank
8 Henley Grange	2.96	Nedford Reserve detention basin; Market Corner pipe upgrades

6.6 Decision-making framework

A decision-making framework has been developed to provide decision-makers with a tool to assess and compare the net benefits of proposed strategies for the management of stormwater within the West Lakes catchment (Tonkin, 2020a). The approach is generally consistent with the 'Optimised Decision Making Guidelines' (ODMG) (NZNAMSG, 2004). The framework is intended to allow a range of objectives to be considered when making a decision.

The process includes consideration of the problem, identification of options and then assessment against an agreed multi-criteria framework. Its intent is to guide the development of sustainable stormwater management solutions.

For the purpose of the West Lakes SMP, the multi-criteria assessment framework includes consideration of flood protection, beneficial use of stormwater, social values, environmental benefit and costs. Full details of the decision-making methodology are provided in Appendix F.

When identifying problems and potential solutions within the West Lakes SMP, it was determined that due to the heavily developed nature of the catchment with limited available space, in most instances there was only one viable solution (such as pipe upgrade or detention) for each of the flooding hotspots. Similarly, the options to address water quality were limited. While the identification of solutions did consider social and environmental constraints and opportunities, it was not possible to utilise the decision-making framework.

It is hoped that the decision-making framework will provide Council with a useful tool for assessing and prioritising small-scale stormwater upgrades across the catchment, where they may be more opportunities to incorporate social and environmental benefits into stormwater works.

6.7 Priorities

The economic analyses described in the preceding sections provide only a single input into the determination of priorities for the recommended works. Consistent with the intent of the decision making framework, other measures that have been taken into account when assigning priorities to the proposed strategies include "flooding hot-spots", the number of properties that stand to benefit from the works, impacts on development and opportunities to leverage other benefits (such as water quality improvement).

The following criteria have been used to assign priorities:

High priority:

- addresses high frequency flooding hot-spots
- reduces flooding for a large number of properties
- small-scale, relatively low-cost actions with interim benefits.

Medium Priority:

- flood risk to a small number of properties with good benefit to cost ratio.

Low priority

- flood risk to a small number of properties with low benefit to cost ratio.

6.8 Summary of flood management actions

Table 6.6 provides a summary of the flood mitigation options described in the preceding sections. A priority and budget estimate are also provided for each option.

Table 6.6 Summary of flood mitigation options

Priority	Project/ Activity Title	Budget estimate	SMA Funding Eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Quantification or Description of Benefit	Other Benefits Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit
High	F1 Gleneagles Reserve storage	$12,726,000	Y	$2,000	D, P	$1,214,000 (in combination with Priority F4 and F5) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 14 properties subject to above floor flooding)	M	Limited disturbance of open space Opportunities for infiltration/reuse Can be staged
High	F2 Nedford Reserve detention basin	$248,000	Y	$2,000	D, Q	$94,000 (in combination with Priority F10) Significant reduction (~180 mm) in flood depths within the road corridor in the 20% AEP event	H	Possibility for landscaping for improved amenity and biodiversity
High	F3 Beatrice Avenue and Trimmer Parade pipe upgrades	$9,117,000	Y	-	D, P	$648,000 (in combination with Priority F8 and F9) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 7 properties subject to above floor flooding)	-	Opportunity to incorporate WSUD
Medium	F4 Crittenden Road to Grange Lakes pipe upgrades	$24,172,000	Y	-	D, P	$1,214,000 (in combination with Priority F1 and F5) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 8 properties subject to above floor flooding)	L	Opportunity to incorporate WSUD
Medium	F5 Matheson Reserve underground tank	$18,960,000	Y	$2,000	D, P	$1,214,000 (in combination with Priority F1 and F4) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 4 properties subject to above floor flooding)	L	Limited disturbance of open space
Medium	F6 Recreation Parade detention basin	$3,765,000	Y	$2,200	D, P, Q	$111,000 (in combination with Priority F7) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 2 properties subject to above floor flooding) Significant reduction (~200 mm) in flood depths within the road corridor in the 20% AEP event	L	Possibility for landscaping for improved amenity and biodiversity
Medium	F7 Sansom Road pipe upgrades	$6,640,000	Y	-	D, P	$111,000 (in combination with Priority F6) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 4 properties subject to above floor flooding)	-	-
Medium	F8 Golfers Avenue pipe and pump upgrades	$3,197,000	Y	-	D, Q	$648,000 (in combination with Priority F3 and F9) Improvements to flooding in roadways (particularly Frederick Road and Lily Avenue) in the 20% AEP event	-	-
Low	F9 Frank Mitchell Reserve underground tank	$15,049,000	Y	$2,000	D, Q	$648,000 (in combination with Priority F3 and F8) Significant reductions (~300 mm) in flood depth within the road corridor in the 20% AEP event	L	Limited disturbance of open space
Low	F10 Market Corner pipe upgrades	$392,000	N	-	D, Q	$111,000 (in combination with Priority F7) Minor reductions in flood depth within the road corridor	-	-

Priority	Project/ Activity Title	Budget estimate	SMA Funding Eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Flood Mitigation Benefit Quantification or Description of Benefit	Other Benefits Rating (H) – High (M) – Med (L) – Low	Other Benefits Qualitative Description of Benefit
High	F11 Education and awareness	$70,000	N	$10,000	Q	Likely to reduce flood impacts on community	M	Public can better respond to flooding. Better community resilience to flooding.
High	F12 Flood mapping outputs	$20,000	N	-	Q	Provide up to date information of flooding within the catchment	-	-
High	Bower Road Culvert Upgrade	N/A	N/A			Identified by the Western Regions Climate Adaption Plan. Will be required around 2050. Work to be undertaken by DIT.		

7 Water quality

This section provides a summary of the modelling undertaken to determine the existing water quality within the study area. An overview of the existing water reuse schemes within the study area is also provided.

7.1 Water quality modelling

The West Lakes catchment is heavily developed, with residential dwellings representing the greatest land use type. The primary pollutants associated with runoff from an urban landscape include sediments (total suspended solids (TSS)), nutrients (total phosphorus (TP) and total nitrogen (TN)), pathogens, oxygen demanding substances and gross pollutants (GP).

The water quality of runoff from the catchment was modelled using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC). In the absence of official guidelines for the application of MUSIC in South Australia at the time of modelling, the modelling is based on the recommendations made by the Goyder Institute following a review of guidelines for the application of MUSIC in other regions (Myers, Cook, Pezzaniti, Kemp, & Newland, 2015).

The model is based on the long-term (2070) state of development within the catchment and has been used to assess the spatial variability of water quality within the study area, as well as determining pollutant loads at the outlets from each sub-catchment into the Lake.

7.1.1 Model set-up

Development of a MUSIC model requires inputs of meteorological data, catchment data, drainage links and water quality improvement measures. The inputs used in the model are described below.

7.1.1.1 Meteorological data

Rainfall data used in the model were obtained from the Bureau of Meteorology (BoM). Rainfall totals at six-minute intervals for the period from 1967-2010 were available from the Adelaide Airport weather station (station number 023034), located approximately 6 km from the study area. Average monthly areal potential evapotranspiration (PET) data were also obtained from the BoM. The PET data used in the model are summarised in Table 7.1.

Table 7.1 Monthly areal potential evapotranspiration data (mm/month)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
260	229	190	121	70	41	50	74	113	167	209	231

7.1.1.2 Catchment data

The definition of MUSIC catchment areas and imperviousness was based on the sub-catchments used to define the hydrology for the floodplain mapping. The floodplain mapping utilised hydrological inputs from almost 5,000 sub-catchments; these sub-catchments were lumped together based on location to form 17 MUSIC catchments with areas typically in the order of 100-200 ha.

The pollutant load parameters applied to each MUSIC catchment are based on the predominant land use within each catchment (typically urban residential) and are consistent with the recommendations in Myers et al. (2015) for lumped catchment modelling for South Australian stormwater management plans. The adopted water quality parameters are summarised in Table 7.2.

Table 7.2 Water quality parameters for lumped catchment modelling

Land use		TSS log_{10} values		TP log_{10} values		TN log_{10} values	
		Mean	SD	Mean	SD	Mean	SD
Urban residential	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	2.18	0.39	-0.47	0.32	0.26	0.23
Commercial	Baseflow	0.78	0.39	-0.60	0.50	0.32	0.30
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34

7.1.1.3 Drainage links

The drainage links within the MUSIC model were defined based on the existing drainage pathways, with all catchments ultimately discharging to the Lake. No routing was applied. This is considered conservative and is consistent with the recommendation of Myers et al. (2015) which states "routing is not required in South Australian MUSIC modelling undertaken for compliance with water quality targets to ensure results are conservative".

7.1.1.4 Rainfall-runoff parameters

The parameters relating to the rainfall runoff processes adopted in the model are summarised in Table 7.3. These parameters are consistent with those used in the SMP.

Table 7.3 Rainfall-runoff parameters

Parameter	Value
Impervious area properties	
Rainfall threshold (mm/day)	1
Pervious area properties	
Soil storage capacity (mm)	40
Initial storage (% of capacity)	30
Field capacity (mm)	30

7.1.1.5 Existing water quality improvement features

A schematic showing the layout of the MUSIC model is shown in Figure 7.1. Given the scale of the model, only water quality improvement measures that are considered to have a significant impact on the water quality at the downstream end of the catchment are included in the model. Small scale water quality improvement features such as soakage pits and rain gardens which will not have a measurable impact on downstream water quality (even when lumped together) due to the small volumes of flow treated are not included in the model. The location of the downstream receiving node is located such that it receives all flows that would discharge to the Lake.

The water quality improvement features included within the MUSIC model for the base case scenario include:

- Gross pollutant traps at catchment outlets discharging to the Lake.
- Royal Adelaide Golf Club wetland.
- Grange Golf Club wetland.

- Detention basin within Gleneagles Reserve.
- Sedimentation within Grange Lakes.

The bathymetry of the water quality improvement features was estimated based on review of the DEM. The operational regimes of the wetlands were based on design drawings and information provided by Council. The depth of the sedimentation area within Grange Lakes was based on a review of available survey and invert levels of the downstream culverts.

The model has been configured to allow interrogation of pollutant concentrations and loads at key points.

7.1.2 Water quality modelling results – validation

The MUSIC model was run to understand the patterns of flow and pollutant generation within the catchment. The model was run initially using the existing level of development. This allowed comparison of the modelling results with the water quality gauge located downstream of the Kirkcaldy wetland. The results of the modelling are summarised in Table 7.4, with a comparison to the recorded flows and pollutant loads. As would be expected, the recorded water quality parameters are highly variable. The maximum and minimum values for the period with records available (2013 to 2018) are provided as well as the value for 2017, which is considered to be an average rainfall year with 414 mm of rainfall recorded at the Adelaide Airport gauge (compared to the average annual rainfall of 437 mm).

Table 7.4 Modelled annual loads at Kirkcaldy wetland (existing level of development)

Parameter	Loads at gauge	Recorded range 2017 value (max min)
Flow (ML/a)	739	753 (306-1572)
TSS (kg/a)	61,400	35,900 (11,200 – 136,800)
TP (kg/a)	178	140 (50 – 330)
TN (kg/a)	1,310	1,200 (350 – 2,700)
GP (kg/a)	8	Not recorded

Acknowledging the highly variable nature of water quality, and the relatively simplistic approach used in building a MUISC model, with catchment loading based on limited available data, it is considered that there is good agreeance between the modelled results and the data recorded at the gauged site (refer Table 2.4).

As such it is considered that the parameters adopted within the modelling are appropriate for assessing the relative improvement provided by the proposed water quality improvement scenarios.

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Aerial imagery from City of Charles Sturt, 2019

WEST LAKES STORMWATER MANAGEMENT PLAN
MUSIC MODEL CONFIGURATION

Figure 7.1

7.1.3 Water quality modelling results – long-term development

The MUSIC model was then run for the entire catchment (long-term development scenario), incorporating the existing water quality improvement measures. The results of the modelling at the downstream receiving node are summarised in Table 7.5. The source loads represent the pollutant generation within the catchment area, while the residual loads are the loads that arrive at West Lakes (i.e. with the existing water quality improvement measures in place). These results form the baseline against which the effectiveness of proposed water quality improvement measures have been assessed.

Table 7.5 Modelled annual loads at downstream receiving node (long-term development scenario)

Parameter	Sources	Residual load	Reduction (%)
Flow (ML/a)	4,840	4,550	6.1
TSS (kg/a)	1,040,000	698,000	32.6
TP (kg/a)	2,110	1,520	28.2
TN (kg/a)	10,200	7,730	24.0
GP (kg/a)	228,000	105,000	54.1

A breakdown of the estimated pollutant loads at the downstream end of each major sub-catchment is provided in Table 7.6.

Table 7.6 MUSIC base case model – annual loads by sub-catchment

Catchment	Flow (ML/a)	TSS (kg/a)	TP (kg/a)	TN (kg/a)	GP (kg/a)
Henley Grange	957	179,000	372	1,790	33,100
Meakin	706	135,000	278	1,400	29,200
Trimmer Parade	870	188,000	378	1,810	41,100
West Lakes Central	138	29,600	60	288	6,550
West Lakes East	468	102,000	204	977	22,000
West Lakes North East	80	16,300	33	164	3,490
West Lakes Shopping Centre	88	18,600	49	277	3,750
West Lakes South	178	23,400	52	260	2,450
West Lakes West	649	112,000	238	1,130	17,200

7.2 Water quality improvement strategies

Opportunities for improving the water quality of runoff within the catchment, thereby decreasing the export of pollutants into West Lakes and subsequently the Port River, have been considered as part of the development of stormwater management strategies within the SMP.

The recommended measures for areas of existing development have been developed in the context of the heavily developed nature of the catchment, with limited 'free' open space available for the implementation of WSUD. The measures, which comprise both structural and non-structural measures are also consistent with Council's Biodiversity Action Plan for Water and Aquatic.

Where there are large scale new developments (land division creating 20 or more residential allotments), consistent with the requirements under the State's new Planning and Design Code, Council should require developers to produce a stormwater management plan which demonstrates mitigation of peak flows to pre-development levels and the incorporation of measures to achieve the specified water quality improvement targets.

7.2.1 Additional gross pollutant traps

There are a number of gross pollutant traps (GPTs) installed within the study area, including on the main discharge points into West Lakes. However, review of the existing infrastructure identifies that not all discharge points have a GPT installed.

The installation of additional GPTs at outlet points which are not currently treated is recommended to further reduce the residual load of gross pollutants that are discharged into the Lake, thereby addressing Goal WQ1. Locations where there are Council owned pipes discharging into the Lake, and where there is currently no GPT are summarised in Table 7.7. The locations of the proposed GPTs are shown in Figure 7.2.

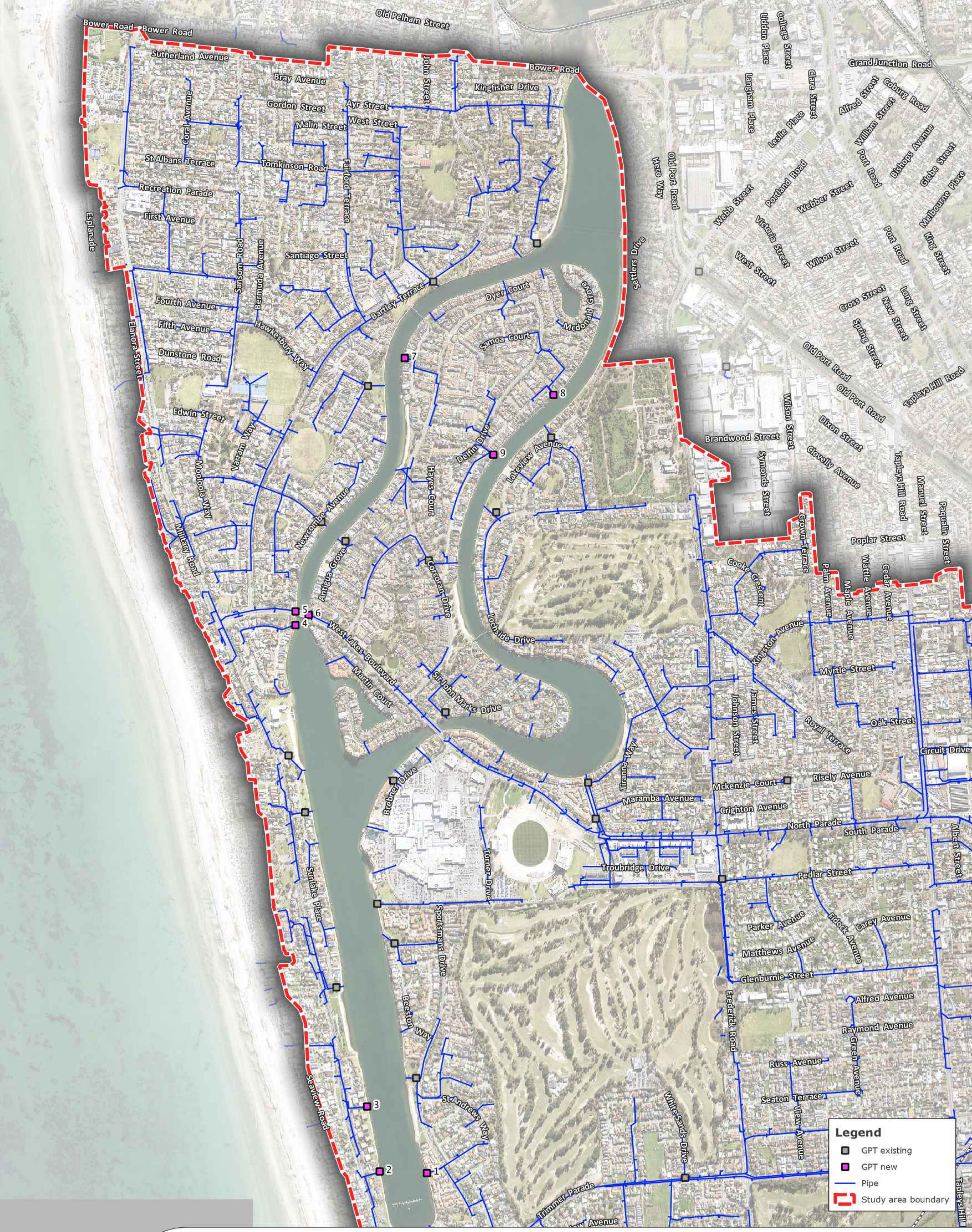
Actual placement of each GPT would be subject to further design development which would need to consider issues such as access for maintenance and the hydraulic impacts on the upstream stormwater network.

The theoretical maximum removal of gross pollutants, as listed in Table 7.7, is based on high-flow GPT units with all pipe flows being directed to the GPT. The assumed pollutant removal efficiencies are based on manufacturer's specifications. The actual reduction in gross pollutants achieved will be dependent on the GPT model selected for each location, the maximum treatable flow rate and maintenance of the units.

Table 7.7 Recommended locations for the installation of GPTs

GPT	Location	Maximum GP removal* (kg/year)
GPT1	Opposite Hoylake Crescent	750
GPT2	Opposite Hallam Terrace	290
GPT3	Near Libby Court	680
GPT4	Annie Watt Circuit	335
GPT5	West Lakes Boulevard bridge	780
GPT6	West Lakes Boulevard bridge	105
GPT7	Near Hayman Court	985
GPT8	Hawaii Court	1,175
GPT9	Between Nareeda Way and Capri Close	835

* Based on 100% of flows in pipe going through the GPT, with 99% removal of GP as per typical manufacturer's specification



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0 500 1,000 1,500 m

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WEST LAKES STORMWATER MANAGEMENT PLAN
PROPOSED GROSS POLLUTANT TRAP LOCATIONS

Figure 7.2

7.2.2 Street scale infiltration measures

Street scale infiltration measures promote the beneficial reuse of stormwater via passive irrigation (addressing Goal RU2). Designed to capture low flows, either directly from roof areas or from surface areas, street scale infiltration measures reduce the volumes of flows and associated loads of sediments and nutrients discharged to receiving waters (addressing Goal WQ1). They also contribute to urban greening with associated improved aesthetics and offsetting of urban heat island effects. The magnitude of the benefits of each infiltration system will be heavily dependent on the size and configuration of the system in addition to the size and characteristics of the contributing catchment.

Street scale infiltration measures can be implemented in a range of forms including:

- simple openings in kerbs
- infiltration pits and wells
- tree pits (with and without connection to the stormwater network)
- infiltration trenches.

Water Sensitive SA have case studies demonstrating the application of a range of infiltration measures that have been implemented by councils across metropolitan Adelaide. Further details on some of the measures that have been implemented are provided in the following sections. When considering which type of system is best suited to application in the West Lakes SMP study area considerations should include contributing catchment, geotechnical conditions, available space, species of vegetation and existing stormwater infrastructure.

City of Burnside B-Pods

As part of the City of Burnside's commitment to water sensitive urban design, they have trialled a number of small-scale, subsurface retention systems to capture and retain water from roof runoff. The water is then allowed to infiltrate, providing passive irrigation to roadside vegetation. In addition to promoting urban greening, the pods also contribute to a reduction in the flow rates and volumes of stormwater being discharged to the receiving environments. Photos of Burnside's B-Pods are provided in Figure 7.3.

Figure 7.3 Burnside Council's B-Pods (watersensitivesa.com)

Tree pits and infiltration trenches

Tree pits divert gutter flows to an infiltration storage to provide passive irrigation of vegetation, whilst also reducing stormwater discharges to the receiving environments. A variety of tree pits have successfully been adopted by metropolitan councils in South Australia. TREENET pits have been used to promote street tree health across the City of Mitcham. City of Adelaide have installed tree pits at over 100 locations to sustain tree health. Photos showing examples of tree pits are provided in Figure 7.4. Where space permits, water may be diverted to infiltration trenches (refer Figure 7.5).

Figure 7.4 TREENET Pit inlet and infiltration pit (City of Mitcham, watersensitivesa.com) and City of Holdfast Bay (https://www.yourholdfast.com/wsud)

Figure 7.5 Infiltration trench, supporting roadside vegetation in Colonel Light Gardens (watersensitivesa.com)

7.2.3 Street scale biofiltration (raingardens)

Raingardens are shallow, planted depressions that provide water quality improvement benefits via biofiltration mechanisms. Raingardens can be implemented at a range of scales from individual residential blocks up to the treatment of whole of catchment flows. Similar to tree pits and infiltration trenches, raingardens reduce flow rates and volumes (particularly during frequent flow events) and also contribute to a reduction in the quantity of sediment and nutrients exported to receiving waters (thereby addressing goals WQ1 and RU2). Secondary benefits are associated with increase greening, improved aesthetics and urban cooling.

Typically constructed within verges or roads, streetscape raingardens receive gutter flows via gaps in the kerbing. Flows are then allowed to pond and infiltrate. A high-level overflow may be provided to discharge flows exceeding the storage capacity of the raingarden into the underground drainage network. Depending on the local soil conditions, raingardens may also include a slotted pipe to collect filtered flows and discharge them into the underground drainage network.

Raingardens are best suited to areas that have relatively flat grades and wide streets, making them well suited to some of the residential areas within the West Lakes SMP study area. Council has already installed a number of rain gardens across their Council area, including in Flinders Park. Raingardens can be retrofitted into existing roads and can be incorporated into road upgrades and traffic calming measures. A typical layout for a streetscape raingarden is illustrated in Figure 7.6.

DesignFlow (2016) estimated that the area of a raingarden required to achieve the State Government's stormwater treatment targets can be approximated as 0.7% of the impervious area of the contributing catchment. Raingardens of a smaller size will still provide some water quality treatment.

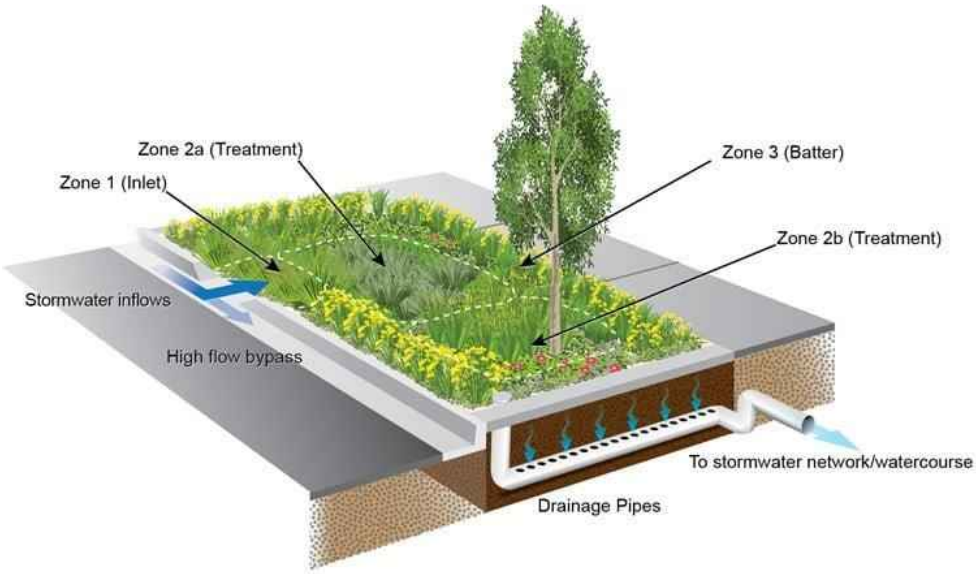

Figure 7.6 Typical layout of a raingarden (Water Sensitive SA)

To test the potential effectiveness of streetscape raingardens within the West Lakes catchment, additional MUSIC modelling was undertaken, incorporating raingardens within a single test catchment (West Lakes West). This catchment has a directly connected impervious area of approximately 165 ha, and hence the work of DesignFlow (2016) estimates that raingardens with a total area of 1.2 ha would be required to achieve the State water quality targets. A single bioretention node at the downstream extent of the West Lakes West catchment was incorporated in the modelling. The modelled treatment effectiveness of the raingardens is summarised in Table 7.8. It can be seen that the construction of 1.2 ha of raingardens results in a significant reduction in pollutants discharged from the catchment, although the raingardens alone do not achieve the specified targets.

Table 7.8 Modelled treatment effectiveness of raingardens for West Lakes West catchment

	Inflow	Outflow	% reduction
Flow (ML/yr)	933	908	2.7
Total Suspended Solids (kg/yr)	206,000	116,000	43.6
Total Phosphorus (kg/yr)	413	281	32.0
Total Nitrogen (kg/yr)	1,950	1,390	28.8
Gross Pollutants (kg/yr)	42,200	22,000	47.8

Consistent with Council's Biodiversity Action Plan (2017), it is recommended that Council implements a policy that requires all planned capital work upgrades to consider opportunities for incorporating raingardens and other WSUD elements into the works. This will provide water quality benefits in addition to greater urban greening across the study area. The level of water quality improvement achieved will be dependent on the size of the raingarden relative to the upstream catchment.

During the detailed design phase, it will be necessary to consider additional site constraints, including:

- Traffic considerations (sight distances, turning circles etc.)
- Impacts arising from the loss of parking spaces
- Property access