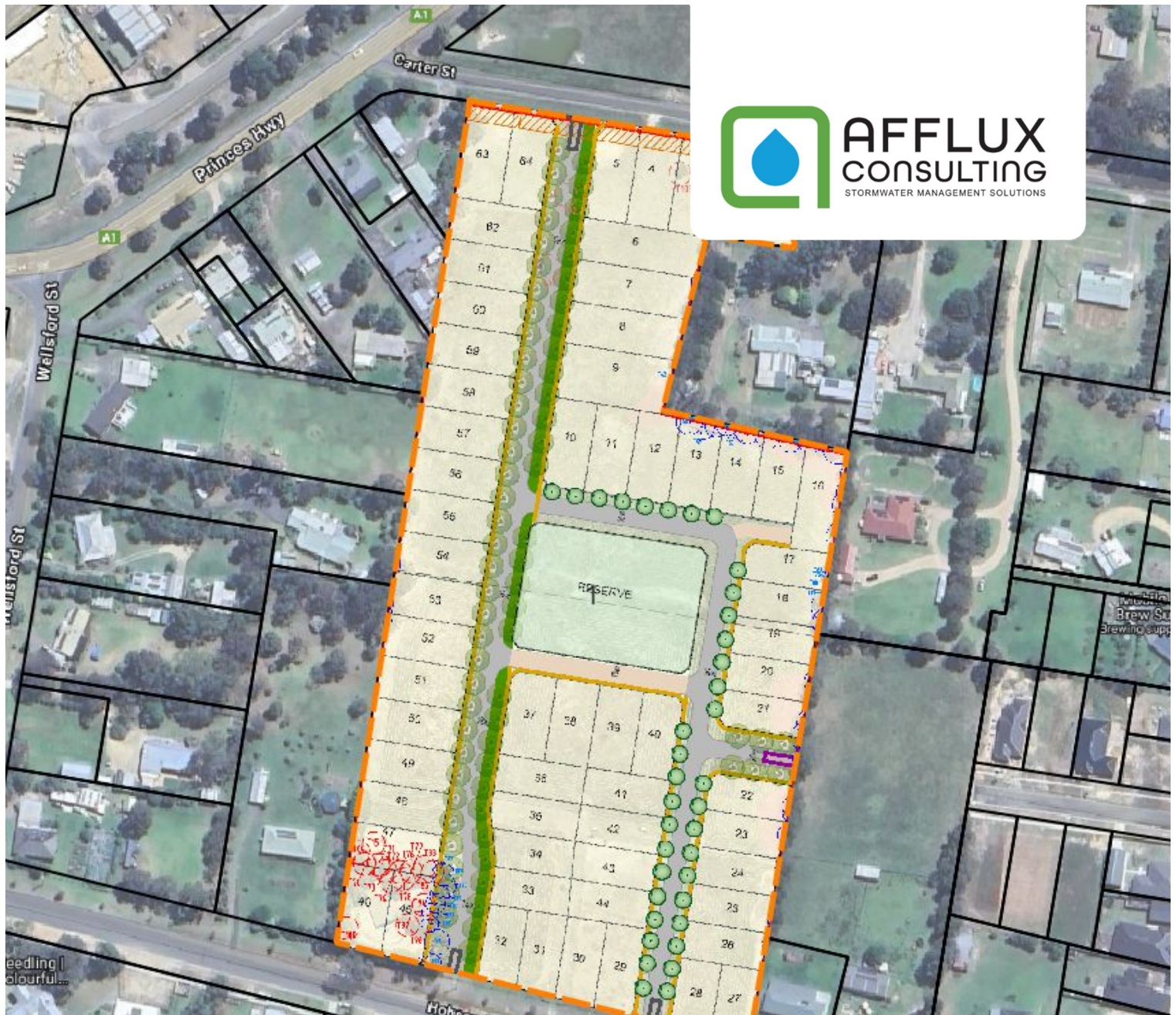




STORMWATER MANAGEMENT PLAN

18 Carter St, Stratford

Date 17 May 2024

Project No. 740

Version 03

Author 

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01	03/04/2024	Initial assessment report
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Climate Change Statement

A wide range of sources, including but not limited to the IPCC, CSIRO and BoM, unanimously agree that the global climate is changing. Unless otherwise stated, the information provided in this report does not take into consideration the varying nature of climate change and its consequences on our current engineering practices. The results presented may be significantly underestimated; flood characteristics shown (e.g. flood depths, extents and hazards) may be different once climate change is taken into account.

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1. Introduction

Afflux Consulting have been engaged by Millar Merrigan to complete a stormwater management plan for the proposed development at 18 Carter St, Stratford (Figure 1). This will cover the major drainage, flooding and water quality associated with the development. It will include an assessment of associated stormwater drainage assets, regional overland flow paths and stormwater conditions within neighbouring properties. The intention of this report is to:

- Provide an assessment of major drainage and flooding associated with site;
- Retention of post development flows to pre-development levels;
- Ensure flooding of the site, or potential off-site impacts are reduced or eliminated;
- Ensure safe conveyance of existing overland flow regimes, if required;
- Meet the EPA best practice environmental management (BPEM) water quality requirements;
- Inclusion and consideration of guidelines and advice for stormwater management in line with Wellington Shire Council and WGCMA requirements; and
- Identification of mitigation and treatment options, if required.

To meet these requirements a range of hydrological, hydraulic and water quality modelling has been undertaken.

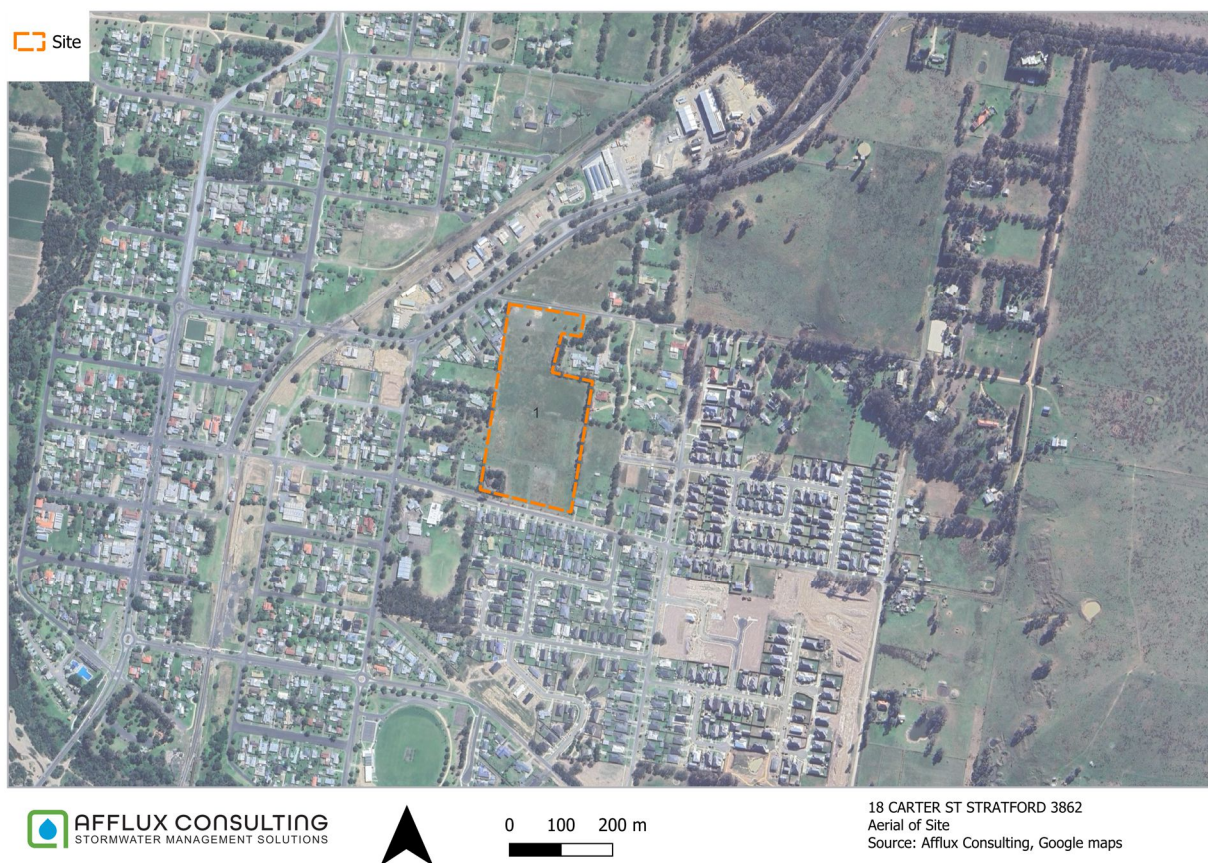


Figure 1. Aerial of site



Source: Millar Merrigan

Figure 2. Proposed Development

1.1. Information Sources

A number of information sources have been used in the formation of this strategy; these include:

- Site inspection
- Aerial imagery
- DEPI planning scheme and cadastral information as accessed online 07/02/24
- Design Guidelines and Guidelines for Development
- Various Environmental Planning instruments and Planning Frameworks
- Preliminary plans and Site survey received from client
- Past models and existing infrastructure information
- Historic flood and water quality studies
- Topographic information including required LiDAR data sourced commercially.

2. Existing Catchment

The existing catchment was delineated for the site and site outlet. The site is very close to the top of several local catchments as can be seen Figure 3. The broader catchment drains southeast towards the Avon River system and consists primarily of existing residential area. The 6-hectare development site is currently undeveloped land.

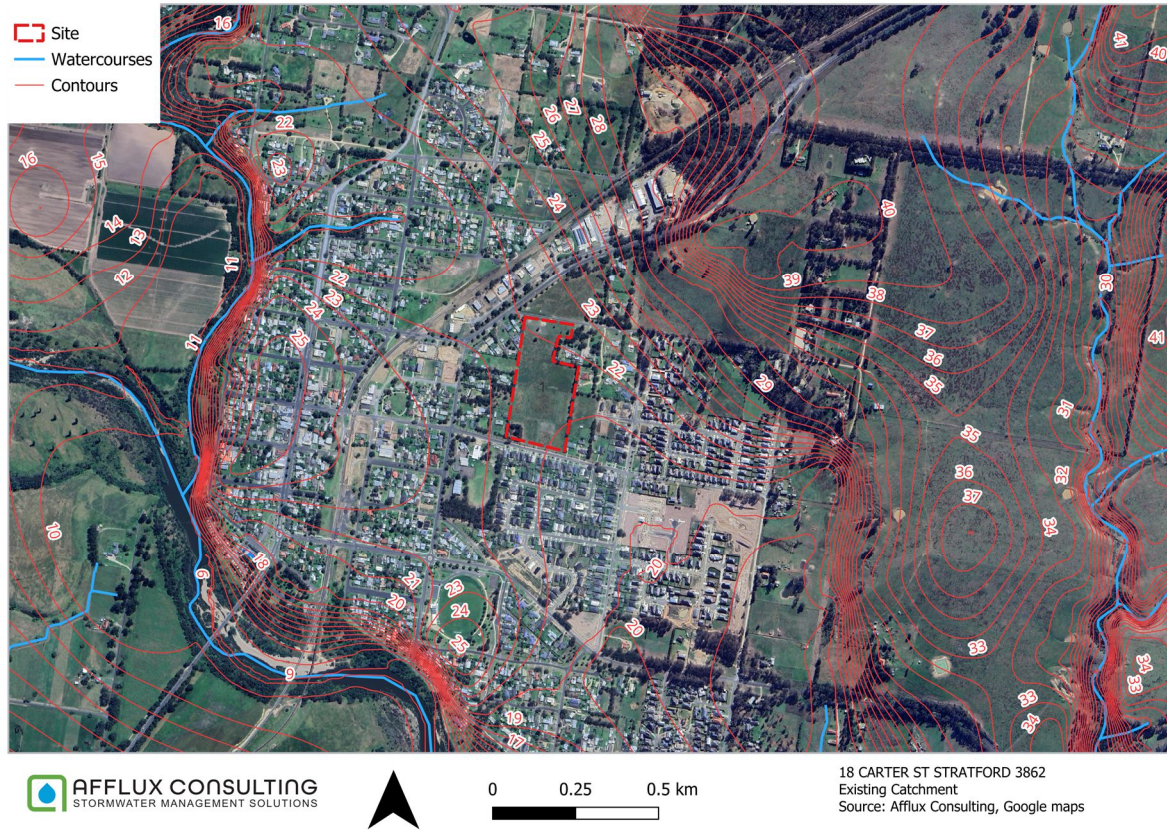


Figure 3. Existing catchment

3. Catchment Design Objectives

All development has the potential to adversely affect downstream environments through the effects of stormwater runoff. Increased impervious areas resulting in increased volumetric and peak flows have been extensively researched and linked to downstream environmental degradation. Contaminants in the runoff have also been linked with adverse changes to water quality and stream ecology. The contribution of increased runoff can be linked to downstream flooding and capacity constraints.

To combat these effects, a range of hydrological and water quality mitigation measures have been researched and legislated. The design objectives for this catchment are considered below.

3.1. General Considerations

The Victorian State Planning Policy Framework includes provisions incorporating the provisions for stormwater management in its integrated water management clauses. As part of its planning requirements, the council incorporates BPEM water quality targets, setting out objectives for stormwater runoff.

3.2. Water Quality Requirements

Current water quality guidelines require developers to ensure that water quality for the site meets best practice load-based reduction targets when compared with the unmitigated developed scenario. As listed by the Victorian EPA Best Practice Environmental Management (BPEM) Guidelines (1999), the development must meet the following:

- 80% Total Suspended Solids (TSS) reduction
- 45% Total Nitrogen reduction
- 45% Total Phosphorus reduction
- 70% Gross Pollutant capture

These water quality requirements will be met in water quality treatment recommendations as part of this development.

3.3. Flood Storage Requirements

The development shall be designed to ensure that flows will not increase above the pre-development levels. Generally, this would be applied to only the 1 % Annual Exceedance Probability (AEP) storm and checked at each site discharge point. Attenuation would be applied at an onsite detention, and reductions in flow peak would be determined at the outlet of the basin. The size and/or requirement of any on-site detention beyond the scope this report and would form part of a site stormwater management plan.

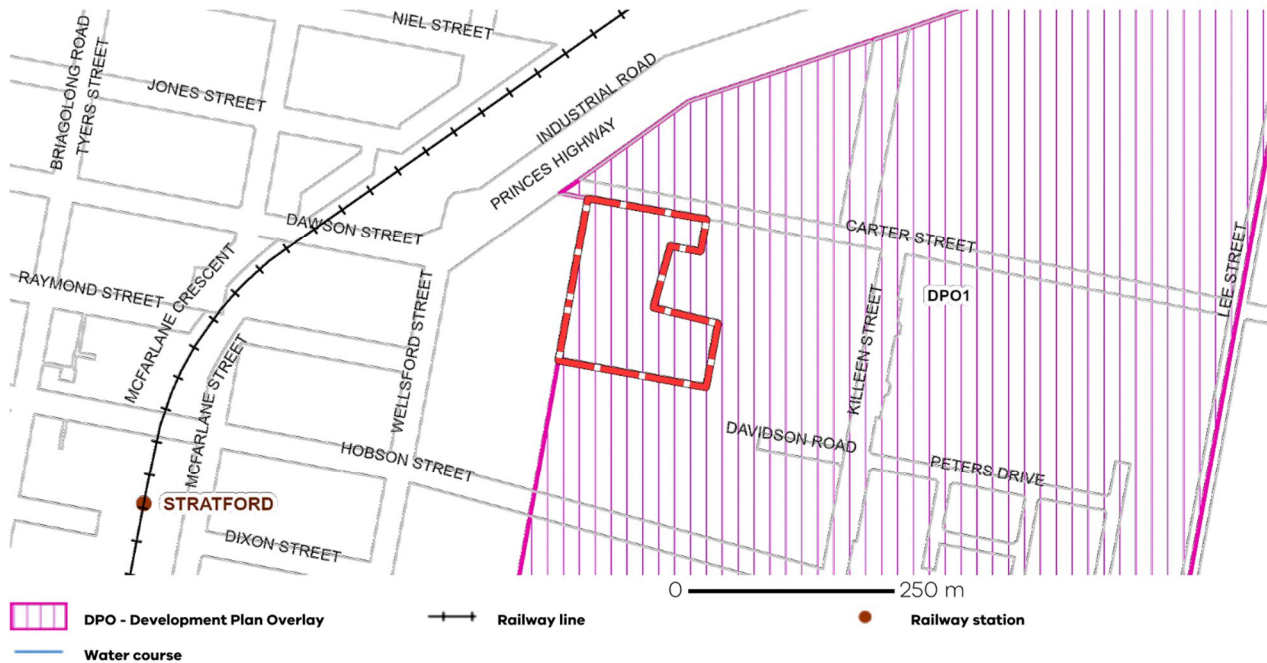
3.4. Flood Protection Requirements

All lots within the development will be provided at least 300 mm freeboard above any predicted 1 % Riverine AEP flood level (with floors a further 300 mm higher). West Gippsland CMA apply a standard 300mm freeboard to all flood levels.

3.5. Additional Planning Controls

3.5.1. Planning Overlays

The development parcel does not have any flood-related overlays. The site is encumbered with a Development Plan Overlay (DPO) as shown in Figure 4, which must be considered during the development process.



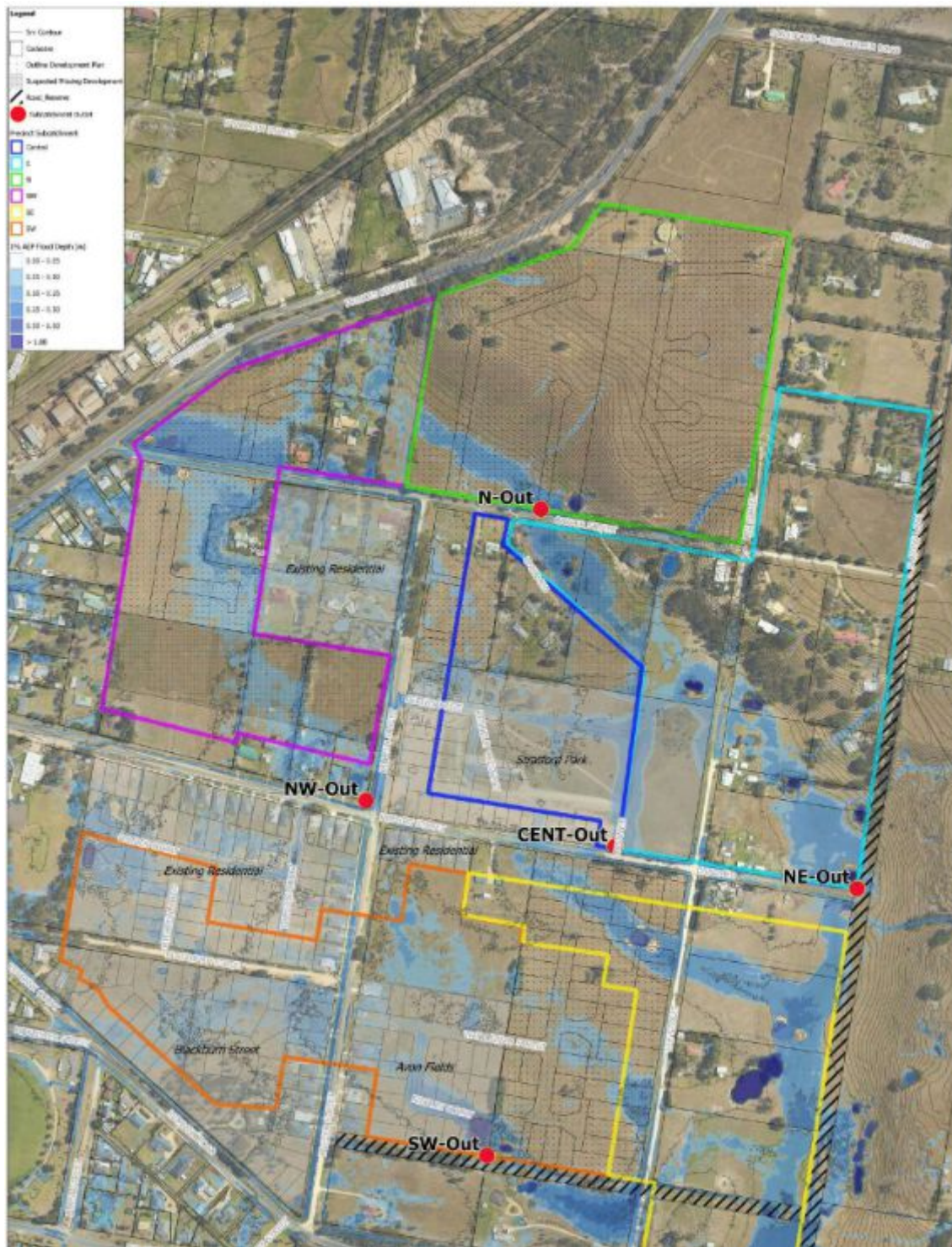
Note: due to overlaps, some overlays may not be visible, and some colours may not match those in the legend

Source: Excerpt from the Victoria Environmental, Land, Water and Planning Property Report

Figure 4. Planning Overlays

3.5.2. East Stratford Drainage Investigation

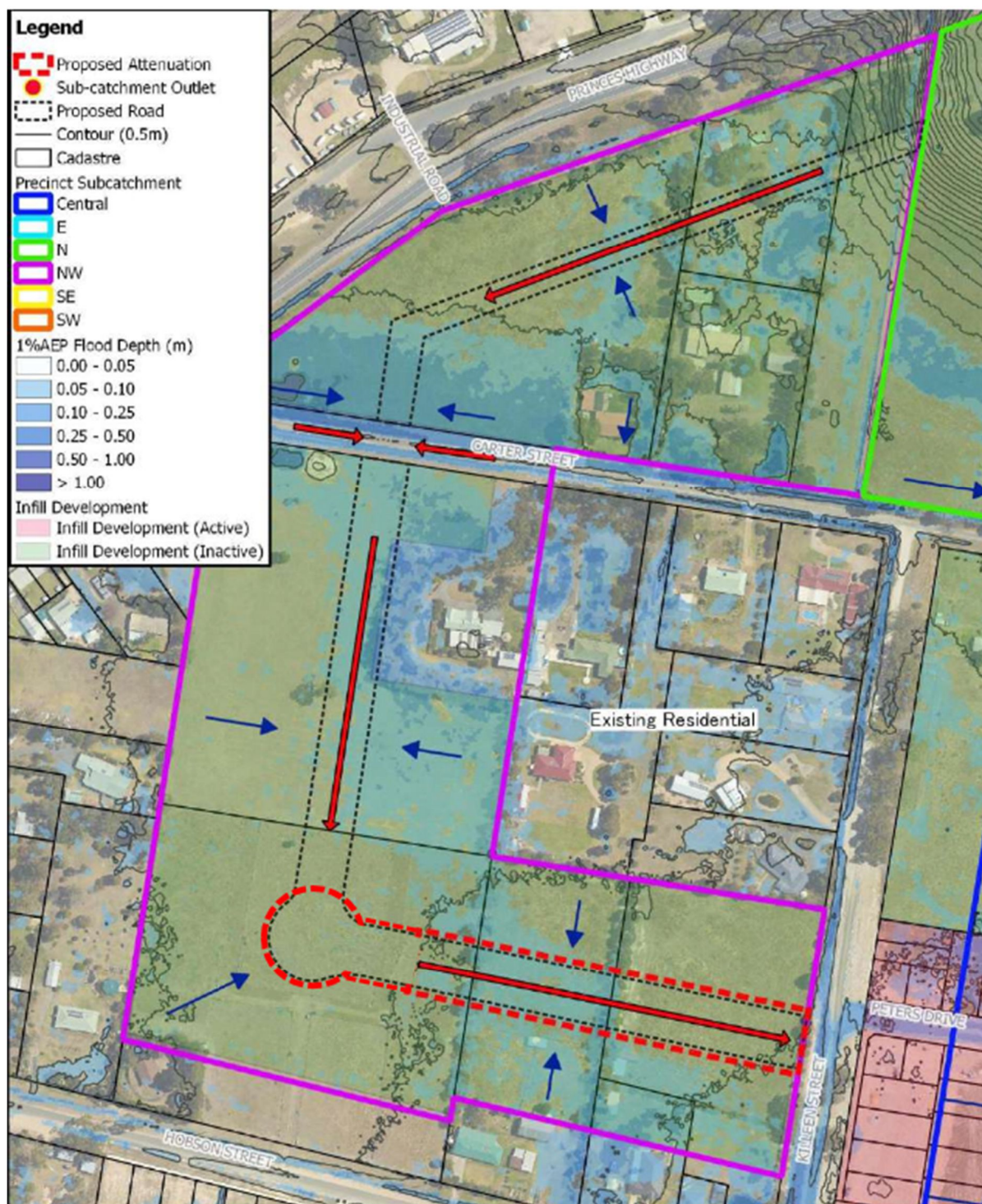
A drainage investigation of East Stratford was completed by Water Technology (WT) for Wellington Shire Council in 2020. This report used flood modelling to investigate potential impacts of proposed development on existing drainage infrastructure in the area. A new drainage strategy is introduced, including both centralised and de-centralised methods to mitigate flood risk. Figure 5 shows the catchment delineation introduced in the report, the relevant sub-catchment being the North-West catchment for this particular site (within purple catchment (NW) below). Note that this catchment is larger than the development site but still provides relevant information about stormwater flow.



Source: Water Technology, 2020

Figure 5. Drainage Investigation Catchment Delineation

Within the north-west catchment, the report suggests that overland flows are conveyed from the north to the south-east into a road attenuation system (presumably underground). This is shown in Figure 6 below.



Source: Water Technology, 2020

Figure 6. Northwest Catchment proposed attenuation

Whilst some of the catchment in this drainage strategy lies outside the development site, the relevant sections should be considered during the design and development of the proposed site, and its implications are discussed in a subsequent section.

3.6. Specific Concerns for This Site

Based on the review of the catchment, and listed objectives and requirements the following stormwater elements should be considered for this site:

- Managing flood extents and ensuring no worsening conditions on adjacent properties
- Surrounding existing development constraints
- Water Quality treatment options
- Appropriate attenuation as required to mitigate peak flows and reduce flooding at Corner of Killeen and Hobson Street.
- Drainage strategy to be in-line with the regional council drainage strategy (WT, 2020) and the Design and Development Overlay.

4. Hydrology

To evaluate the hydrology of the proposed development a number of hydrological models have been formed and compared. Primarily a DRAINS model has been built to represent the pre and post development hydrology. This section describes the model and its outputs.

4.1. Sub-Catchment Delineation

Sub-catchments are grouped by examining the drainage asset locations and expected flow direction. Generally, the sub-catchment delineation for developed areas follows catchments of main drainage lines so that the pipe network is accurately modelled. The imperviousness level adopted for most developed catchments ranges and is checked against aerial imaging. Catchment delineation for undeveloped areas is governed predominantly by topography. Therefore, impervious levels adopted are often lower. FI values may deviate from previous investigations due to new developments in the area.

For this site, the sub-catchment delineation for this area is shown in Figure 7, with the fraction impervious (FI) summarised in Table 1. The main drainage asset is the trunk drain along Killeen St, on the eastern border of Catchments C and E. The Water Technology drainage investigation confirms that the delineated sub-catchments all drain towards Killeen St.

The only change between existing and developed conditions is the FI for catchment B, where the proposed development is located. Other sub-catchments are not included in the proposed development, so their FI remains unchanged in the modelling. The site outlet was chosen to assess the site flow as it represents the amount of stormwater runoff flowing off the development site. This includes runoff from catchment A and B.

The site outlet is shown in Figure 7 and is represented in the DRAINS model by the link 'OF119', as shown in Figure 8.

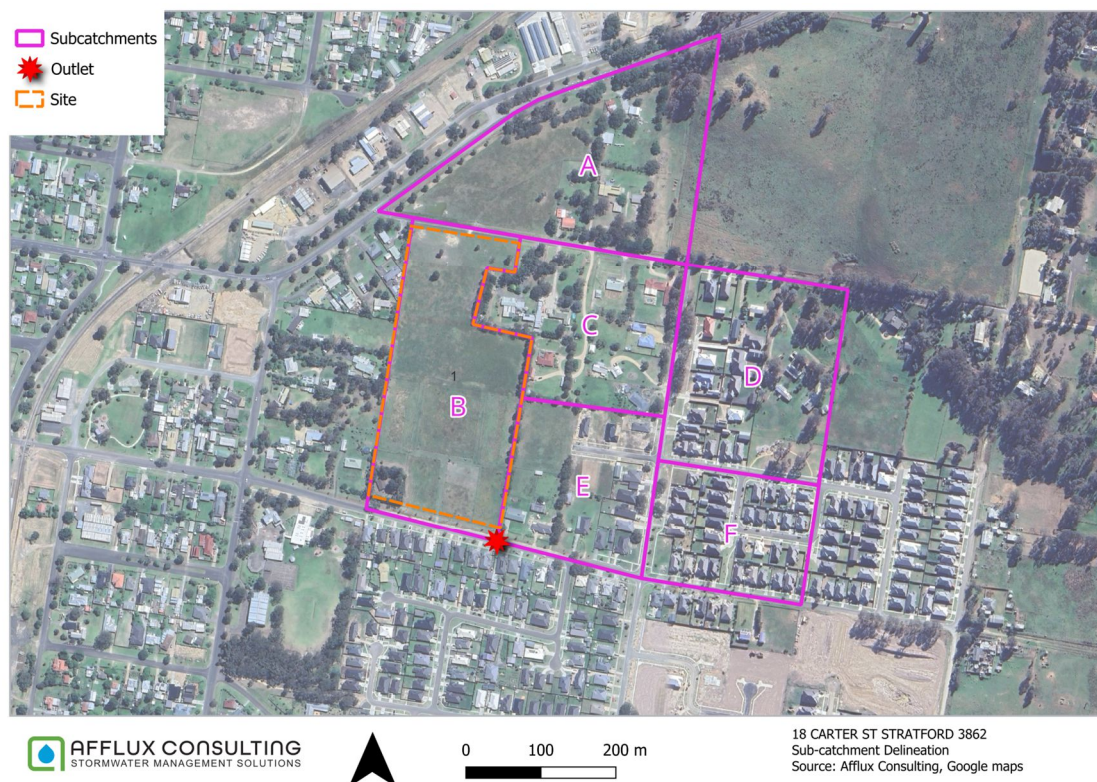


Figure 7. Sub-catchment Delineation

Table 1. Sub-catchment characteristics

Catchment Name	Area (ha)	FI (existing)	FI (developed)
A	7.41	0.2	N/A
B	6.46	0.05	0.8
C	4.77	0.3	N/A
D	5.73	0.6	N/A
E	4.03	0.5	N/A
F	3.48	0.8	0.8

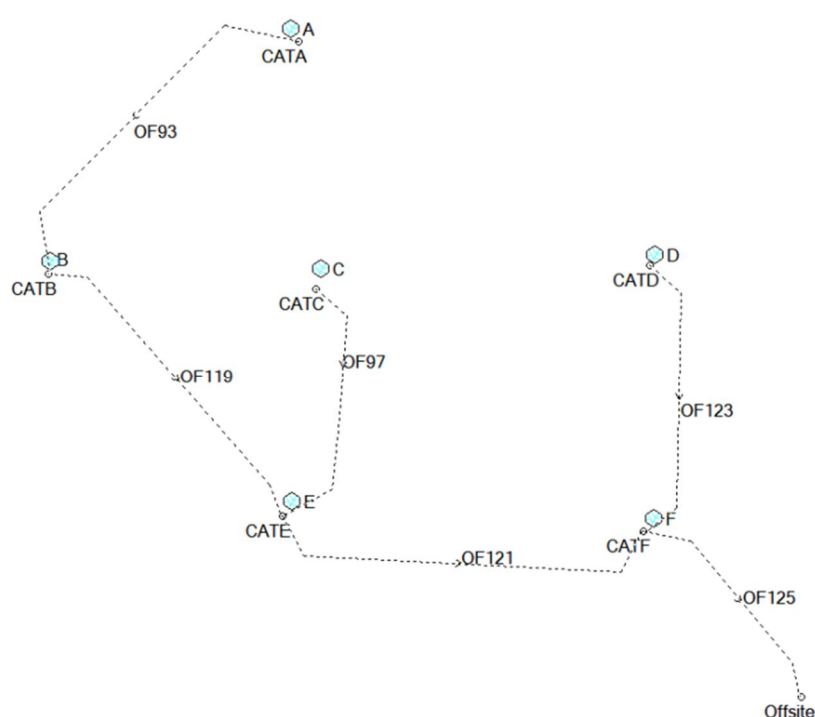


Figure 8. Representation of existing DRAINS model

4.2. Rainfall Information

Rainfall depths were extracted from the BoM IFD database. The temporal rainfall patterns were taken from the ARR Data Hub as per guidelines, and as shown below, Southern Slopes VIC/NSW data set was applicable for this site as shown in Figure 9.

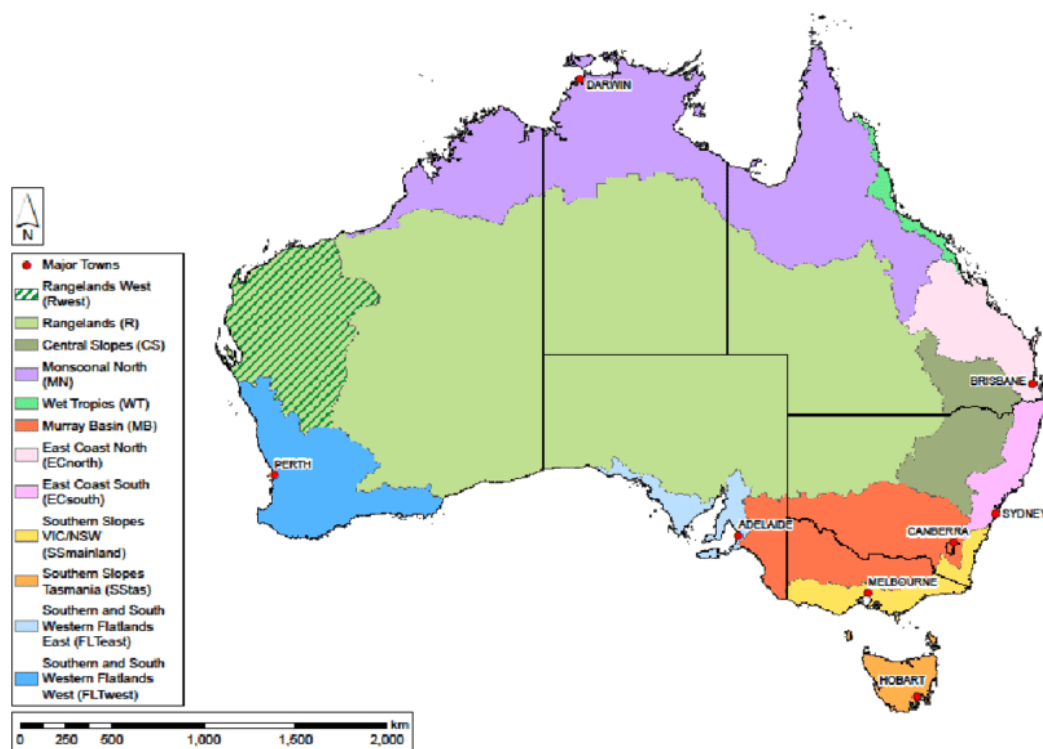


Figure 9. Map of temporal pattern regions

4.3. Rainfall Losses

In addition, the ARR Data Hub provides recommendations for losses as shown below in Figure 10 and Figure 11. The ARR19 tool estimates losses and reductions using the information from Data Hub. The supplied loss file was found to be suitable with loss factors appropriate to the catchment, given the predominantly rural catchment. The rainfall intensities for the site are shown in Figure 12. The specific characteristics chosen for this model are summarised in Table 2.

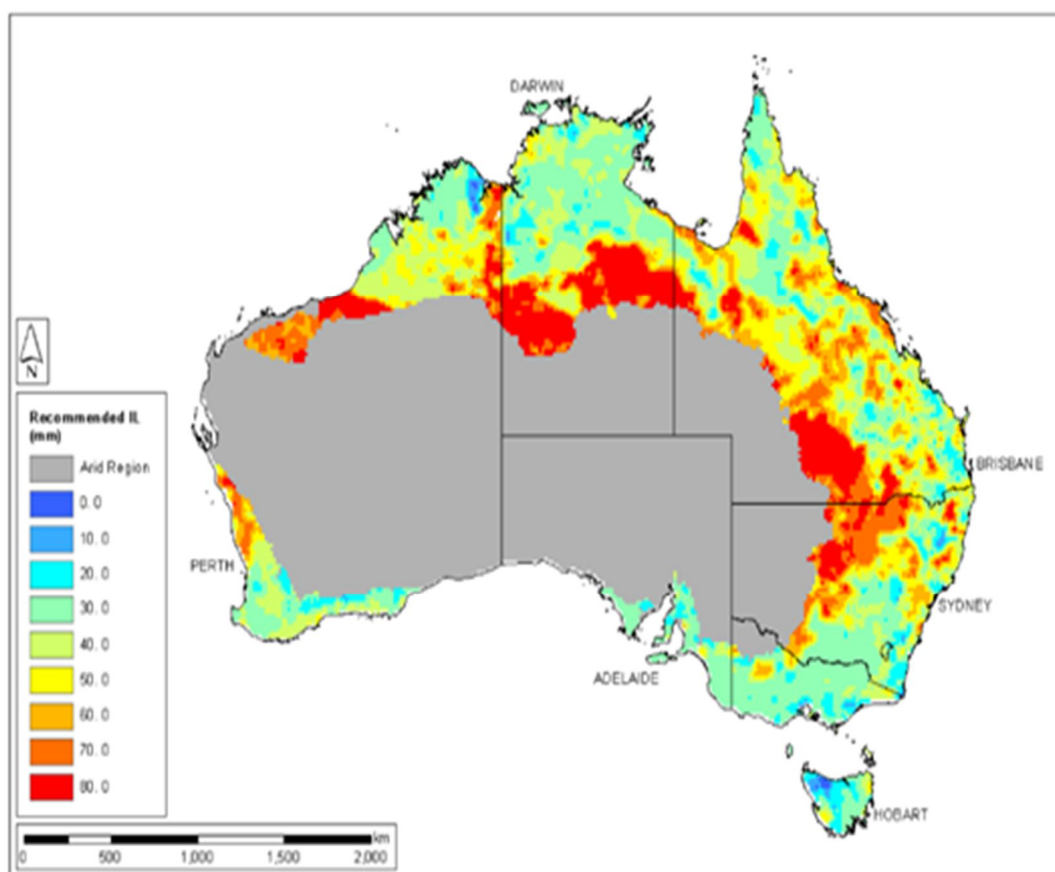


Figure 10. ARR 2016 recommended Initial Loss

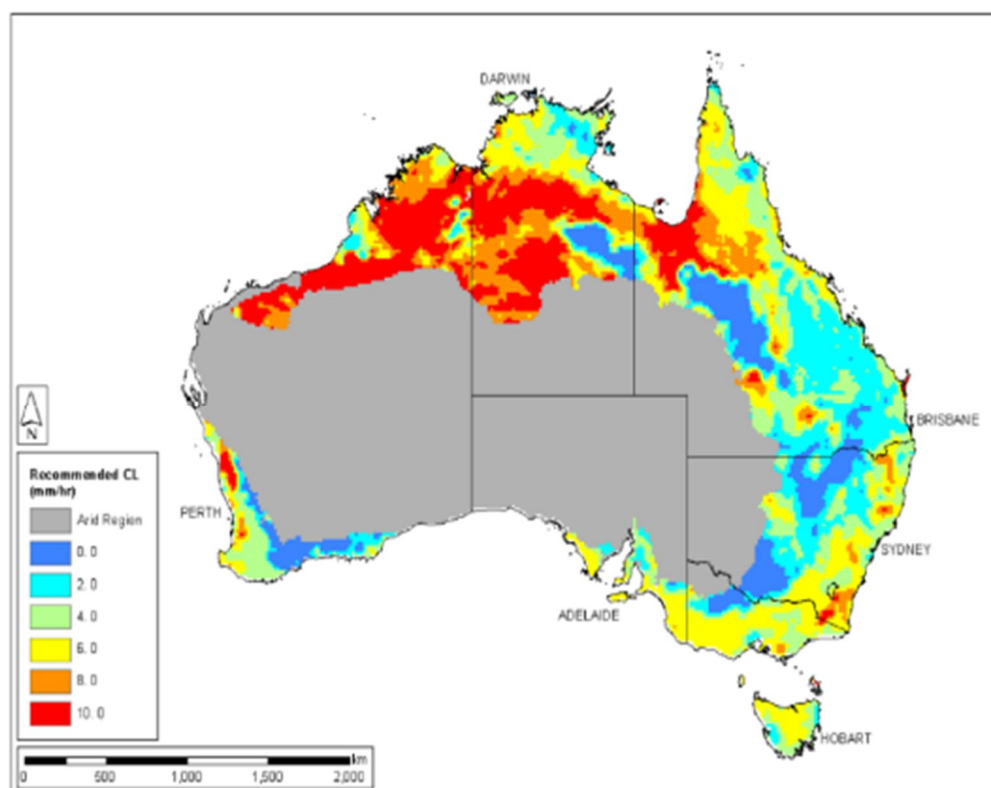


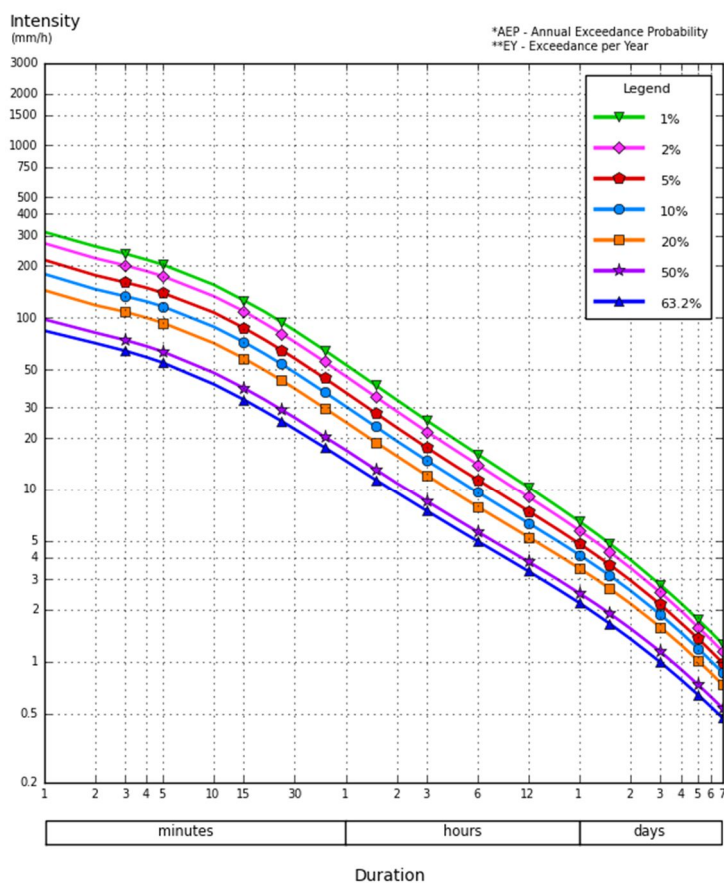
Figure 11. ARR 2016 recommended Continuing Loss

Table 2. Estimated Loss Model

Model Name	EastStratford.drn
Region	Southern Slopes
Loss Model	Initial-Continuing Loss
Impervious Losses	IL: 1 mm CL: 0 mm/h
Pervious Losses	IL: 17 mm CL: 2.5 mm/h
ARR Data Hub Location	S E (accessed 16/01/24)

4.4. Modelling Method

The site's 1% AEP (Annual Exceedance Probability) flood discharge was estimated following ARR 2019 (Australian Rainfall and Runoff, 2019) processes.



©Copyright Commonwealth of Australia 2016, Bureau of Meteorology (ABN 92 637 533 532)

Figure 12. Rainfall Intensity data (mm/hr)

The Ensemble Event approach was adopted using a set of 10 temporal rainfall patterns from gauged local catchments. The run suite included the 5-minute to 9-hour storm durations for each of the temporal patterns used to derive a set of hydrographs for the 1% AEP storm event. Each hydrograph was run through the

hydrologic model; only the mean for the critical duration storm results was selected for design as recommended.

4.5. Site Flow Results

For the purpose of assessing flood impacts from the development site, the outflow for existing and developed conditions from Catchment A and B (OF 119) are shown in Figure 13 and Figure 14. Effectively this shows the flow rates at the site outfall assuming the development proceeds.

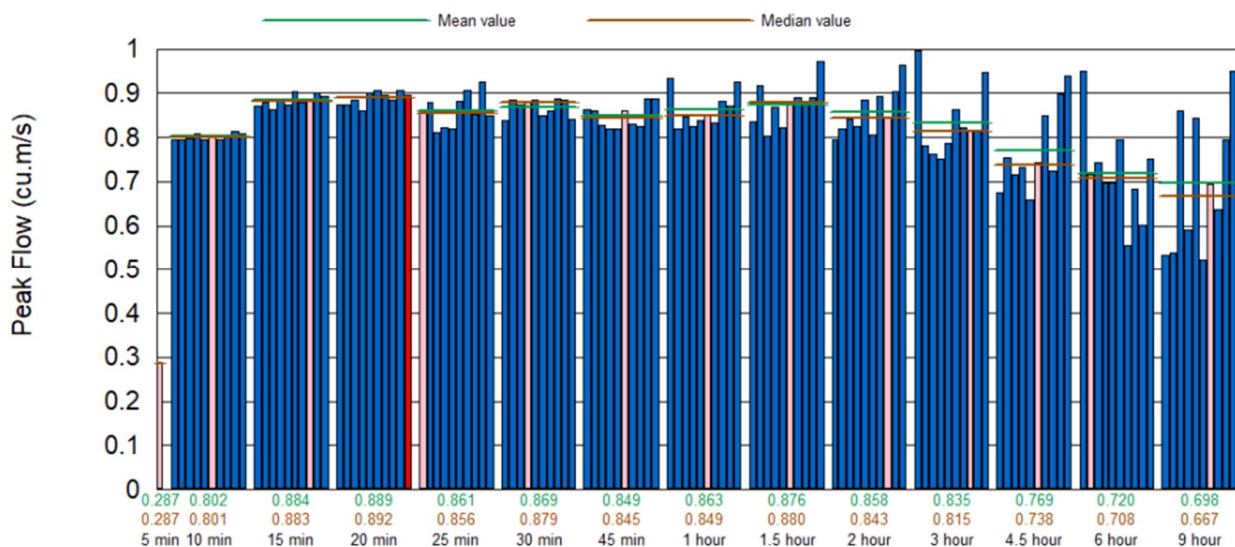


Figure 13. Mean Peak Flow Chart for OF 119 in Existing Conditions

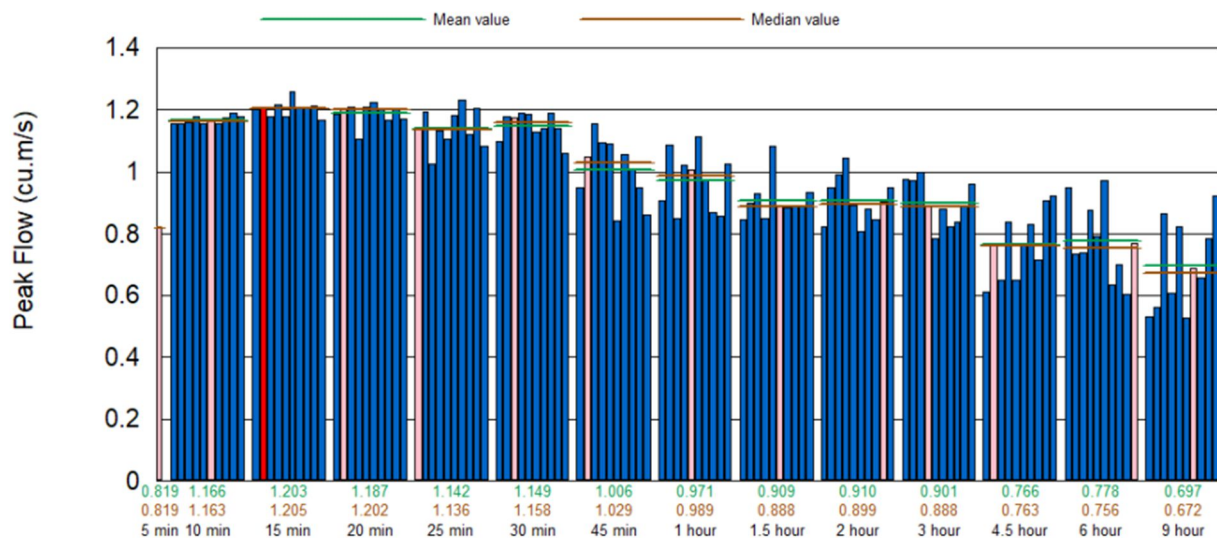


Figure 14. Mean Peak Flow Chart for OF 119 in Developed Conditions

To mitigate flood risk at this site, the outflow must be restricted to pre-development conditions. In this case, it must be reduced from 1.2 m³/s to 0.9 m³/s. This is achieved through attenuation, which is discussed in the subsequent section.

4.6. Required Attenuation Storage

Stormwater flows must be restricted to pre-development levels to mitigate flood risk between the development site and the river outfall. The East Stratford Drainage Investigation (WT, 2020) proposes an attenuation volume of 4965 (5,000) m³ for this Northwest catchment, with the following strategy objectives:

- Decrease observed flooding located at the corner of Hobson Street and Killeen Street;
- Provide continuous overland flow path to eliminate nuisance flooding in rare storm events;
- Provide stormwater attenuation to reduce pressure on the Killeen Street trunk drain;
- Provide guidance for future infill development;

(Note the WT, 2020 report does assume a reasonably high level of imperviousness)

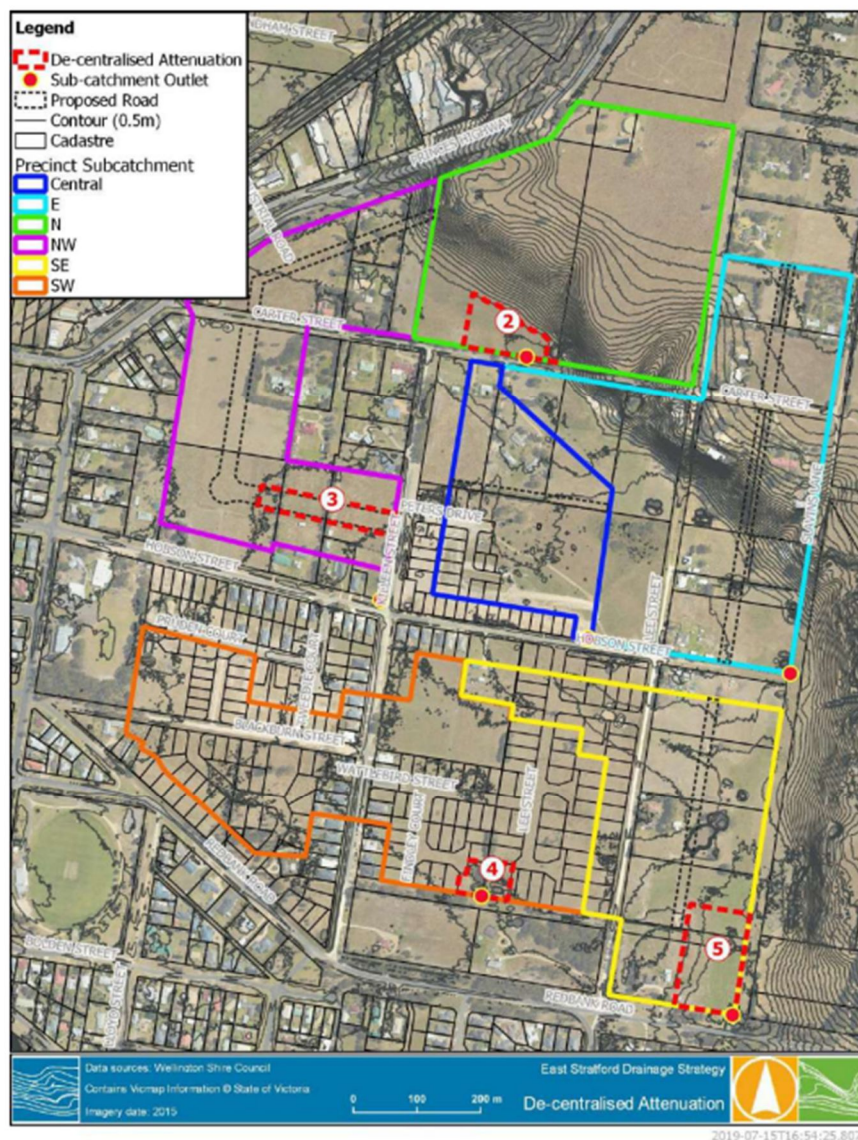


FIGURE 5-3 DE-CENTRALISED ATTENUATION

Figure 15. De-centralised Storage Option (Storage 3)

The suggested volume services the entire north-west catchment (Figure 6) which includes two parcels to the east of this site. To provide the storage and catchment objectives for the site two scenarios have been considered.

4.6.1. In-Street Storage

The WT Drainage Investigation calls for a storage of approximately 5,000m³ of below ground storage in the road network of the subdivision. The proposed layout would require the following adjustments:

- The road network and development pattern has resulted in a catchment reduction to this storage from 18.8 ha down to approximately 13.8 ha.
- That being said it is unrealistic that all of the catchments could be contained in a single road reserve. To avoid duplication of underground storages, it is suggested that a single storage be installed on the most direct flow path.
- Given the catchment reduction, a storage in the order of 3,000m³ is suggested, with associated drainage assets to convey flows.
- As an underground storage as suggested by the strategy, and for a 16m road reserve and 6m pavement, this would require:
 - 2.4x1.2m box culverts for ~0.6km
 - Or 4.8x1.2m culverts for ~0.3km.
- Whilst both options could fit within the road reserve, both the economical cost and practical considerations are expected to be insurmountable.
- Based on this, the underground storage as suggested by the strategy is not recommended, therefore drainage assets do not need to be considered.

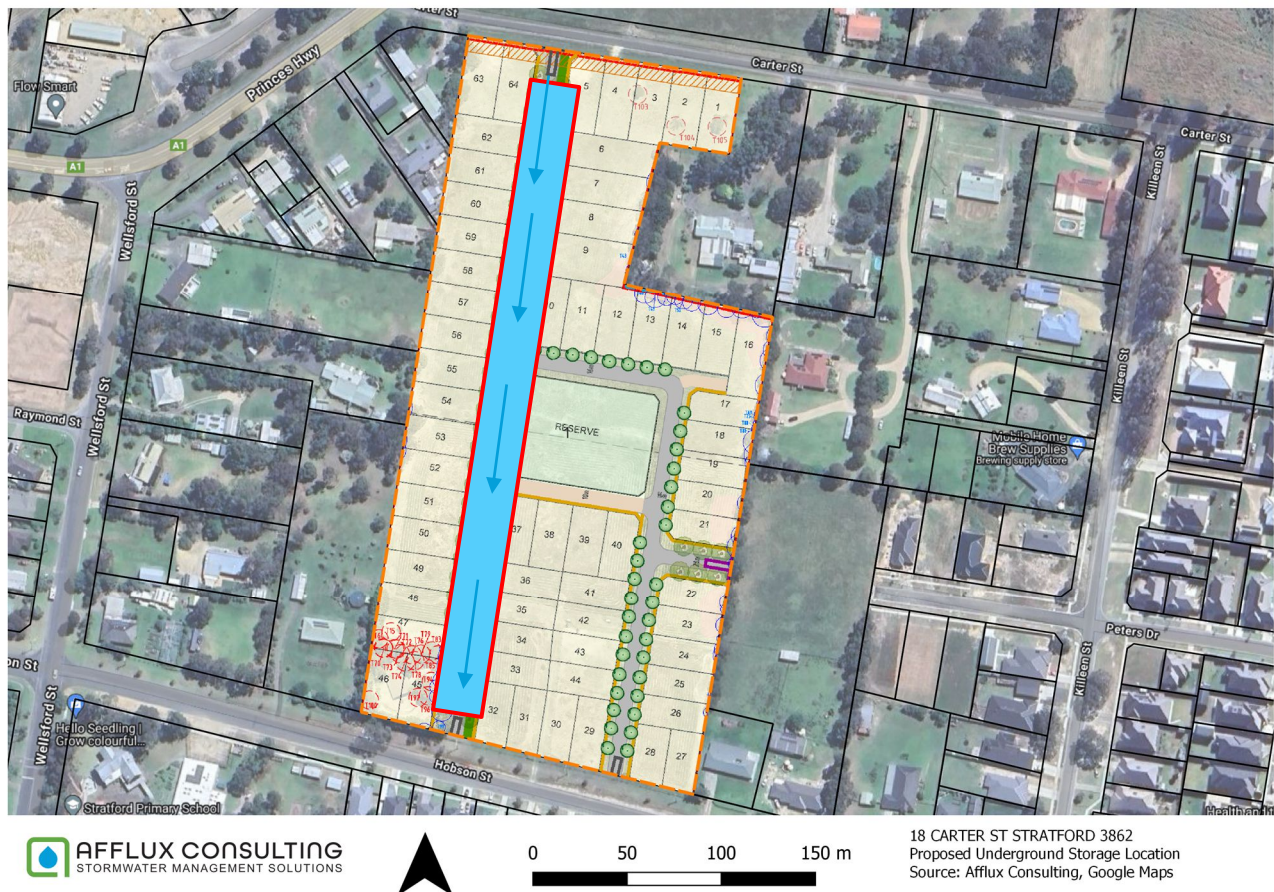


Figure 16. Proposed Underground Storage Location

4.6.2. Alternative Attenuation in Open Space

The development plan considers an open space reserve of 3,500m² in the centre of the site. Alternative attenuation could be integrated with this open space and service all flows coming from north of the site. The catchment area contributing to this central attenuation is 10.53 Ha, which includes ~7.5Ha of the catchment area to the north (Catchment A) and approximately half of the development site. Downstream flows are not considered as they will not feed into this central attenuation basin, however, downstream flows will be reduced after introduction of attenuation.

Based on this smaller catchment area of 10.53 ha, as shown in Figure 17, the Boyd's Formula was used to calculate the storage required, summarised in Figure 18.

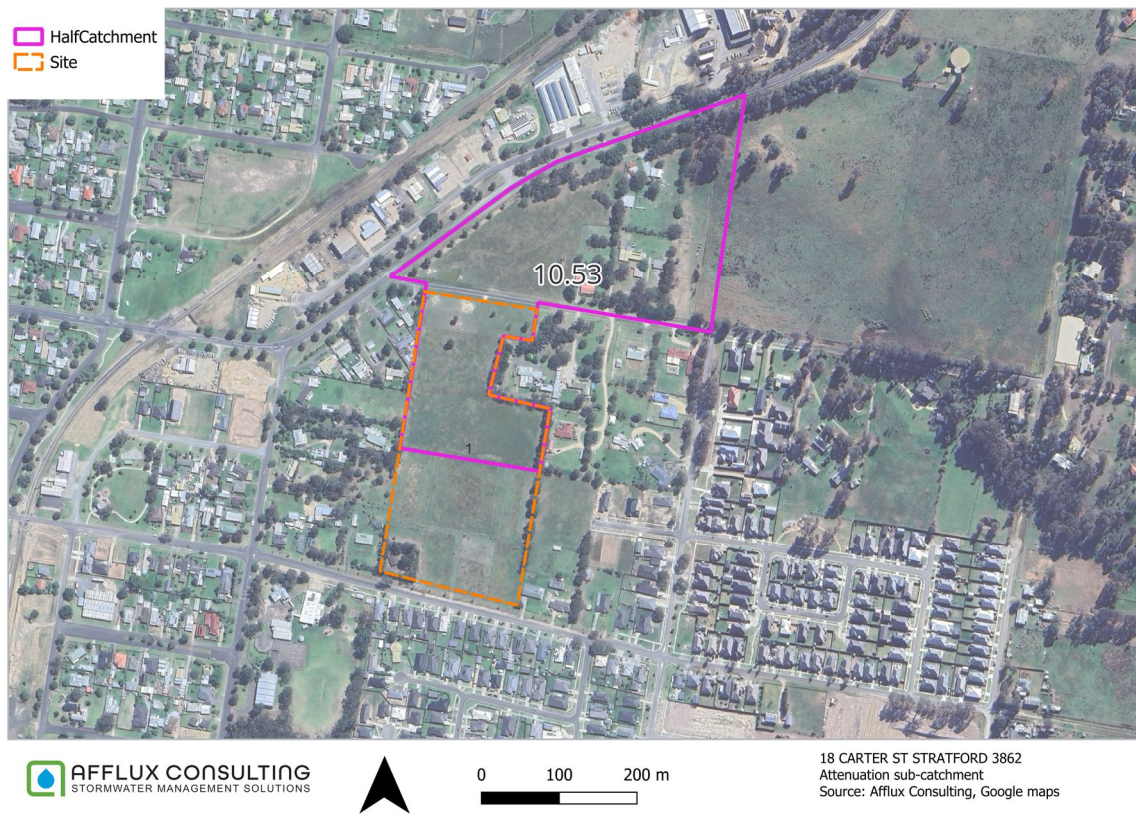


Figure 17. Attenuation service area

BOYDS FORMULA

$$S_{\max} = V_1 (1 - Q_p/I_p)$$

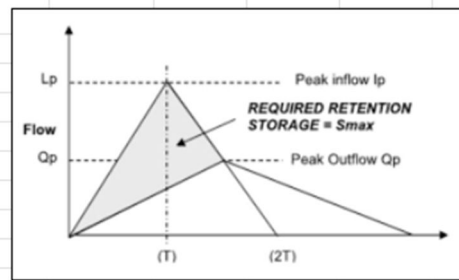
$$I_p = 100y * (\sum CA/360)$$

$S_{\max}$ = Maximum Volume of temporary Storage (m^3)

V_1 = Volume of inflow flood (m^3)

I_p = Peak discharge of inflow hydrograph (m^3/s)

Q_p = Peak discharge of outflow hydrograph (m^3/s)



Catchment Area (A) =
Runoff Coefficient (100 Year) =
100 Year Effective Catchment Area $\sum CA$ =
Restricted outflow requirement (Q_p) =

10.50	ha
0.731	
7.68	ha
0.9	m^3/s

Storm Duration	Smax
5	1028
10	1443
15	1608
20	1683
25	1663
30	1608
45	1295
60	851
90	-197
120	-1368
180	-3894
270	-7879
Maximum Storage	1683

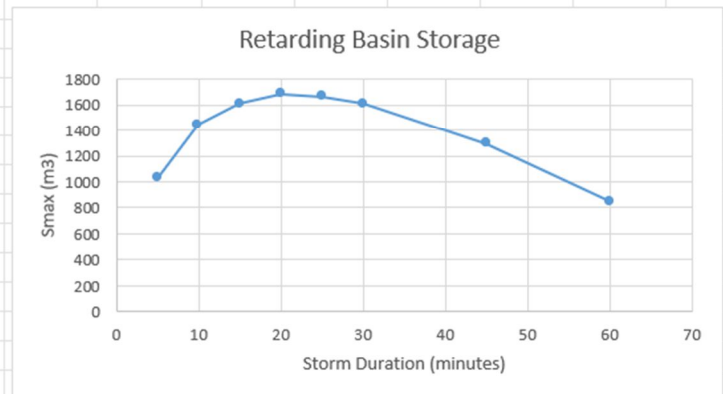


Figure 18. Boyd's Formula Calculations – attenuation sizing

From this, the attenuation requirement is reduced to approximately 1600 m^3 . This could be achieved by an approximate depression of the open space by approximately 0.5m to meet the required storage. A similar regional development setting is shown in Bass Coast below (Figure 19).



Figure 19. Similar Open Space Storage

4.6.3. Centralised Storage option

The WT development plan also considered a larger regional storage option as shown in Figure 20 below. The regional storage does not require any additional trunk drainage from this part of the catchment and as such could be negotiated with Council. It may be necessary that the open space option be used as a temporary asset until the final basin is constructed. At a total cost of ~\$7.5m it is expected that this option would require a scheme charge in the order of \$60k/Ha of development land.

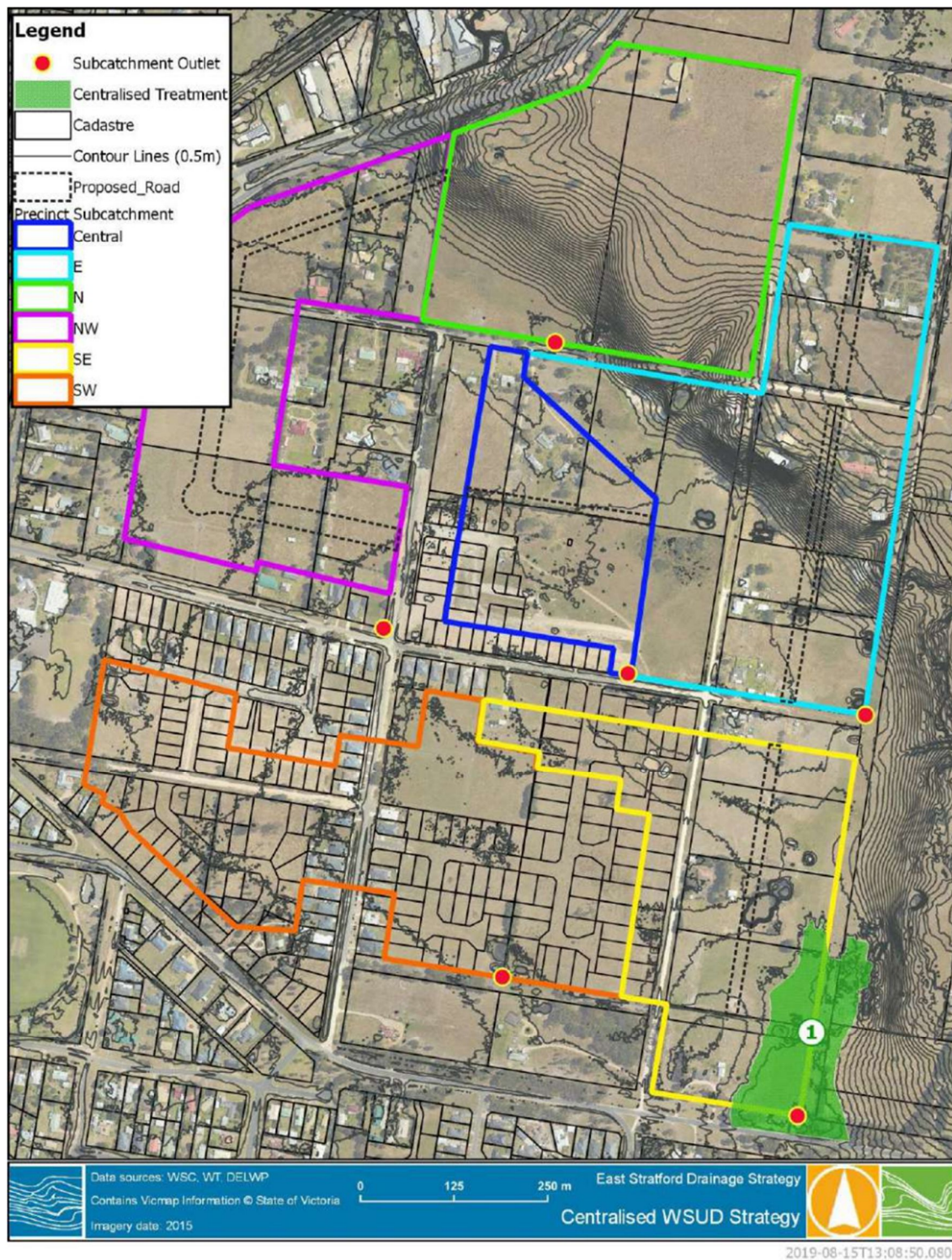


FIGURE 6-1 CENTRALISED WSUD ASSET

Figure 20. Centralised Storage and Treatment Option

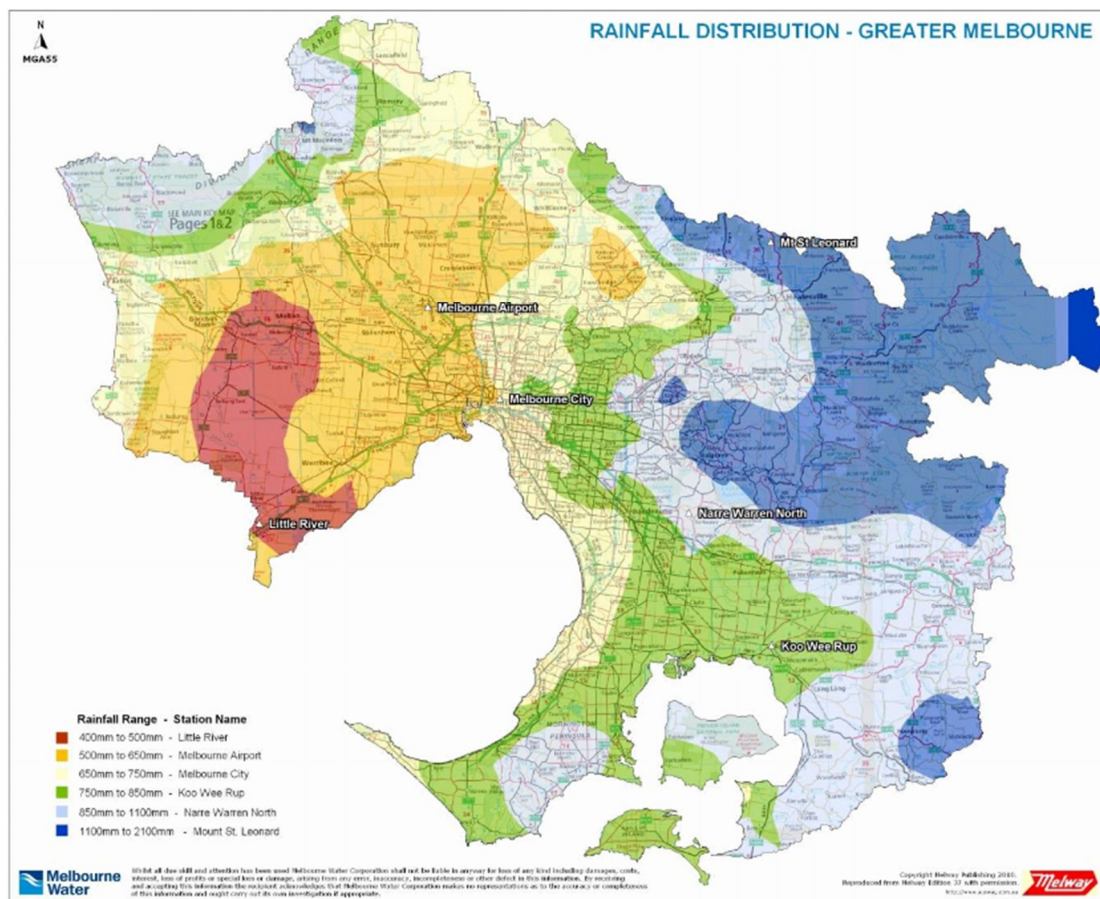
5. Water Quality

The water quality for this site has been assessed for the development. Treatment is modelled to ensure water quality for the site meets best practice load-based reduction requirements. The water quality works must coincide with the proposed development to ensure runoff does not directly discharge into the existing drainage system to the detriment of downstream water quality.

As with the site hydrology, two options have been considered.

5.1. Rainfall Information

The project site does not fall within any rainfall ranges defined by Melbourne Water, seen in Figure 21. The Bureau of Meteorology estimates a mean annual rainfall of approximately 637 mm for Stratford (BOM, 2024). This value falls within the rainfall range corresponding with the Melbourne Airport isopleth, with a reference period of 1971-1980, and hence this was applied in the MUSIC model. Rainfall was run at a 6-minute interval to match the lowest Time of Concentration of the catchment.



Source: Melbourne Water MUSIC Guidelines

Figure 21. Greater Melbourne rainfall distribution

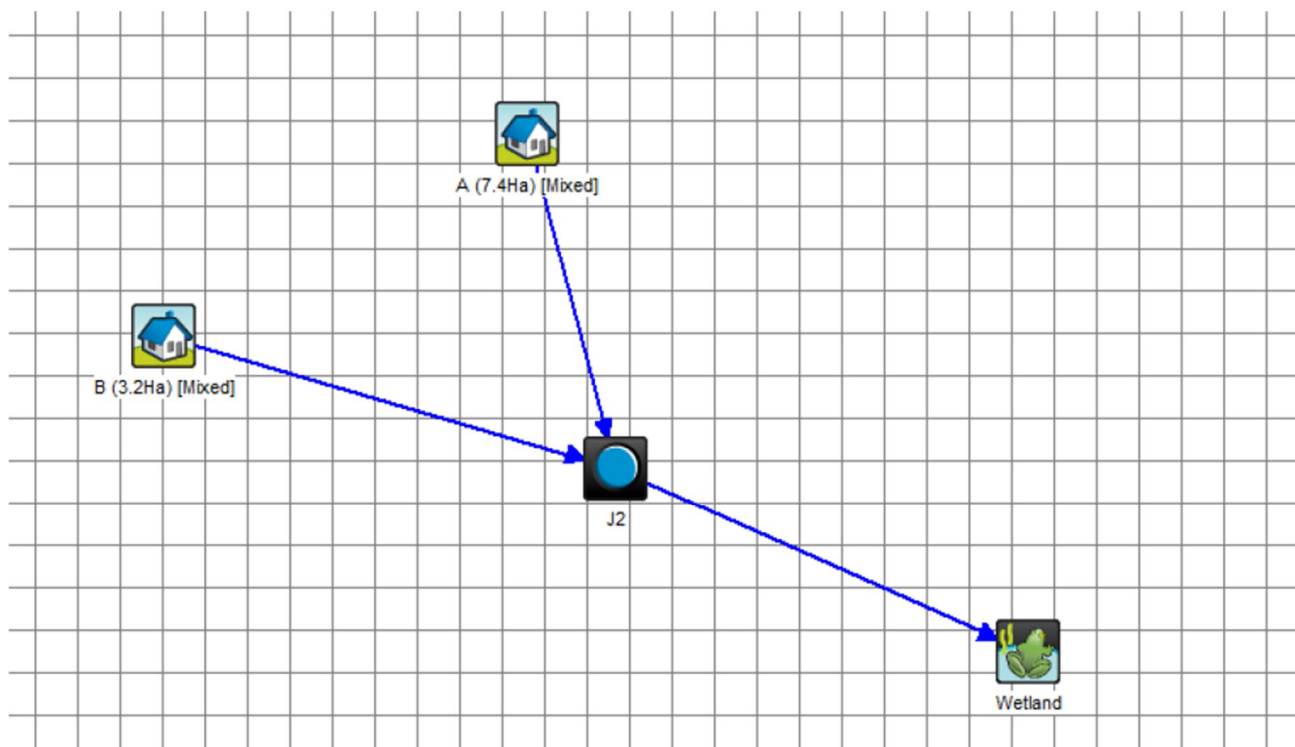
5.2. MUSIC Model Setup

To ensure that the development meets the BPEM requirements of Clause 56-7.04 a MUSIC model (v6) has been created for the catchment. MUSIC modelling is an industry standard approach to determine water quality treatment and sequencing. Guidance for model inputs was sourced from the IDM as well as Melbourne Water's MUSIC guidelines.

In order to reach BPEM Guidelines the model has been set up with the following notes:

- The model has been designed in alignment with proposed layout;
- The model is built using the most recent guidelines including soil losses field capacity;
- The model is built with an assumed 350 mm EDD;
- The model is built using rainfall templates that include a 9-year period of rainfall data ;
- The measured catchments are in alignment with hydrological models; and
- Source node sub-catchment areas for the developed conditions are separated by impervious fraction as per Table 1 discussed in the Hydrology section, in alignment with MUSIC guidelines.

All other parameters were set as per Melbourne Water Guidelines. A schematic view of the MUSIC model is shown in Figure 22. Only the relevant sub-catchments in the northern half of the broader catchment, as detailed in the previous section, were included. The treatment train is discussed in more detail in the next section.



Source: EastStratford_2.sqz

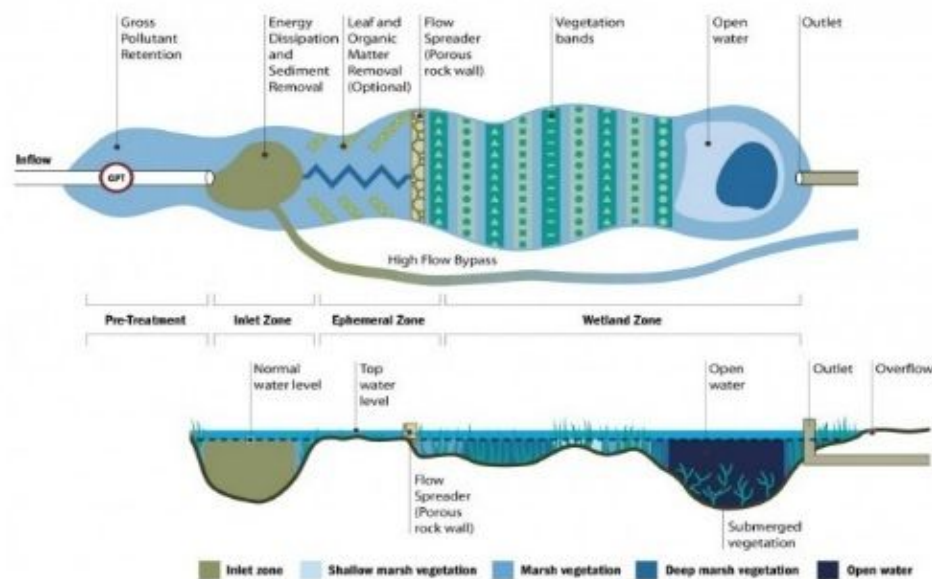
Figure 22. MUSIC model layout

5.3. Option 1 – Onsite Treatment Conversion of Open Space to Wetlands

The open space area could be converted to a treatment system that would ideally include the attenuation storage volume. Given that raingardens are generally incompatible with large attenuation storage volumes, a wetland system has been proposed.

5.3.1. Wetlands

Wetlands are designed to service the three-month flow or equivalent from the site. A schematic representation of a wetland is shown below in Figure 23.



Source: urban green-blue grids, (www.urbangreenbluegrids.com)

Figure 23. Schematic representation of a typical wetland

5.3.2. Sediment Control

The sedimentation basin was sized using the Fair and Geyer equations, with the results summarised below. The flow for the 10.53 ha catchment was determined using the rational method. For a 1-year ARI storm event, peak flow is 0.41 m³/s. The wetland and sediment basin has then been modelled in MUSIC as a wetland node with an inlet pond as shown in Figure 25.

Source	Parameter	Basin 1
Melbourne Water requires R = 95% for a 125 micrometer particle	Target	Very fine sand
Pond shape assumption (Figure 10.5)	λ	0.26
	n	1.35
From Table 1	V_s (m/s)	0.011
Use rational method to obtain 1 Year ARI flow for sub catchment	Q (m ³ /s)	0.41
Area of basin	A (m ²)	350.00
	V_a	9.39
	Q/A	
EDD	d_e (m)	0.35
Depth of permanent pool	d_p (m)	1.20
Lower of 1m or d_p	d^* (m)	1.00
	$(d_e + d_p)$	1.1
	$(d_e + d^*)$	
Fraction of Initial Solids Removed	$R =$	95%

Figure 24. Sedimentation Basin Sizing - Fair and Geyer

Properties of Wetland	
Location	<u>Wetland</u>
Inlet Properties	
Low Flow By-pass (cubic metres per sec)	0.00000
High Flow By-pass (cubic metres per sec)	100.0000
Inlet Pond Volume (cubic metres)	420.0
Estimate Inlet Volume	
Storage Properties	
Surface Area (square metres)	1400.0
Extended Detention Depth (metres)	0.35
Permanent Pool Volume (cubic metres)	560.0
Initial Volume (cubic metres)	560.00
Vegetation Cover (% of surface area)	50.0
Exfiltration Rate (mm/hr)	0.00
Evaporative Loss as % of PET	100.00
Outlet Properties	
Equivalent Pipe Diameter (mm)	37
Overflow Weir Width (metres)	3.0
Notional Detention Time (hrs)	72.1
☐ Use Custom Outflow and Storage Relationship	
Define Custom Outflow and Storage	Not Defined
Re-use...	Fluxes...
Notes...	More
X Cancel ⬅ Back ✔ Finish	

Figure 25. MUSIC model wetland parameters

As shown, the proposed wetland will require an area of 1400m² and a sediment basin with an area of approximately 350m² (total area ~1,800m²) for effective treatment of stormwater runoff from the catchment. This area does not include egress, inlets, outlets, or any other peripheral space required.

The sedimentation basin requires maintenance to ensure removal of sediment remains effective. Figure 26 summarises calculations for cleanout frequency. This sediment pond should be cleaned approximately every 7 years.

Source		Basin 1
	Side slopes (1:3)	3.00
	Actual Basin Depth (m)	1.55
	Permanent Pool Depth (m) (not incl EDD)	1.20
	Aspect ratio of basin 1:3	3.00
	NWL Width estimate (m)	10.80
	NWL Length estimate (m)	32.40
Check not too small to construct (at least 2m)	Base Width	3.60
	Cross-sectional area (m²)	8.64
Not Including EDD	Estimated volume of basin (m³)	280.02
Includes EDD	Estimated total volume (of excavation) (m³)	361.69
Just urban catchment considered	Catchment Area (ha)	10.53
(Willing and Partners 1992)	Sediment load (m³/ha/yr)	1.60
(Alison et al 1998)	Gross Pollutant Load (m³/ha/yr)	0.40
Maximum Allowed Cleanout Frequency	Cleanout frequency required (yr)	6.6
Assumes cleanout when basin permanent pool 50% full		
	Cleanout frequency required = (years)	1/ $\frac{(1.6+0.4)A_{\text{catchment}}}{0.5d_{\text{basin}} \cdot A_{\text{basin}}}$
<i>Try to minimise cleanouts - ideally, once every 5 years /clean out when sediment level is 500mm below NWL</i>		

Figure 26. Summarised calculations – cleanout frequency

To accommodate the cleanout process, an adjacent dry out area must be included. As Figure 27 shows, this should be approximately 241 m² in size.

The wetland and sedimentation basin will require a total area of at least ~2,000m². This fits within the proposed open space in the development plan, which is stated to be 3478 m².

Source		Basin 1
	By Catchment	
Just urban catchment considered	Catchment Area (ha)	10.53
(Willing and Partners 1992)	Sediment load (m³/ha/yr)	1.60
(Alison et al 1998)	Gross Pollutant Load (m³/ha/yr)	0.40
	Using Ideal Cleanout Frequency	
	Ideal Cleanout (yr)	5.00
	Volume at the end of ideal cleanout year (m³)	105.30
Stacked half a meter high	Required Area for dryout (m²)	210.60
Calculated above	Using Maximum Allowed Cleanout Frequency	
	Maximum Cleanout (yr)	6.65
Sediment volume	Volume at the end of maximum cleanout year (m³)	140.01
Stacked half a meter high	Required Area for dryout (m²)	280.02
	By Basin	
Clean out when sediment 500mm below NWL	Depth sediment can accumulate (m)	0.70
	Volume in Basin (m³)	116.84
Stacked half a meter high	Required Area for dryout (m²)	233.69
	Average (m²)	241

Figure 27. Summarised calculations – sediment dryout area

5.3.3. Wetland Treatment

The results of the MUSIC simulation provide an estimation of the expected nutrient reduction performance from the proposed treatment, as seen in Figure 28. These meet the water quality requirements set out by BPEM.

Treatment Train Effectiveness - Wetland			
	Sources	Residual Load	% Reduction
Flow (ML/yr)	23.2	21.9	5.8
Total Suspended Solids (kg/yr)	4010	769	80.8
Total Phosphorus (kg/yr)	8.69	2.72	68.7
Total Nitrogen (kg/yr)	63.8	32.9	48.5
Gross Pollutants (kg/yr)	824	0	100

Figure 28. MUSIC model results - Treatment Efficiencies

5.4. Option 2 – Regional Treatment

As per the WT drainage scheme a regional treatment option was considered at the base of the catchment. This option would require offsets to be paid towards the construction of this asset.

Although WT's report states that this centralised option does not provide drainage for the NW catchment, here we are only considering Nutrient treatment and in this respect the actual connection to the wetland is theoretically not required. The nutrient removal from the catchment is a function of wetland size, not inflow catchment.

The WT wetland size (Figure 29) is based on a rule of thumb calculation of catchment size and is set at 3ha. Adding the 10.5ha of this catchment would increase the wetland to 3.4ha on this basis.

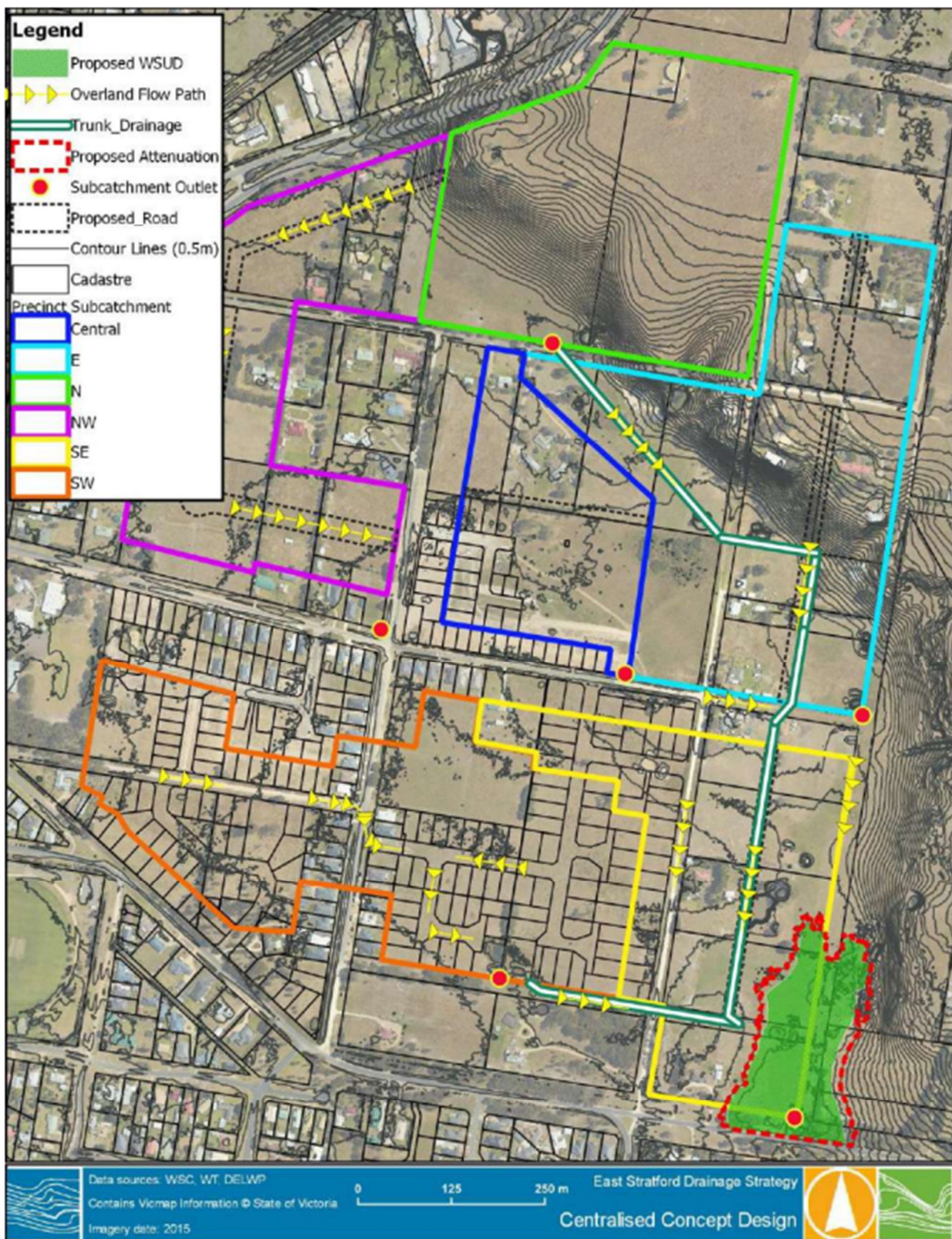


FIGURE 8-1 CENTRALISED STRATEGY

Figure 29. Regional Treatment Option (WT, 2020)

5.5. Option 3 – Local Assets

A local assets option was explored in the WT drainage scheme and provided 3 raingardens within this subdivision. This option is viable if used without the storage components. Proposed sizing is provided below. These assets could be distributed around the proposed subdivision layout but would require approximately the same total surface area (~2,000m²). This is indicated in the WT report, shown in Figure 30 and Table 3.

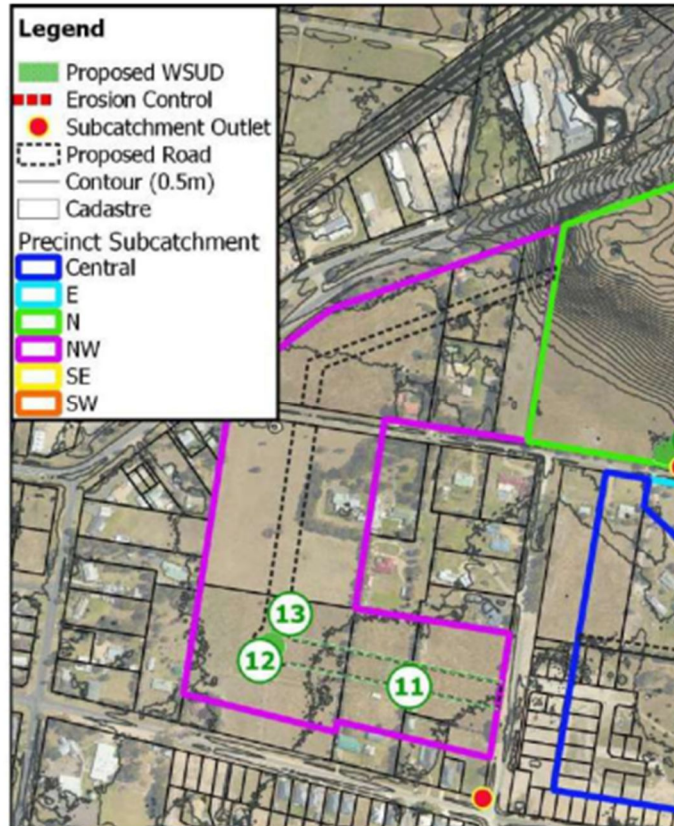


Figure 30. Local Assets Option

Table 3. Indicative WSUD Asset Sizing (WT, 2020)

Feature	Type	Treating sub-catchments	Contributing Area (m ²)	Asset Size (m ²)
2	Bioretention Basin	N	162,896	1,629
3	Sedimentation Basin	N	1,629*	130
4	Vegetated Swale	E	123,535	1,235
5	Wetland	C, E	267,995	10,720
6	Sedimentation Basin	C, E	10,720*	857
7	Vegetated Swale	SE	76,220	762
8	Wetland	SW, SE	327,988	13,120
9	Sedimentation Basin	SW, SE	13,120*	1,049
10	Bioretention Swale	SW	190,068	1,901
11	Bioretention Swale	NW	71,276	713
12	Bioretention Basin	NW	71,276	713
13	Sedimentation Basin	NW	1,426*	482

*Indicative size taken as percentage of wetland size

6. Design Requirements

Based on the modelling outcomes, the following Design Requirements are recommended.

6.1. Drainage

6.1.1. Attenuation

As described in this report, the underground storage option for this site is not seen as a practical or viable method for the proposed residential street network. This leaves either a temporary (or permanent) storage option on the open space reserve, or the centralised regional storage option. The proposed storage is approximately 1,600 m³ and can sit in the airspace above a wetland system. A schematic of a retarding basin design is shown in Figure 31.

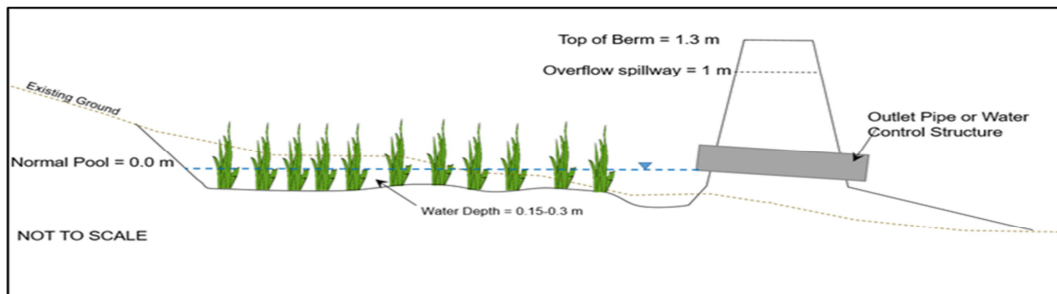


Figure 31. Retarding basin concept design

As this option provides regional storage, it would generally be accepted that this land would be part of an offset payment if this option is favoured for ultimate conditions. Figure 32 summarises proposed storage at the site.



Figure 32. Site Storage Proposed Locations

The concept drainage plan for site is shown in Figure 33, with the attenuation assets, associated drainage network, and FFLs included.

Final detailed plans should include:

- Safe conveyance of overland flows towards on-site attenuation locations
- An appropriate drainage network design for the developed site, including safe discharge from the site
- Buildings offset to ensure safe conveyance of flood waters between building interfaces at site boundaries;

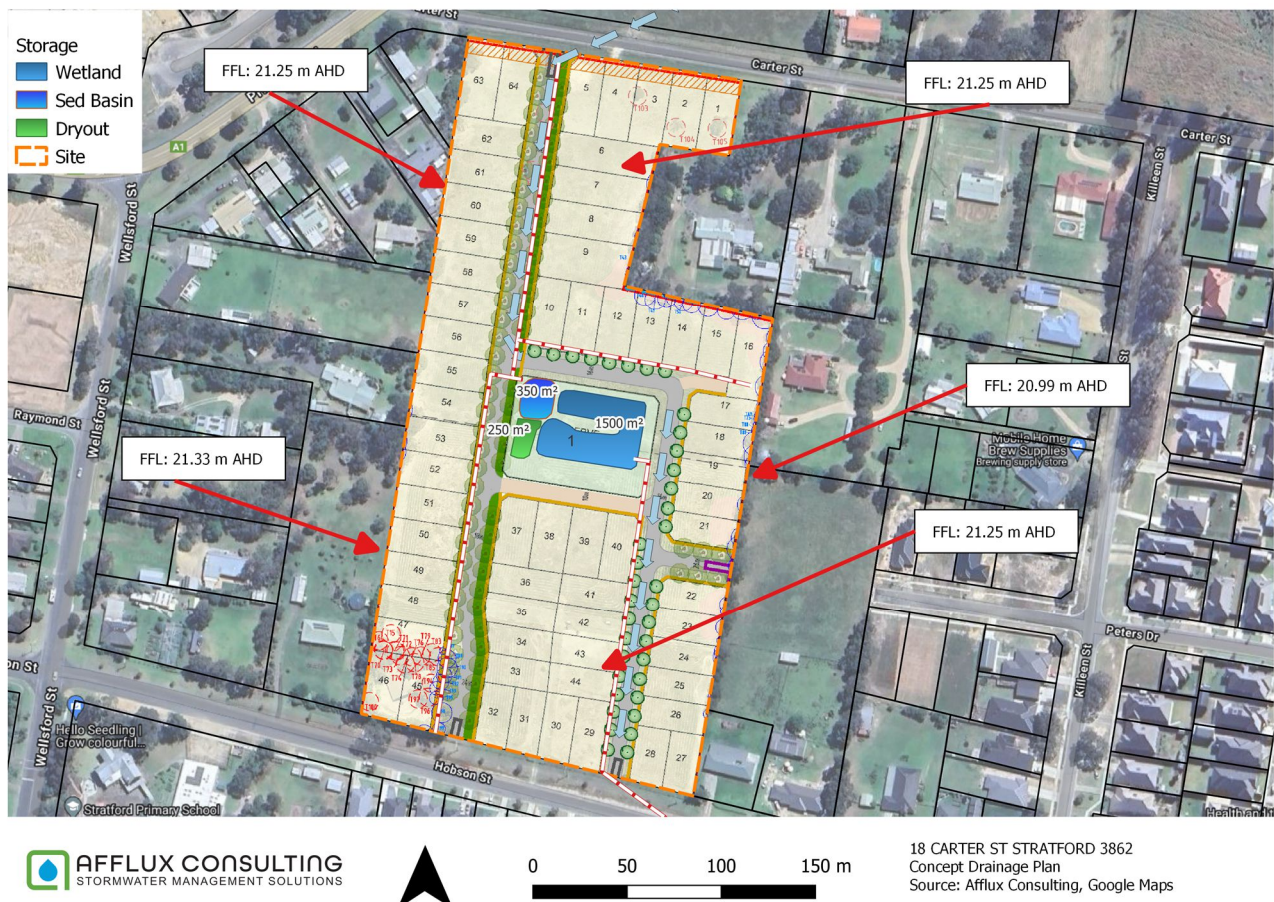


Figure 33. Concept Drainage Plan

7. Conclusions

This report presents a stormwater management plan for the proposed development at 18 Carter St, Stratford within Wellington Shire Council. The site has important interactions with its immediate catchment, and these interactions have been considered in this report. To maintain the behaviour of the hydraulic systems, including flood plain storage and water quality requirements, this report presents the following requirements:

- Either onsite or offsite storage be negotiated with Council
 - Discharge from the developed site (Catchment A and B) must be restricted to its predevelopment flows – 0.9 m³/s.
 - If on-site storage is preferred, it can be incorporated into the open space in the centre of the development plan. A volume of approximately 1600 m³ is required to service the Northern portion of the broader catchment (Catchment A and half of Catchment B).
 - For effective treatment of stormwater runoff, a 350 m² sediment pond and 1,500 m² wetland is required, servicing the same area as above.
- If offsite water treatment is preferred, the regional council option should be used with some minor size upgrades. This will require minimal upgrades as part of this site, other than ensuring safe overland flow paths. Drainage contributions towards this asset would then be
- Underground storage is not recommended by this report given the impracticalities of size and extent.

8. Abbreviations and glossary

For clarification, provided are terms referred to within this report and their definitions as applicable to stormwater and water engineering.

TERM (Abbreviation)	DEFINITION
Afflux	A measure of the increase in water elevation (or flood level difference) at a given location, relative to the water elevation that would have occurred.
Alluvium\alluvial material	Extensive deposits of sand, silt and/or clay formed by a river or flood, typically forming a floodplain. Alluvium is generally unconsolidated.
Annual Exceedance Probability (AEP)	The likelihood of a storm event or flood occurring or being exceeded within any year. Where, $AEP = 1 - e^{\left(\frac{-1}{ARI}\right)}$
Attenuation	Reduction in the magnitude of a flood peak
Australian Rainfall and Runoff (ARR)	Australian Rainfall and Runoff guidelines document.
Average Recurrence Interval (ARI)	A statistical estimate of the average length of time (in years) between equivalent (or larger) flood events. Note. Events do not occur at regular intervals. This is an average and not the expected elapsed time until the next exceedance. e.g. a “100 year ARI flood event” has a 1% exceedance probability each year.
Australian Height Datum (AHD)	Vertical height in meters above the mean sea level.
Baseflow	The slow component of catchment runoff, not immediately in response to a storm event. Encompasses interactions with seepage and groundwater discharge into a waterway.
BPEM	Best practice environmental management guidelines used for planning, designing or managing stormwater systems or urban land uses
Catchment	The upstream land and water surface area that drains to a specified location under consideration.
Consequence	Outcome or impact of an event.
Critical Storm Duration	The length of time of a rainfall event that results in the peak flow or level at a particular location of interest for a given AEP.
Cumec	An abbreviation of cubic meters per second, a unit of discharge (m ³ /s)
Drainage Network or System	A system of natural or constructed flow paths within a catchment used to convey runoff to its outlet. This may include surface or subsurface systems such as pipes, channels, gutters, overland flow paths, culverts, water storages, etc.

Design Event	A probabilistic or statistical flood or rainfall event used for flood/flow estimation processes for a given AEP.
DELWP	Department of Environment, Land, Water and Planning
EPA	Environmental protection agency
Extended Detention	Distance above normal water level in where stormwater is temporarily stored
Evaporation	The transfer of water, as vapour, from a water surface to the air
Evapotranspiration	The transfer of water, as vapour, from near the earth's surface to the air. Includes open water surfaces, ice, frost, soil and transpiration from plants.
Freeboard	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation.
Flood	Inundation of normally dry land by water that has exceeded the capacity of the normal confines of waterbodies, water storages or watercourses.
Flood Frequency	Descriptor for the annual exceedance probability or average recurrence interval of a flood
Floodplain	The land area which experiences flooding during high discharge events.
Hazard	Potential for damage or harm. Considered alongside consequence and likelihood of occurrence.
Hydrological Analysis	Developing and understanding a set of relationships to determine how rainfall is converted into runoff or streamflow (includes consideration of climate, losses, soil types, etc).
Hydraulic Design	The process of numerically analysing actual or expected flow conditions (such as water surface elevation and velocity) associated with a given hydraulic structure or overland flow.
Infiltration	The downward movement of water into a catchment surface or infiltration system. Largely governed by soil conditions, vegetation and antecedent moisture content.
Loss rate	Removal (loss) of water from the rate of rainfall that occurs during the process of forming stormwater runoff. Usually measured in units of mm/hr. The assumed loss rate usually varies across the drainage catchment in accordance with known or assumed surface conditions.
Local Authority	Any local or regional external authorities (including local and State Governments or non-government authorities) that have a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur.
Manning's 'n' Roughness Coefficient	The numerical representation of the hydraulic roughness of a conduit, flow path or channel as used in the Manning's formula.
Rainfall Excess	The portion of rainfall that contributes to streamflow
Rainfall Intensity	The rate at which rain falls, typically measured in mm/hour.

Runoff	The part of rainfall (or snow/hail) not lost to infiltration, evaporation, transpiration or depression storage that flows from the catchment area past a specified point.
Sedimentation Basin	A basin or tank in which sediment collects primarily through the actions of gravitational settlement. The basin facilitates low-velocity, low-turbulent flows to facilitate the settling of coarse sediment particles from stormwater runoff.
Soil Erosion	The detachment and transportation of soil and its deposition at another site by wind, water or gravitational effects. Although a component of natural erosion, it becomes the dominant component of accelerated erosion as a result of human activities, and includes the removal of chemical materials.
Stage	Elevation of the water surface in a stream measure to some convenient datum
Storm	In hydrology this includes any rainfall event. Unlike common usage implying a period of extreme weather with intense rain and strong wind.
Stormwater Flooding	Inundation by local runoff caused by heavier than usual rainfall. Stormwater inundation is caused by local runoff before it has entered a watercourse or joined watercourse flow. In a rural setting and within large rural allotments, we define stormwater flooding as sheet flow caused by local runoff before it has concentrated into a watercourse, including a drainage channel, stream, gully, creek, river, estuary, lake or dam, or any associated water holding structure.
Surface Water or Inundation	Any water collecting on the ground or in an open drainage system or receiving water body. In this report we use these terms to discuss water before it is categorised into flood, stormwater or other.
Temporal pattern	The time sequence of rainfall intensity. A representation of the variability of rainfall throughout a storm event.
Water Balance	An account of all the water in a specified system. Includes measurement of all inflows, outflows and changes in stored water volumes.
Wetland	A natural or constructed area of land inundated temporarily or permanently with shallow water that is usually slow moving or stationary

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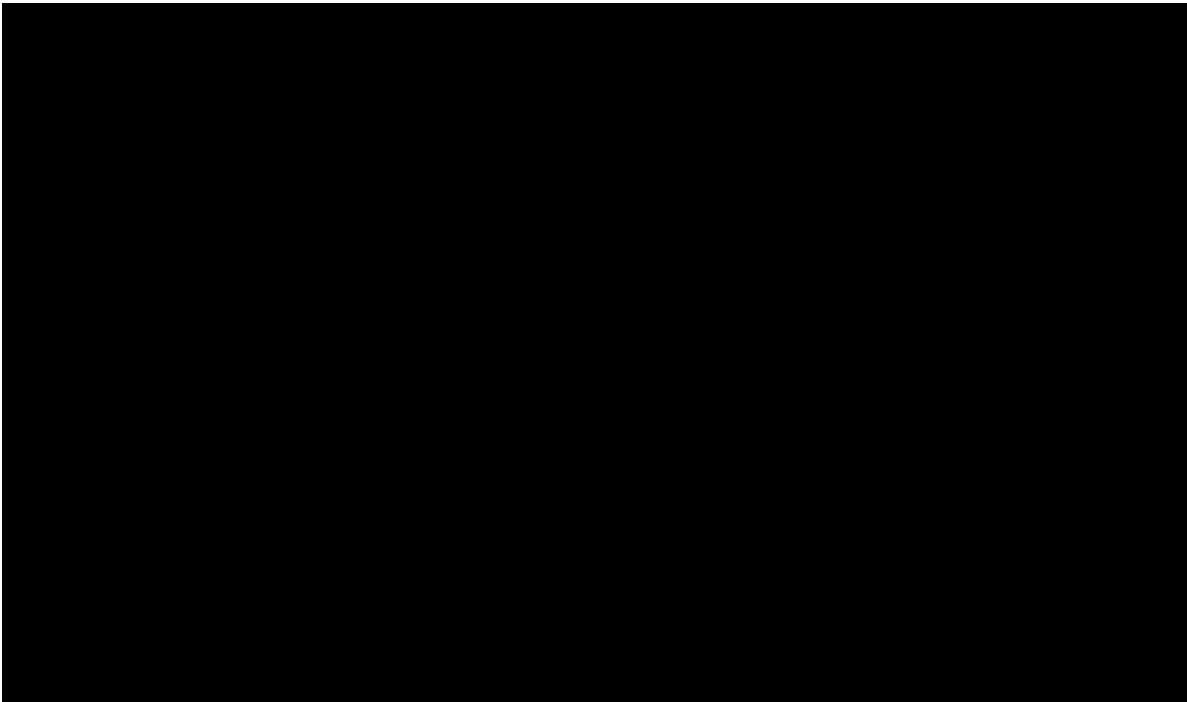
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