

19 January 2022

NL213311

Upper Hunter Shire Council
Paul Smith
PO Box 208
Scone NSW 2337

Dear Paul,

Re: Review of Stormwater Management Plan at 150 Gundy Road, Scone

Northrop Consulting Engineers have been engaged by Upper Hunter Shire Council (UHSC) to review the Stormwater Management Plan prepared for the proposed development (DA163/2017) at 150 Gundy Road, Scone.

This desktop review has been undertaken generally in accordance with the below methodology:

- General review of the applicants stormwater and flooding reports and the proposed stormwater management strategy.
- Technical review of model parameters including a comparison of the applicants peak flow, generated using DRAINS, with other studies completed in the area.
- Review of the proposed development and the documentation provided to confirm the proposal satisfies, or otherwise, the relevant stormwater and flood related Local Environmental Plan (LEP) and Development Control Plan (DCP) requirements.

This assessment has considered the following legislation policies and guidelines:

- Upper Hunter Shire Council Local Environmental Plan (LEP) (2013).
- Upper Hunter Shire Council Development Control Plan (DCP) (2015) in particular Sections 3 (Subdivisions), 10a (Floodplain Management), 11f (Soil and Water Management) and 13a (Specific Localities - St Aubin's Estate).
- Upper Hunter Shire Council Draft Engineering Guidelines for Subdivisions and Developments.
- National Resources Access Regulator (NRAR) Guidelines for controlled activities on waterfront land (2018).
- NSW Government Flood Prone Land Policy.
- NSW Floodplain Development Manual (2005).
- Australian Rainfall and Runoff (2019).

		Date
Prepared by	NM	19/01/2022
Checked by	LG	19/01/2022
Admin	BBR	19/01/2022

NL213311 / 19 January 2022 / Revision A

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This correspondence has been prepared based the following reports and studies which have been provided by Council for the purposes of this investigation:

- Stormwater Management Plan for DA – Peppertree Estate, Gundy Road, Scone prepared by ACOR Consultants Pty Ltd Revision 01 dated 19 August 2021, herein referred to as the “Stormwater Mangement Plan (ACOR, 2021)”.
- Stormwater Drainage Strategy Peppertree Estate Scone prepared by MM Hyndes Bailey and dated November 2017.
- The Scone Bypass Flood Study prepared by GHD and dated December 2015.
- Scone Floodplain Management Study and Plan prepared by Bewsher Consulting and dated 1999.

Presented below is a technical review of the DRAINS models, a review of the concept stormwater management strategy, and an assessment of the proposal with respect to the relevant Upper Hunter Shire Council Development Control Plan (DCP) and Local Environmental Plan (LEP) controls.

Technical Review

Modelling Approach

The Stormwater Management Plan (ACOR, 2021) has used DRAINS to estimate the peak flow approaching the western and south-western boundaries.

The modelling methodology involved:

- Generating peak flows for pre to post developed scenarios for a range of design storm events from the 20% to 1% AEP and durations ranging from 5 minutes to 6 hours.
- Comparing peak flow results at the western and south-western boundaries of the site.

The DRAINS model was prepared generally using ARR 2019 procedures. Two runoff routing methods have been adopted, namely:

- The RAFTS storage routing model has been used for the large rural catchments upstream and existing catchment conditions.
- The proposed developed catchment has been modelled using the Initial Loss – Continuing Loss (IL-CL) model.

Model Parameters

The model parameters presented in the Stormwater Mangement Plan (ACOR, 2021) report as well as the DRAINS models provided have been reviewed with the results of the investigation summarised in the following **Table 1**.

Table 1 - DRAINS Model Review

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment
Initial Losses	<ul style="list-style-type: none"> Storm Initial Loss values used in the DRAINS model are summarised below. <ul style="list-style-type: none"> Impervious Area Initial Loss (mm): 1.0 Pervious Area Initial Loss (mm): 34.0 	<ul style="list-style-type: none"> The latest advice commissioned by the NSW Office of Environment and Heritage (OEH), recommends practitioners undertaking hydrological modelling in NSW should use the NSW Specific Hierarchy Approach. Based on this hierarchy, Option 5 is expected to be the most suitable strategy for this study. Which includes the use of the ARR Data Hub storm losses combined with the Transformational Pre-burst rainfall, and a reduction of the data hub continuing losses by a factor of 0.4. Options 1, 2, 3 and 4 of the hierarchy are expected to be omitted due to following reasons. <ol style="list-style-type: none"> Both adopted flood studies for Scone (1999) and the most recent Scone Bypass flood study (2015) do not present any calibrated catchment losses. The subject site is not located in an NSW FFA-reconciled losses catchment with the closest gauge located in Rouchel Brook (The Vale) approximately 19km away. Further to the above, ARR 2019 recommends consideration to in-directly connected impervious areas as a fraction of the total impervious area, with a suggestion of 60-80% of the rural pervious losses to be used for indirectly connected impervious losses. It is noted that it is not possible to adopt this strategy when using RAFTS routing (due to single impervious and pervious catchments) however, may be adopted for the developed areas when using the IL/CL method.

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment
Continuing Losses	<ul style="list-style-type: none"> Storm Initial Loss parameters values used in the DRAINS model are summarised below. <ul style="list-style-type: none"> Impervious Area Continuing Loss (mm/hr): 0.0 Pervious Area Continuing Loss (mm/hr): 1.5 	<ul style="list-style-type: none"> As mentioned above, it is recommended that the default continuing loss value provided by the ARR Data Hub be reduced by a factor of 0.4 in accordance with the latest NSW Specific advice.
Pre-Burst Rainfall	<p>Section 5.3.3 suggests:</p> <ul style="list-style-type: none"> Median Pre-Burst depths have been used for the investigation 	<ul style="list-style-type: none"> As mentioned above, the latest NSW Specific advice recommends the Probability Neutral Burst Initial Losses (PNBIL) should be used for studies in NSW. The PNBILs are generated through the use of the Transformational Pre-Burst rainfall and the storm losses provided in the ARR Data Hub discussed above. DRAINS uses the Transformational Pre-Burst rainfall automatically in lieu of the Median pre-burst, if the ARR Data Hub text file contains the Transformational data (which is the case when requesting this data across NSW). Review of the DRAINS models provided suggests the Transformational Pre-Burst rainfall has been loaded into the DRAINS models correctly, rather than the Median Pre-Burst as suggested in Section 5.3.3.
Rainfall Data	<p>Section 5.3.3 suggests:</p> <ul style="list-style-type: none"> Bureau of Meteorology IFD Depths have been used. 	<ul style="list-style-type: none"> Review of the rainfall depths contained in the DRAINS models suggests the correct depths have been used for the area.
Impervious Fraction	<p>Section 5.3.5 suggests:</p> <ul style="list-style-type: none"> For the upstream catchments, a fraction impervious of 0.35 has adopted. A fraction impervious of 0 has been adopted for the predeveloped site (existing rural property). A fraction impervious of 0.75 has been adopted for the proposed subdivision. 	<ul style="list-style-type: none"> The adopted impervious fractions are generally in accordance with the UHSC Draft Engineering Guidelines for Subdivisions and Developments. It is noted that an open space impervious percentage of 35% for the upstream rural catchments is considered high given these catchments are largely undeveloped and made up of pastoral grasses. As such, a sensitivity test is recommended

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment
		<p>to review the impact this assumption has on the detention modelling.</p> <ul style="list-style-type: none"> • In addition, as mentioned above, the latest ARR 2019 guidelines recommend consideration to splitting the Total Impervious Area (TIA) into the Effective Impervious Areas (EIA) and In-Directly Connected Impervious Areas (ICIA). This strategy may be adopted for the developed areas when using the IL/CL method. • As a minimum a sensitivity test using this strategy should be considered to review the impact this assumption has on the detention modelling.
Time of Concentration	<p>Section 5.3.5 suggests:</p> <ul style="list-style-type: none"> • The time of concentration for the catchments that are modelled using RAFTS are determined automatically by the program. • For the catchments utilising IL-CL model a minimum of 5 minutes has been used for the impervious catchments and 10minutes for the pervious catchments. 	<ul style="list-style-type: none"> • This strategy for determining the time of concentration is considered reasonable.
Surface Roughness	<p>Section 5.3.5 suggests:</p> <p>The following Manning's roughness values have been adopted for the catchments modelled using RAFTS:</p> <ul style="list-style-type: none"> • A Manning's value of 0.05 for the external catchments. • A Manning's value of 0.04 for the predeveloped catchments. • A Manning's value of 0.04 for the stream traversing through the site (waterways and minimal vegetation and trees). 	<ul style="list-style-type: none"> • The adopted hydrological roughness values are considered to be within a reasonable range, based on a review of aerial imagery and google street view.

Peak Flow Comparison

The modelled pre-developed peak flows have been compared against the flows observed in the Scone Bypass Flood Study (GHD, 2015) and the MM Hyndes Bailey Study (2017) as presented in **Table 2** below.

Note that, due to the larger modelled catchment size in the Scone Bypass Flood Study (GHD, 2015), peak flows were reduced by a factor of ~0.6 (based on the ratio of catchment size) to provide an approximation of the flows to compare with the Stormwater Management Plan (ACOR, 2021).

Table 2 - Peak Flow Comparison at the Western Site Boundary

Model	10% AEP	1% AEP
Scone Bypass Flood Study (GHD, 2015)	6.93	28.56
Stormwater Management Plan (ACOR, 2021)	25.40	47.60
MM Hyndes Bailey (2017) (Table 4)	-	29.8

The results presented in **Table 2** suggests a higher peak flow is observed in the Stormwater Management Report (ACOR, 2021) when compared to other studies performed in the area. The higher peak flow is expected to result in a wider flood extent when compared to the extents presented in MM Hyndes Bailey report (2017). As such, flooding in the second order creek should be re-assessed using the latest guidelines. These differences in peak flow should be discussed in the Stormwater Management Plan (ACOR, 2021).

Stormwater Management Strategy

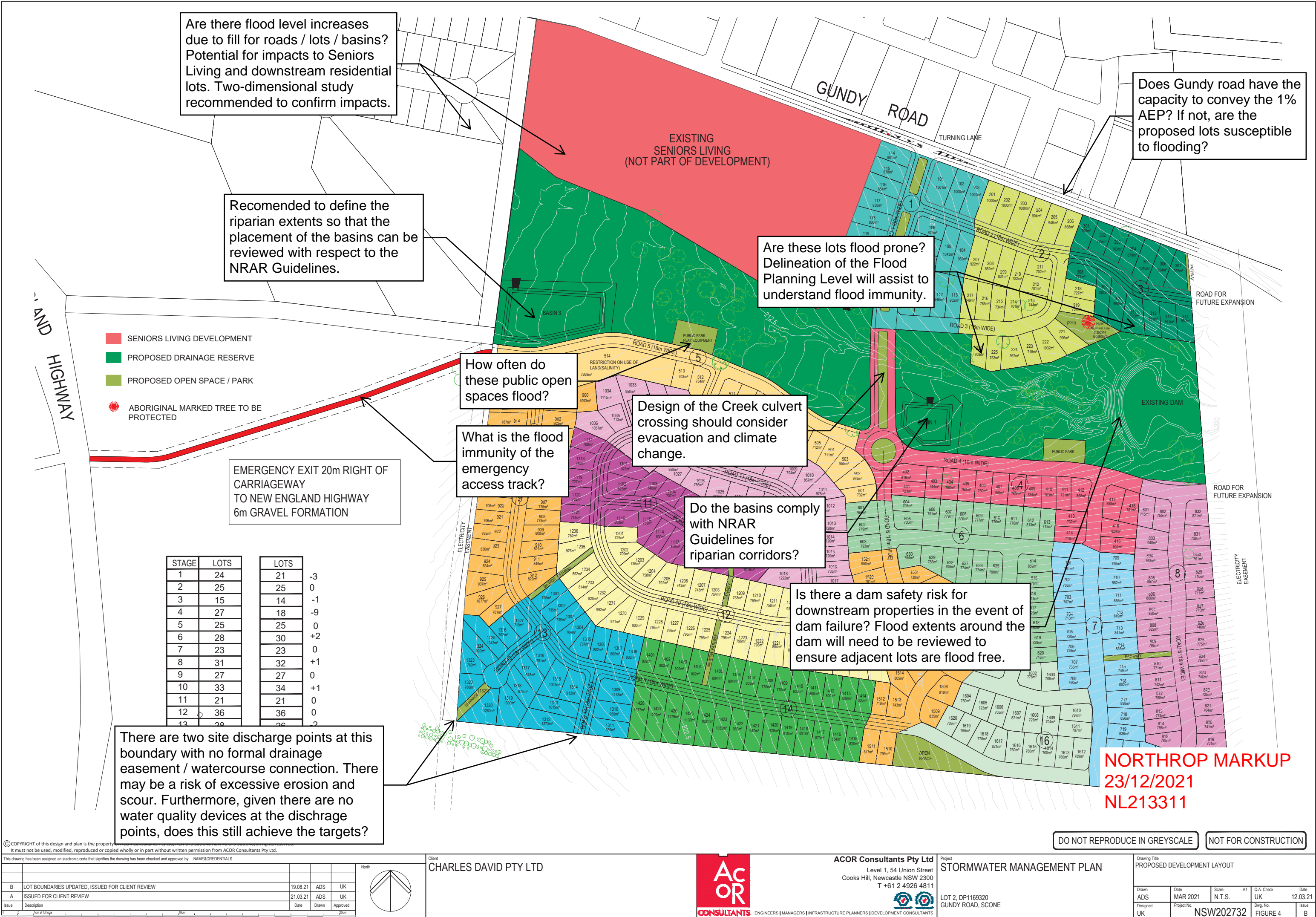
A review of the proposed Concept Stormwater Management Plan (ACOR, 2021) has been prepared with comments presented in **Figure 1** and summarised below.

Flooding

The Stormwater Management Plan (ACOR, 2021) refers to the MM Hyndes Bailey report (2017) for the flood extents through the second order creek. The modelling presented in the MM Hyndes Bailey report (2017) has been prepared with flows derived using the Regional Flood Frequency Estimation tool and flood extents determined using HEC-RAS.

As previously discussed, peak flows are considerably higher in the Stormwater Management Report (ACOR, 2021) than the MM Hyndes Bailey report (2017). The modelling has also been prepared based on an old layout with the flood extents not reflective of the development layout presented in the Stormwater Management Report (ACOR, 2021).

Following a review of the above studies, we are unable to accurately determine the extent of the 1% AEP flood event and evidently the extent of the Flood Planning Area for the proposed layout. This information is required to determine whether the proposed lots, roads and infrastructure are susceptible to flood and whether they are sited in accordance with the LEP / DCP / NSW Floodplain Development Manual.



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Issue	Description	Date	Drawn	Approved
B	LOT BOUNDARIES UPDATED, ISSUED FOR CLIENT REVIEW	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK



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Project
STORMWATER MANAGEMENT PLAN
LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawn	Date	Scale	A1	Q.A. Check	Date
ADS	MAR 2021	N.T.S.	UK	12.03.21	
Designed	Project No.	Issue	Figure	Issue	
UK	NSW202732	FIGURE 4	B		

In addition, it is possible the section of the development located on the southern side of the creek may become a high flood island during a major / extreme flooding event. An emergency exit track from the development is proposed however, it is not possible to determine the flood immunity of this track from the documentation provided. It is recommended the design of emergency access track, or the creek culvert crossing be reviewed with consideration to risk to life and evacuation from this area.

As mentioned, the MM Hyndes Bailey report (2017) reviews an old development layout and does not consider existing case flood behaviour. As such, it is not possible to determine if there are any adverse flood impacts due to fill for roads, lots and the bio retention basins within the existing second order creek.

There are sensitive sites adjacent to the proposed development, namely the senior's living village (HammondCare Strathearn House) as well as residential properties downstream. We recommend a two-dimensional flood study be prepared using the latest developed layout to confirm whether there are any significant adverse flood impacts in these properties. This study may also be used to verify the requirement for no stormwater detention for the proposed development.

Furthermore, Section 3.4 of the Stormwater Management Report (ACOR, 2021) highlights the potential for the existing road-side swales in Gundy Road to overtop during major events. An assessment on the capacity of Gundy Road to convey overland flow during the 1% AEP should be prepared and stormwater upgrades proposed as necessary to ensure the proposed lots fronting Gundy Road are not flood prone.

Stormwater Infrastructure

There is an inconsistency in the size of the creek culvert crossing between the MM Hyndes Bailey (2017) report and those proposed in the Stormwater Management Report (ACOR, 2021). Each report suggests the following:

- MM Hyndes Bailey (2017): 10 x 1500mm x 750mm
- Stormwater Management Report (ACOR, 2021): 11 x 2400mm x 750mm

This discrepancy should be discussed in the Stormwater Management Report (ACOR, 2021) with consideration to the risk to life and evacuation requirements as discussed in the above flooding section.

Furthermore, it is unclear whether blockage has been considered in the design of the proposed culvert crossing. Similarly, it is not possible to determine the flood immunity and available freeboard to the culvert crossing under today's and future climate scenarios. These should be discussed in the Stormwater Management Report (ACOR, 2021).

Riparian Extents

The Stormwater Management Report (ACOR, 2021) suggests the creek bisecting the proposed development is a second order watercourse. The applicant should address whether the proposed bio-retention basins, that are to be placed adjacent to the watercourse, comply with the NSW Natural Resources Access Regulator (NRAR) guidelines for Controlled Activities on Waterfront Land.

Riparian extents are not presented in the documentation and as such, it is not possible to assess the NRAR requirements with the information provided.

South-Western Corner

There are two site discharge points in the south-western corner of the site; one discharging into the electrical easement and another to connect to a future road corridor. From the information provided, it does not appear that these outlets connect to a formal drainage easement or watercourse connection.

Without a formal drainage connection, there is a risk of excessive erosion and scour downstream of these discharge points. The applicant should review whether mitigation measures are required to ensure the downstream ecosystem, road and stormwater infrastructure, farms and properties are not adversely impacted.

Furthermore, there are no end of line water quality devices proposed at this location (GPT / Bio-retention). As this catchment discharges to a separate watercourse, the water quality assessment should confirm that the treatment targets can be met at each site discharge point.

Existing Dam

Section 3.5 notes that the existing farm dam is to remain as part of the development. The applicant should consider whether there is a dam safety risk for the proposed and existing properties downstream of the dam in the event of failure.

Similarly, an access track will be required to ensure the condition of the dam can be assessed and maintained as required.

Local Environmental Plan

The proposed development has been reviewed with respect to the Upper Hunter Shire Council Local Environmental Plan (2013), in particular Par 5.21 – Flood Planning. A summary of how the Stormwater Management Plan (ACOR, 2021) archives, or otherwise, the LEP requirements is presented in the below **Table 3**.

Table 3 - UHSC LEP (2013) requirements

Item	Description	How Addressed?
Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development:		
(a)	<ul style="list-style-type: none"> is compatible with the flood function and behaviour on the land, and 	<ul style="list-style-type: none"> As the existing and latest developed case flood behaviour has not been defined, it is not possible to assess this adequately.
(b)	<ul style="list-style-type: none"> will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and 	<ul style="list-style-type: none"> A pre-to-post detention assessment has been performed however, there is the potential for flood impacts to occur as a result of fill within the creek. As the Flood Planning Area and site flood behaviour for the latest layout has not been defined, it is not possible to assess this adequately
(c)	<ul style="list-style-type: none"> will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and 	<ul style="list-style-type: none"> As the existing and developed case flood behaviour has not been defined for the latest layout, it is not possible to assess this adequately.
(d)	<ul style="list-style-type: none"> incorporates appropriate measures to manage risk to life in the event of a flood, and 	<ul style="list-style-type: none"> It is not possible assess this adequately based on the information provided.

Item	Description	How Addressed?
(e)	<ul style="list-style-type: none"> will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. 	<ul style="list-style-type: none"> It is not possible assess this adequately based on the information provided. There is the potential for erosion and siltation of the watercourse downstream of the south-western site discharge points.
In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters:		
(a)	<ul style="list-style-type: none"> the impact of the development on projected changes to flood behaviour as a result of climate change, 	<ul style="list-style-type: none"> Climate change has not been considered as part of the investigation. As such, it is not possible assess this adequately based on the information provided.
(b)	<ul style="list-style-type: none"> the intended design and scale of buildings resulting from the development, 	<ul style="list-style-type: none"> A concept layout has been provided and therefore, the scale of the development can be adequately assessed.
(c)	<ul style="list-style-type: none"> whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood, 	<ul style="list-style-type: none"> Risk to Life and evacuation is not discussed in the information provided. As such, it is not possible assess this adequately based on the information provided.
(d)	<ul style="list-style-type: none"> the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion 	<ul style="list-style-type: none"> As the site flood behaviour has not been defined using the latest layout, it is not possible to assess this adequately.

Development Control Plan

The proposed development has been reviewed with respect to the Upper Hunter Shire Council Development Control Plan (2015). The controls with respect to both flooding and stormwater management have been assessed.

Flooding

Development controls defined in Part 10a (Floodplain Management) of Council's DCP are applicable for land that is located below the Flood Planning Level and/or has been classified by it's Planning Certificate to be susceptible to flooding. The Section 149 Planning Certificate provided by Council suggests part of the subject site is susceptible to flooding and as such, Part 10a of the DCP applies.

Table 16 of Part 10a presents the provisional matrix and provisional development controls for development susceptible to flooding. The matrix has been reproduced as **Table 4** below.

Table 4 - Floodplain Management Prescriptive provisions matrix (Table 16 of UHSC DCP Part 10a)

Proposed Land use	Section of Floodplain			
	Flood Planning Level (FPL) to Probable Maximum Flood (PMF)	Low Hazard	High Hazard	Other Flood Prone Land (Hazard Unknown)
1 Single Dwelling Houses		1,2,5		
2 Agriculture & Recreation		2,5		
3 Sheds / Garages / ancillary Residential		1,2,5		
4 Commercial and Industrial Uses		2, 6		
5 Medium to High Density Residential				
6 Critical or Sensitive Facilities	3			
7 Land Subdivision	4			
8 Tourist Development				
9 Caravan parks - short-term sites		5,6		
10 Permissible Earthworks		7		



Flood related development controls do not apply



Flood related development controls apply (refer to numbered prescriptive criteria in Table 17 Prescriptive Criteria)



If the proposal is to be pursued further, a performance based assessment is to be provided demonstrating that the proposed development is compatible with the flooding characteristics of the site (refer to the section "Performance based assessment" and Table 19 Detailed Assessment Criteria).

As part of the site is expected to be located between the FPL and the PMF as well as below the 1% AEP, a joint civil and flood report and a performance-based assessment is required in accordance with the requirements set out in the DCP.

The requirements to be satisfied for the performance-based assessment are summarised below:

- The development proposal is compatible with the established flood hazard of the land. In areas where flood hazard has not been established through previous studies or reports, the flood hazard must be established in accordance with the Floodplain Development Manual.
- Development will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.
- Development incorporates appropriate measures to manage risk to life and property from flood.
- Development will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.
- Development is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
- Development is consistent with the principles of Ecologically Sustainable Development.

In addition to the above, Council advise that the proposed lots are required to be protected from run-on water from upstream catchments using diversion banks or an appropriate diversion system via an easement.

It is noted that the information contained in the Stormwater Management Report (ACOR, 2021) and MM Hyndes Bailey report (2017) by does not provide enough information to enable assessment of the proposed development with respect to the relevant flood items outlined in the LEP and DCP. As outlined in the DCP, a joint flood and civil report will need to be prepared to enable assessment of latest layout.

Stormwater Management

The DCP requirements relating to Stormwater Management contained in part 11f.6 of Council's DCP are summarised in the below **Table 5**. A summary of how the proposal satisfies, or otherwise, these Stormwater Management requirements is also presented in **Table 5**.

Table 5 - DCP requirements

Item	DCP Requirement	How addressed?
M. Stormwater design objectives	<ul style="list-style-type: none"> • Apply the stormwater drainage approach advocated by Engineers Australia in 'Australian Rainfall and Runoff' to design surface levels so that very large (major system) 1% AEP (100year ARI) events can flow around the buildings without relying on underground pipes and that the Main drainage system design and construction: <ul style="list-style-type: none"> ○ retains, and where practical, restores natural water courses, native riparian vegetation, wetlands and other natural landscape features, ○ incorporates effective measures to manage and treat stormwater and maintain healthy aquatic ecosystems, ○ satisfies acceptable risk management standards for public safety and flood protection, and ○ within new developments local drainage shall be designed to avoid local flooding in accordance with the aims and objectives of the NSW Floodplain Development Manual. (April 2005). 	<ul style="list-style-type: none"> • Riparian extents are not presented or discussed in the Stormwater Management Report (ACOR, 2021). • Water Quality devices are proposed however, confirmation of the treatment effectiveness at the south-western discharge point is requested. • Public safety, flood protection (including the Flood Planning Area), risk to life and evacuation is not discussed in the Stormwater Management Report (ACOR, 2021) • The Stormwater Management Report (ACOR, 2021) proposes a suitable major and minor design strategy for the local stormwater network which is expected to be progressed with greater detail during future detailed design project phases.
	<ul style="list-style-type: none"> • Pipe (minor) systems are installed to cater for frequent surface flows up to 20% AEP (5 year ARI). This balances cost of drainage and occurrence of inundation. 	<ul style="list-style-type: none"> • Section 5.2.1 of the Stormwater Management Report (ACOR, 2021) notes the minor system stormwater network will be designed to cater for the 20% AEP. • A preliminary layout for the stormwater drainage system is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)

Item	DCP Requirement	How addressed?
M. Stormwater design objectives cont.	<ul style="list-style-type: none"> Runoff from impermeable surfaces is to be managed by stormwater source controls that: <ul style="list-style-type: none"> Contain frequent, low-magnitude flows, Maintain the natural balance between runoff and infiltration, so as to promote appropriate groundwater, soil salinity and stream flow characteristics, Remove some pollutants prior to discharge to receiving waters, and Prevent nuisance flows from affecting adjoining properties. 	<ul style="list-style-type: none"> Section 6.2 of the Stormwater Management Report (ACOR, 2021) presents a range of water quality improvement devices, including rainwater tanks, Ecosol GPTs and bioretention basins. This treatment train is generally in accordance with current best practice. A MUSIC model has been prepared to demonstrate that the proposed treatment devices treat stormwater runoff generally to the satisfaction of Council Further review is requested to confirm discharge in the south-western corner achieves the necessary treatment targets and frequent discharge via the two headwalls will not create excessive scour, and impact downstream waterways, properties and infrastructure.
	<ul style="list-style-type: none"> Ensure that appropriate long-term arrangements are in place to allow for continued use and maintenance of existing drainage systems. 	<ul style="list-style-type: none"> Maintenance access into the basins and the existing farm dam is not presented in the design drawings. Assuming Council will eventually take ownership of the proposed GPTs and bio-retention basins, maintenance schedules and frequency is expected to be similar to other similar water quality throughout the LGA.
	<ul style="list-style-type: none"> The ultimate discharge for collected stormwater runoff shall be to a street drainage system, to an inter-allotment drainage line, or by approval, to a public area. The system shall be “gravity” drained. Pumping of stormwater is not permitted. 	<ul style="list-style-type: none"> Individual lot runoff is expected to be assessed on a lot-by-lot basis. Runoff from the proposed development is proposed primarily to the second order water course. As mentioned, discharge through the electrical easement and to private land in the south-western corner will need to be reviewed to ensure it does not create a significant adverse impact. A formal drainage easement is expected to be required. All lines proposed are expected to be drained under gravity.

Item	DCP Requirement	How addressed?
	<ul style="list-style-type: none"> The development site shall provide an overland flow path for the major storm event (1% AEP). 	<ul style="list-style-type: none"> Section 5.2.2 notes the major local conveyance network will include overland flow through the road carriageway and footpath. Flows through the road network will be limited to a maximum velocity-depth product of less than 0.4m²/s. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
N. Stormwater drainage design – residential	<ul style="list-style-type: none"> All public stormwater management assets are to be installed outside the riparian zone of creek lines. 	<ul style="list-style-type: none"> It is not possible to assess this accurately as the riparian zones are not presented in the design drawings.
	<ul style="list-style-type: none"> All urban lots must have connection to the Council's stormwater management system via direct access to the street gutter or interallotment drainage via a dedicated easement. 	<ul style="list-style-type: none"> A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	<ul style="list-style-type: none"> New buildings are not to be constructed over or compromise the integrity of drainage lines or easements originating from outside the site. 	<ul style="list-style-type: none"> Not applicable.
	<ul style="list-style-type: none"> Where an existing drainage line runs under a proposed building, the drainage line and any associated easement is to be diverted around the building. Redundant easements are to be extinguished and new easements are to be created. 	<ul style="list-style-type: none"> Not applicable.
	<ul style="list-style-type: none"> Where an existing drainage system across the site is retained, access to the existing system is not to be affected by the proposed development. Also, the development is to be designed so as not to degrade the structural integrity of the system. 	<ul style="list-style-type: none"> Section 3.5 notes that the existing farm dam is to remain on site. Access to the second order watercourse and the existing dam will need to be provided as part of the proposed development to ensure they can be monitored and maintained as required.

Item	DCP Requirement	How addressed?
N. Stormwater drainage design – residential cont.	<ul style="list-style-type: none"> Water re-use within the dwelling and for landscaping purposes is encouraged, through the installation of rainwater tanks. 	<ul style="list-style-type: none"> Section 6.2.2.7 notes roof rainwater runoff will be captured in 3kL rainwater tanks and reused within the household.
	<ul style="list-style-type: none"> Stormwater drainage complies with AS 3500.3. 	<ul style="list-style-type: none"> Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	<ul style="list-style-type: none"> Pits are installed to collect water from the low points in yards. 	<ul style="list-style-type: none"> A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	<ul style="list-style-type: none"> Down pipes and pits are to be connected to the 'discharge controls' for the site. 	<ul style="list-style-type: none"> Individual lot runoff is expected to be assessed on a lot-by-lot basis and designed in accordance with AS3500.3. A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	<ul style="list-style-type: none"> The site discharge indicator for the development is no more than 0.3 determined under Water Smart Practice Note No. 11 – Site Discharge Indicator. Preliminary storm water design details demonstrating ability to comply with this requirement are to be submitted with the development application. 	<ul style="list-style-type: none"> It is not possible to assess this requirement based on the information contained in the Stormwater Management Report (ACOR, 2021).
P. Flooding, runoff regimes & stormwater collection	<ul style="list-style-type: none"> Development is to be designed so that runoff from low intensity, common rainfall is equivalent to the runoff from a natural catchment. This can be achieved by intercepting and storing runoff in extended storage detention basins and discharging at greatly reduced rates. 	<ul style="list-style-type: none"> Section 5.3.8 and Section 5.3.9 note that post developed flows on the western site boundary, through the second order creek, do not increase beyond the pre-developed state. As such, no detention is required.

Item	DCP Requirement	How addressed?
P. Flooding, runoff regimes & stormwater collection cont.	<ul style="list-style-type: none"> Alternatively, existing degraded downstream streams can be sympathetically engineered to re-establish a natural riparian eco system that can cope with the changed hydrological regime. 	<ul style="list-style-type: none"> Section 5.3.9 notes the post developed flows have increased compared to the predeveloped flows on the south-western boundary. However, as there is no downstream development that can be impacted by this increase, a detention basin is not proposed. The Stormwater Management Report (ACOR, 2021) suggests this has been previously agreed by with Council. Section 3.5 notes that a hydraulic analysis has been undertaken by MM Hyndes Bailey (Stormwater Drainage Strategy Peppertree Estate Scone, 2017) on the second order stream traversing through the site. Review of this report suggests flood impacts have not been assessed as a result of the introduction of fill within the 1% AEP.
	<ul style="list-style-type: none"> Developments are to be designed in accordance with Australian Rainfall and Runoff and the NSW Floodplain Development Manual. 	<ul style="list-style-type: none"> The development has been modelled using DRAINS, the RFFE tool and HEC-RAS. As previously discussed, some updates to this modelling methodology and the parameters used are recommended to ensure the investigation is prepared in accordance with current best practice guidelines.
	<ul style="list-style-type: none"> Development is to be designed so that overflows do not adversely affect neighbouring properties by way of intensification, concentration or inappropriate disposal across property boundaries. This can be achieved by securing appropriate easements over downstream properties or discharging overflows directly to the street system where feasible. 	<ul style="list-style-type: none"> As mentioned, discharge through the electrical easement and to private land in the south-western corner will need to be reviewed to ensure it does not create a significant adverse impact. A formal drainage easement is expected to be required. Section 3.5 notes that a hydraulic analysis has been undertaken by MM Hyndes Bailey (Stormwater Drainage Strategy Peppertree Estate Scone, 2017) on the second order stream traversing through the site. Review of this report suggests flood impacts have not been assessed as a result of the introduction of fill within the 1% AEP.

Item	DCP Requirement	How addressed?
P. Flooding, runoff regimes & stormwater collection cont.	<ul style="list-style-type: none"> Overflows from paved areas adjacent to the property boundary are to be directed by a kerb or formed gutter to drain away from neighbouring properties. 	<ul style="list-style-type: none"> A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate). Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	<ul style="list-style-type: none"> Surface levels are to be graded such that sites are generally free draining with sufficient overflow capacity to ensure that waters do not enter buildings when underground drainage systems are beyond their capacity. 	<ul style="list-style-type: none"> A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate). Design of the local major and minor network will need to be performed assuming the sites fully developed state (without infiltration or detention). Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	<ul style="list-style-type: none"> Drainage pits are to be installed so that nuisance water does not collect at low points. 	<ul style="list-style-type: none"> A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	<ul style="list-style-type: none"> Gutters, down pipes and pits are to be connected to the stormwater management system for the site. Australian Standard 3500.3 sets appropriate standards for stormwater collection and is to be followed when constructing new development. 	<ul style="list-style-type: none"> Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.

Item	DCP Requirement	How addressed?
	<ul style="list-style-type: none">Public use areas satisfy relevant flood safety criteria as assessed with reference to the NSW Floodplain Development Manual.	<ul style="list-style-type: none">Section 4 notes that the development will consist of three public parks and an open space which are shown in the design drawings.Public safety, flood protection (including the Flood Planning Area), risk to life and evacuation is not discussed in the Stormwater Management Report (ACOR, 2021). Not enough information is provided to be able to assess this accurately.

Recommendations

Presented below is a summary of the recommended updates to the Stormwater Management Strategy (ACOR, 2021).

- Model hydrology should be updated to consider the use of the latest NSW Specific Rainfall Losses and Hierarchy Approach recommended by NSW OEH and the ARR 2019 EIA/ ICIA split.
- Definition of riparian extents should be prepared and placement of Water Quality devices in accordance with NRAR Controlled Activities on Waterfront Land guidelines should be reviewed.
- The design for the creek culvert crossing should be reviewed with respect to blockage and climate change and the difference in sizing with previously completed studies for the area should be discussed.
- The proposed evacuation access track and/ or culvert crossing should be reviewed with respect to risk to life and evacuation.
- The difference between peak flows observed in the Stormwater Management Plan (ACOR, 2021) and other similar studies in the area should be discussed.
- A detailed two-dimensional flood assessment and report be prepared in accordance with the UHSC DCP Part 10a to analyse (as a minimum):
 - The existing case flood behaviour including hydraulic categories (i.e. floodway, flood storage and flood fringe).
 - The developed case flood behaviour, including a review of the sizing of the proposed creek culvert crossing.
 - The flood impact of the proposed development for the full range of storm events up to and including the PMF.
 - Define the Flood Planning Area (FPA) for the proposed development.
 - Ensure all proposed lots, roads and infrastructure are positioned in accordance with Council's LEP/ DCP and the NSW Floodplain Policy.
 - Define tailwater levels for the proposed local stormwater network.
 - Review the impact of climate change.
 - Measures to manage the risk to life and property including a review of the sizing of the proposed creek culvert crossing and / or the proposed evacuation access track.
 - Review Gundy Road overland flow capacity to confirm whether the proposed lots fronting Gundy Road are flood prone.
 - Review development compliance with the necessary flooding related LEP/ DCP requirements and the NSW Floodplain Policy.
 - Review the findings with respect to stormwater detention presented in the Stormwater Management Plan (ACOR, 2021).
- Review necessary stormwater management measures for the south-western corner to ensure stormwater discharge does not adversely impact both water quality and quantity at the site discharge point and within downstream waterways.

- The existing Dam, to be maintained post development, should be reviewed from a dam safety perspective to determine whether it is required to be declared for the purposes of the Dam Safety Act 2015.

Conclusion

A peer review of the Stormwater Management Report (ACOR, 2021) has been presented herein.

It was concluded that a Flood Study should be prepared, and the Stormwater Management Plan updated, to enable a detailed assessment of the proposed development in accordance with Upper Hunter Shire Council's Local Environmental Plan (2013) and Development Control Plan (2015). A number of recommendations have been made for the reports to assist in satisfying the LEP / DCP requirements.

We trust this is what you require and if you have any queries, please feel free to contact the undersigned on (02) 4943 1777.

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Attachment 1 – Stormwater Management Report (ACOR, 2021)

Stormwater Management Plan for DA

Peppertree Estate, Gundy Road SCONE

Prepared for: Charles David Pty Ltd

Document no: NSW202732_R01.01

Revision no: 01



Source: Near Maps

Disclaimer

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Revisions

Revision	Description	Date	Prepared by	Approved by
01	For Approval	19 August 2021	Ulrika Knight	Josh Rhodes

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1 Introduction

ACOR Consultants have been engaged by Charles David Pty Ltd C/- MM Hyndes Bailey & Co to prepare a Stormwater Management Plan for Development Approval for a residential subdivision development at Lot 2 (DP1169320) Gundy Road, Scone.

The stormwater drainage items addressed in this report include:

- Stormwater conveyance/network;
- Stormwater detention
- Operational water quality management incorporating Water Sensitive Urban Design (WSUD) principles
- Construction water quality management incorporating soil and water management.

2 Previous Stormwater Drainage Assessments

The following stormwater drainage assessment have been completed previously for the proposed subdivision development at this site by others:

- *Stormwater Drainage Strategy Peppertree Estate Scone* by MM Hyndes Bailey dated November 2017
- *Stormwater Quality Report* by Barker Ryan Steward dated November 2017
- *Stormwater Drainage Strategy Supplementary Report 70-80% Impervious Peppertree Estate Scone* by MM Hyndes Bailey dated November 2019

The site layout for the proposed subdivision has been revised and as such an updated Stormwater Drainage Management Plan is required and is contained within this report.

3 Site

3.1 Location

The site is located east of Scone at Lot 2 Gundy Road, Scone. The proposed development is bounded by Gundy Road to the north, rural properties to the east and south, and abuts to the age care facility "Strathearn" to the north west. Refer to Figure 1 for Locality Plan.

3.2 Topography

The existing site comprises of approximately 57 Hectares of gently sloping grasslands. There is a second order stream traversing through the site from east to west. The stream divides the proposed development into a northern section and a southern section.

The northern section of the site grades at approximately 4% from the north east to the south west towards the stream. The levels on site for the northern section range from approximate RL 226m AHD at the north east boundary to RL 214m AHD at the south west boundary at the stream.

Most of the southern section of the site grades at approximately 5% from the south east to the north west towards the stream. There is a crest in the southern section of the site that runs from east to west which means that a small section of the southern area grades to the south west. The levels for the southern section range from approximately RL 243m AHD at the south east boundary to RL 208m AHD at the north west boundary at the stream and RL 215m AHD at the south west boundary.

A farm dam is located within the site at the eastern end of the stream.

Refer to Figure 2 for the existing site topography.

3.3 Existing Land Use and Vegetation

The site in its current condition is mostly cleared grassland with some trees within the stream.

3.4 External Catchments

There is an upstream catchment north east of the site that drains to the culverts under Gundy Road and then feeds the stream through the development site from the east. This catchment is approximately 98 Hectares and is mostly grassland with some trees. The most northern part of this catchment is within the Scone Mountain National Park and has more vegetation than the lower section of the catchment.

There is an upstream catchment to the east of the site that feeds the stream through the development site. This catchment is approximately 53 Hectares and is mostly grassland.

The development site has frontage to Gundy Road. Gundy Road has a grassed swale along both sides of the road. In minor storm events, flows are directed to the west along Gundy Road but in major storm events the flows that cannot be contained within the grassed swale overflow into the development site and are directed south west to the stream traversing through the site.

The upstream external catchments draining through the development site are shown in Figure 3.

3.5 Existing Flowpaths and Water Bodies

There is a second order stream traversing through the site from east to west. This stream is fed from the upstream catchments to the north east under Gundy Road and to the east of the site. The stream is not well defined in places but is generally in good condition with minimal scouring.

A hydraulic analysis was undertaken by MM Hyndes Bailey on the second order stream. The results from the study are detailed in MM Hyndes Bailey report *Stormwater Drainage Strategy Peppertree Estate Scone* dated November 2017, Section 5.

There is a farm dam located at the eastern site boundary within the stream. This dam is to remain, but further investigation will be required at the construction certificate stage to ensure that the overflows from the dam for 1% AEP flows are safe and do not impact the proposed residential lots.

4 Proposed Development

The proposed development will consist of four hundred and one (401) residential lots, three (3) public parks and an open space, as well as associated roads, stormwater drainage infrastructure including detention and water quality basins. The subdivision is proposed to be development in sixteen (16) stages. The lot areas and staging details are shown in Table 1.

Table 1: Lot areas and staging details

Development Stage	Lot numbers	Lot areas m ²
1	101 – 121 (21 lots)	701 – 1301
2	201 – 226 (25 lots and a park)	701 – 1032
3	301 – 314 (14 lots)	739 – 1100
4	401 - 418 (18 lots and a park)	703 – 898
5	501 – 525 (25 lots and a park)	703 – 1094
6	601 – 630 (30 lots)	705 – 1055
7	701 – 723 (23 lots)	707 – 982
8	801 – 832 (32 lots)	701 - 1348

9	901 – 927 (27 lots)	706 - 1077
10	1001 – 1034 (34 lots)	708 - 1222
11	1101 – 1121 (21 lots)	701 - 1016
12	1201 – 1236 (36 lots)	709 - 1070
13	1301 – 1327 (26 lots and drainage easement)	702 - 1373
14	1401 – 1428 (28 lots)	770 - 1277
15	1501 – 1521 (21 lots)	707 - 977
16	1601 – 1620 (20 lots and open space)	704 – 821

Access to the subdivision will be from Gundy Road.

Stages 1, 2 and 3 are located on the northern side of the stream adjacent to Gundy Road.

The remainder of the stages are located on the southern side of the stream. A road crossing with reinforced concrete box culverts is proposed to span the stream to the southern side of the development.

Figure 4 shows the development layout for the subdivision.

5 Stormwater Quantity Management

5.1 Objectives

The objectives of the stormwater quantity management for the site are:

- Provide a stormwater conveyance system in accordance with Australian Rainfall and Runoff's minor/major system philosophy and the requirements of Upper Hunter Shire Council (UHSC). The minor stormwater conveyance system will be designed to convey peak flows from the 20% Annual Exceedance Probability (AEP) storm event and the major stormwater conveyance system will be designed to convey the peak flows from the 1% AEP storm events.
- Provide stormwater detention to reduce the peak flows from the site to or below the current peak runoff from the site.

5.2 Stormwater Conveyance

5.2.1 Minor Storm Event Conveyance

Minor system stormwater conveyance for the development will be a via a traditional pit and pipe system. The minor stormwater system will have the capacity to convey the peak flows from a 20% AEP storm event.

Figures 5 and 6 show a preliminary layout for the stormwater drainage system.

5.2.2 Major Storm Event Conveyance

Major system stormwater conveyance for the proposed development will be via overland flow. This will be via traditional trunk drainage utilising the road carriage way and footpath. The major stormwater system will have the capacity to convey the peak flows from a 1% AEP storm event, containing flows within the road reserve and limiting velocity depth product to or below 0.4 m²/s.

5.3 Stormwater Detention

5.3.1 General

Stormwater detention needs to be provided to ensure that the post development flows from the total site are reduced to the predevelopment flows for AEPs from 20% to 1% so that downstream properties are not impacted by increased flows from this proposed development.

The previous stormwater drainage study only considered the development site in the modelling.

This stormwater drainage study is a full catchment analysis and includes the upstream catchments that drain through the stream traversing through the proposed development.

5.3.2 DRAINS Modelling

DRAINS modelling was undertaken to determine the predeveloped and developed peak flows at the western boundary for a range of AEPs from 20% to 1%, for storm durations ranging from 5 minutes to 6 hours. ARR 2019 procedures were utilised in the DRAINS models.

The available detention volumes from the rainwater tanks which are a requirement of BASIX for each dwelling were not accounted for in the modelling.

The large undeveloped rural catchments were modelled using RAFTS storage routing model within DRAINS. For sub-catchment routing, RAFTS uses the equation:

$$S = BX \cdot IBFL \cdot PERN \cdot 0.285 A^{0.52} \cdot (1+U)^{-1.97} \cdot Sc^{-0.50} \cdot Q^{0.715}$$

where BX is a calibration factor similar to RORB's kc, IBFL is a factor for modelling overbank flow, PERN is a factor that adjusts the catchment routing factor to allow for catchment roughness, A is the sub-catchment area (km²), U is the fraction of the catchment that is urbanized, and Sc is the main drainage slope of the sub-catchment.

For routing along stream reaches, RAFTS applies a translation over a nominated time, or performs Muskingum-Cunge routing based on the stream cross-section and roughness.

The proposed developed catchments were modelled using the Initial Loss – Continuing Loss (IL-CL) model. The IL-CL hydrology procedure in DRAINS is an alternative to Horton (ILSAX). Both methods are accepted in the ARR 2019 guidelines and discussed in Book 5 Chapter 3. The IL-CL model and its parameters are set out in Section 3.5.3 of ARR 2019.

5.3.3 Rainfall Data

The Australian Rainfall and Runoff Data Hub was used to obtain data (Storm Losses, Temporal Patterns, BOM IFD Depths, Median Preburst Depths and Ratios and Interim Climate Change Factors) for the development site.

5.3.4 Fraction Impervious

The fraction impervious to be used in stormwater drainage modelling is outlined with UHSC DRAFT Engineering Guidelines for Subdivisions and Developments Table 5.5 and shown in Table 2.

Table 2: Fraction Impervious for Various Land Use

Land Use	Fraction Impervious
Normal residential lot only	0.6
Normal residential lot including half road	0.65
Half width road reserve	0.8
Public recreation areas	0.4
Open space (natural bushland)	0.35

For the upstream catchments, a fraction impervious of 0.35 was adopted for rural/natural bushland.

To be conservative in determining the predeveloped and post developed flows at the western boundary, a fraction impervious of zero (0) was adopted for the predeveloped site (existing rural property) and a fraction impervious of 0.75 was adopted for the proposed subdivision in the DRAINS models.

5.3.5 Time of Concentration

Time of concentration for the catchments that are modelled using RAFTS was determined by the program. Catchment information such as area, fraction impervious, catchment slope and a Manning's n value are entered into the Sub-Catchment Data.

The Manning's n values adopted for the modelling are in line with recommendations from Australian Rainfall and Runoff: A Guide to Flood Estimation Table 6.2.2. The relevant land use and the recommended Manning's n range are shown in Table 3.

Table 3: Land Use Type and Recommended Manning's n

Land Use Type	Recommended Manning 'n'
Open pervious areas, nominal vegetation (grassed)	0.03 – 0.05
Open pervious areas, moderate vegetation (shrubs)	0.05 – 0.07
Open pervious areas, thick vegetation (trees)	0.07 – 0.12
Waterways/channels – minimal vegetation	0.02 – 0.04
Waterways/channels – vegetated	0.04 – 0.1

A Manning's n value of 0.05 was adopted for the external catchments (rural/natural bushland).

A Manning's n value of 0.04 was adopted for the predevelopment site catchment (rural grassed).

A Manning's n value of 0.04 was adopted for the stream traversing through the development site (waterways with minimal vegetation and trees).

The minimum time of concentration adopted for the developed catchments utilising the Initial Loss – Continuing Loss Model are 5 minutes for the impervious catchments and 10 minutes for pervious catchments. This is the time of concentration for lot runoff. Additional flow travel times were added to the developed catchments in accordance with Queensland Urban Drainage Manual Section 4.6.7.

5.3.6 Predeveloped Peak Discharge

The peak discharge for the predeveloped catchments in accordance with Figure 3 are shown in Table 4.

The two upstream catchment (EXTL A and B) and Site A catchment all discharge at the western boundary of the site. Site B catchment discharges at the south west boundary of the site.

Table 4: Predeveloped Catchment Flows

Catchment Name	Area (Ha)	Predeveloped Peak Discharge m ³ /s (AEP)				
		20%	10%	5%	2%	1%
EXTL A	97.773	12.9	17.3	20.8	25.9	30.3
EXTL B	52.601	6.11	7.5	9.39	12.1	14.5
SITE A	48.752	2.3	3.07	3.89	4.89	602
Peak discharge at west boundary		20.9	25.4	31.8	40.3	47.6
SITE B	9.217	0.523	0.737	0.921	1.18	1.42
Peak discharge at south west boundary		0.523	0.737	0.921	1.18	1.42

The DRAINS input data and results are contained in Appendix A.

5.3.7 Post Development Peak Discharge

The details for catchments EXTL A and EXTL B are as per the predeveloped model and the flows are the same.

Catchment Site A has been divided into catchments to represent the existing stream traversing the site, and the subdivision development at relevant discharge points. Refer to Figure 7 for the post development catchment plan.

The proposed road crossing the existing stream was also incorporated into the DRAINS model. Reinforced concrete box culverts (RCBC) were modelled as detailed below:

- Top of road RL 216.0
- Pavement thickness allowed for 500mm
- 2400x750 RCBC – 11 culverts required
- Invert of RCBC RL214.575
- Length of culverts 30m

The peak discharge for the post developed catchments at the western boundary and the south west boundary are shown in Table 5.

Table 5: Post developed Peak Flows

Storm Event (AEP)	Post Developed Peak Discharge m ³ /s (AEP)	
	At west boundary	At south west boundary
20%	20.3	0.891
10%	25.6	1.1
5%	31.5	1.3
2%	40.2	1.58
1%	47.2	1.81

The DRAINS input data and results are contained in Appendix A.

5.3.8 Post versus Predeveloped Peak Discharge

The comparison of the predeveloped and post developed peak flows at the western boundary are shown in Table 6.

Table 6: Post versus Predeveloped Peak Flows at Western Boundary

Storm Event (AEP)	Peak Discharge at Western Boundary m ³ /s (AEP)		Difference %
	Predeveloped	Post developed	
20%	20.9	20.3	-2.9%
10%	25.4	25.6	0.8%
5%	31.8	31.5	-0.9%
2%	40.3	40.2	-0.2%
1%	47.6	47.2	-0.8%

The comparison of the predeveloped and post developed peak flows at the south west boundary are shown in Table 7.

Table 7: Post versus Predeveloped Peak Flows at South West Boundary

Storm Event (AEP)	Peak Discharge at South West Boundary m ³ /s (AEP)		Difference %
	Predeveloped	Post developed	
20%	0.523	0.891	70%
10%	0.737	1.100	49%
5%	0.921	1.300	41%
2%	1.180	1.580	34%
1%	1.420	1.810	27%

5.3.9 Detention Basins

It is a standard requirement for most councils including UHSC, that stormwater detention be provided to ensure that the post developed from are reduced to the predeveloped flows for AEPs from 20% to 1% so that downstream properties are not impacted by increased flows from this proposed development.

The stormwater drainage modelling undertaken is a catchment wide analysis and includes the upstream catchments running through the site as well as the proposed development. As the proposed development is at the downstream end of the overall catchment draining to the western boundary of the site, the flow travel times from each catchment are important.

Generally, with this sort of catchment configuration, the post development flows are found to only increase marginally or not at all. As the post developed catchment times of concentrations are shorter, the flows from the developed catchment have already travelled downstream before the flows from the larger undeveloped upstream catchment have arrived downstream.

This is evident in the post developed peak flows draining to the western boundary via the existing stream shown in Table 6. The post developed peak flows are below the predeveloped peak flows for all storm events except for 10% AEP. The increase in flows for the 10% AEP is less than 1% which is within the accuracy of the stormwater

drainage modelling and will have minimal impact downstream. Therefore, no detention basins are required to reduce the post developed flows at the western boundary.

With the catchment configuration for this site, providing detention at the downstream end of the catchment will only increase the flows at the western boundary as the travel flow times for the developed catchments are lengthened due to the detention basin. This will result in the flows discharging from the basin aligning with the large upstream flows and increasing the overall peak flows at the western boundary.

As detailed above, approximately 9.2 hectares of the southern catchment of the site currently drains to the south west. With the proposed development, this area will be reduced to approximately 4.9 hectares.

As can be seen from Table 7, the post developed flows have increased compared to the predeveloped flows due to the increased fraction impervious of 75% for the proposed development.

As there is no downstream development that can be impacted by this small flow increase, a detention basin to reduce the flows will not be provided at this location. This strategy was previously agreed to by council.

6 Stormwater Quality Management

6.1 Objectives

The objectives of the Stormwater Quality for the site are:

- Meet the water quality objectives of Upper Hunter Shire Council (UHSC) for the operational phase of the site by using best practice stormwater treatment measures.
- The strategy for stormwater quality management as detailed in the report prepared by Barker Ryan Stewart *Stormwater Quality Report* dated November 2017 has been approved by Council, and states:

“Consultation was undertaken with Council to set a water quality target that would meet the objectives of the UHSC DCP, that is ‘to ensure that stormwater generated from development does not result in pollution of water courses or receiving waters’. Mathew Pringle, Director of Environmental and Community Services advised that the pre-development forested condition of the site would be a suitable guide and an acceptable target for this development.”

6.2 Operational Phase Water Quality Management

6.2.1 General

To meet the water quality requirements of UHSC, a range of water quality improvement devices will be required.

The proposed water quality improvement devices for the site will include:

- rainwater tanks
- Ecosol GPTs
- bioretention basins

The above water quality improvement devices act as a treatment train, progressively reducing pollutants as they pass through each one.

6.2.2 Stormwater Quality Modelling

6.2.2.1 Introduction

The MUSIC model version 6.3 was used to assess the pollutant generation from the development and the performance of the stormwater quality treatment train.

6.2.2.2 Rainfall Data and Evaporation Data

The rainfall data and evapotranspiration data collected from the Liddell Power Station was used in line with the previous MUSIC modelling undertaken by Barker Ryan Stewart (as discussed above).

6.2.2.3 Soil Types

As detailed in the Barker Ryan Stewart report, the soil profile at the development site is composed of heavy clay underlain by coarse light medium clay. This information was obtained from *"The Soils Essential Report – NSW Soil and Land Information System for Scone High School"*.

6.2.2.4 Catchments

The catchments for the MUSIC modelling are the same as the catchment used in the DRAINS modelling discussed above. Refer to Figure 7 for the post development catchment plan.

The catchments for the MUSIC modelling were subdivided into road areas, roof areas and remaining lot areas as detailed in Table 8.

Table 8: MUSIC Modelling Catchments

Catchment	CAT 1	CAT 2	CAT 3 & 6	CAT 4
Number of lots	70	60	235	36
Lot areas (Ha)	3.83	3.74	13.29	2.67
Roof areas (Ha)	1.75	1.50	5.88	0.90
Road areas (Ha)	1.67	2.64	6.73	1.37
Total catchment area (Ha)	7.25	7.87	25.90	4.94

A fraction impervious of 80% was adopted for the roads.

The residential lots were divided up into roof areas and remaining lot areas. It was assumed that for an average size lot (800m²) with a fraction impervious of 75% and a roof area is 250m², the remaining lot is 550m² with a fraction impervious of 64%. Therefore, conservatively a fraction impervious of 65% was adopted for lots (excluding roof area).

In line with UHSC advice, the pre-existing (forest) catchment was model in MUSIC to compare the mean annual pollutants loads with the post developed catchment.

Currently the site is used for farming/agriculture, so this catchment type was also model in MUSIC for comparison.

6.2.2.5 MUSIC Model Source Inputs

The source data for the MUSIC model was adopted from the Sydney Catchment Authority (SCA) MUSIC Manual in line with the modelling undertaken by Barker Ryan Stewart.

Table 9: MUSIC Source Node Soil Properties

Soil Parameter	Value
Rainfall Threshold (mm/day)	Roofs 0.3 / Roads 1.5 / Land uses 1.0
Soil Storage Capacity (mm)	90
Initial Storage (% of Capacity)	25
Field Capacity	58
Infiltration Capacity Coefficient – a	135
Infiltration Capacity Coefficient – b	4
Groundwater Initial Depth (mm)	10
Groundwater Daily Recharge Rate (%)	10
Groundwater Daily Base Flow (%)	10
Groundwater Daily Deep Seepage Rate (%)	0

6.2.2.6 Catchments Pollutant Mean Concentrations

The pollutant Event Mean Concentration (EMC) values were adopted from SCA MUSIC Manual for both the base flows and storm flows. The base flow values are shown in Table 10 and the storm flow values are shown in Table 11 for various catchment types.

Table 10: Base Flow Pollutant Event Mean Concentration Values

Catchment Type	Base Flow Pollutant Event Mean Concentration Values					
	TSS (log 10)		TP (log 10)		TN (log 10)	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Forest	0.78	0.13	-1.52	0.13	-0.52	0.13
Agriculture	1.30	0.13	-1.05	0.13	0.04	0.13
Road (mixed)	1.10	0.17	-0.82	0.19	0.32	0.12
Roof	0	0	0	0	0	0
Residential lots	1.20	0.17	-0.85	0.19	0.11	0.12

Table 11: Storm Flow Pollutant Event Mean Concentration Values

Catchment Type	Storm Flow Pollutant Event Mean Concentration Values					
	TSS (log 10)		TP (log 10)		TN (log 10)	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24
Agriculture	2.15	0.31	-0.22	0.3	0.48	0.26
Road (mixed)	2.20	0.32	-0.45	0.25	0.42	0.19
Roof	1.30	3.20	-0.89	0.25	0.30	0.19
Residential lots	2.15	0.32	-0.60	0.25	0.30	0.19

6.2.2.7 MUSIC Model Treatment Train

The stormwater quality treatment train consist of three parts; rainwater tanks, Ecosol GPTs and bioretention basins. A schematic of the MUSIC model is shown in Appendix B.

A brief description on each treatment measure is listed below.

- **Rainwater Tanks** - Rainwater tanks receive water from the roof area of each lot. A 3kL rainwater tank was assumed for each standard residential lot. Water captured in the rainwater tanks is expected to be reused for toilet flushing, clothes washing, hot water and garden irrigation. An average of 4 persons was assumed for each house. The reuse per house was adopted from SCA MUSIC Manual Table 5.4. The reuse adopted for each lot is shown in Table 12.

Table 12: Rainwater Tank Reuse (per lot)

Rainwater Reuse	
Internal (kL/yr/dwelling)	343
External (kL/yr/dwelling)	55
Total (kL/yr/dwelling)	398

- **Ecosol GPTs** are proposed to be installed at all pipe outlets. The GPTs remove gross pollutants, sediment and attached nutrients. The MUSIC node for the GPT was provided by Ecosol. The removal efficiencies have been confirmed via independent testing. An equivalent product could be used. The flows to the GPT will be limited to the 50% of the peak 63.2% AEP storm in accordance with SCA MUSIC Manual Table 5.5. Table 13 shows the removal efficiencies of the Ecosol GPT.

Table 13: Ecosol GPT Removal Efficiencies

Gross Pollutant Removal (%)	TSS Removal (%)	TP Removal (%)	TN Removal (%)
98	61	29	1

- **Bioretention Basins** are the final part of the treatment train for this development. Three bioretention basin are proposed to be provided. Bioretention systems remove sediments (TSS) as well as nutrients (TN and TP) from the stormwater. The bioretention basin consists of a shallow dry basin with deep rooted vegetation and grass on the surface, over an infiltration/filtration area and an underdrain area.

Vegetation in the bioretention basins will be in accordance with Upper Hunter Shire Council requirements.

To avoid potential salinity problems, an impermeable HDPE liner is to be provided in the bioretention basins to prevent any water infiltrating into the surrounding basin areas.

The MUSIC inputs for the three bioretention basins are shown in Table 14.

Table 14: Bioretention Basin MUSIC Model Inputs

	Basin 1	Basin 2	Basin 3
Extended Detention Depth (m)	0.3	0.3	0.3
Surface Area (m2)	1800	480	4800
Filter Area (m2)	1500	400	4000
Unlined Filter Material (m)	80	80	80
Saturated Hydraulic Conductivity (mm/hr)	100	100	100
Filter Depth (m)	0.4	0.4	0.4
TN Content of Filter Media (mg/kg)	800	800	800
Orthophosphate of Filter Media (mg/kg)	55	55	55
Exfiltration Rate (mm/hr)	0	0	0
Base Lined	Yes	Yes	Yes
Vegetation Removing Plants	Yes	Yes	Yes
Under Drain Present	Yes	Yes	Yes

6.2.2.8 Stormwater Quality Modelling Results

The mean annual pollutant loads from the MUSIC model for the pre-existing site (forest), predeveloped site (agricultural) and the post developed site (residential subdivision) are shown in Table 15.

Table 15: Mean Annual Pollutant Loads

	Mean Annual Pollutant Loads		
	Pre-existing Forest	Predeveloped Agricultural	Post developed Residential Subdivision
TSS (kg/yr.)	2610	11000	1290
TP (kg/yr.)	5.35	45.1	12.6
TN (kg/yr.)	61.6	212	107
Gross Pollutants (kg/yr.)	2480	2480	7.79

For the post developed (residential subdivision), the Mean Annual Pollutant Loads for TSS have been reduced below the pre-existing conditions (forest), but the TP and TN could not be reduced with the proposed treatment train.

The Mean Annual Loads for the post developed site have been reduced to below the predeveloped site conditions (agriculture) as shown in Table 15.

Most councils within the Hunter provide targets for the pollutant reductions for TSS, TP and TN. For example, the reductions in the average annual loads for Maitland Council are 85% for TSS, 45% for TP and 45% for TN.

Table 16 below shows the reductions achieved in the average annual loads for the proposed development, and hence the effectiveness of the proposed treatment train. The percentage reductions are higher than required for most councils in the Hunter.

Table 16: MUSIC Model Treatment Train Effectiveness

	Source Mean Annual Load	Residual Mean Annual Load	% Developed Reduction
TSS (kg/yr.)	16900	1290	92.4
TP (kg/yr.)	33.7	12.6	62.5
TN (kg/yr.)	282	107	62
Gross Pollutants (kg/yr.)	4250	7.79	99.8

The results of the MUSIC modelling show that the proposed water quality treatments sufficiently reduce the pollutants to an acceptable level. The MUSIC modelling summary report detailing the inputs and results are shown in Appendix B.

6.3 Construction Phase Water Quality Management

6.3.1 General

During the construction phase of the development, an Erosion and Sediment Control Plan will be implemented to minimise the water quality impacts. The erosion and sediment controls will be in accordance with Landcom's Managing Urban Stormwater: Soils and Construction Volume 1, 4th Edition (Landcom, 2004) and the requirements of UHSC. Erosion and sediment controls will be required preconstruction, during construction and post construction until the site is stabilized. The expected erosion and sediment control measures will include stabilized site access, sediment fence, gully pit sediment barriers, rock outlet scour protection and a temporary sediment basin. Erosion and sediment control plans will be provided for the development at the Construction Certificate stage.

6.3.2 Pre-Construction Erosion and Sediment Control

Due to the topography of the site, the preconstruction erosion and sediment controls will be limited to stabilized site access, sediment fence and a temporary sediment basin until the initial bulk earthworks is undertaken. The proposed water quality basins will be used as a sediment basin while construction is being undertaken.

6.3.3 During Construction Erosion and Sediment Control

During the construction phase of the development, the erosion and sediment controls will consist of installed sediment fence, a constructed sediment basin, gully pit sediment barriers and permanent rock outlet scour protection.

Regular inspection and maintenance of the erosion and sediment controls is required during the construction process.

6.3.4 Post Construction Erosion and Sediment Control

The contractor/developer will be responsible for the maintenance of the erosion and sediment control devices from the practical completion of the works for a minimum of 6 months or until stabilization has occurred to the satisfaction of Council.

It is standard practice to delay the construction of the bioretention filtration media in the basin until a significant proportion of the contributing lots are built on and established.

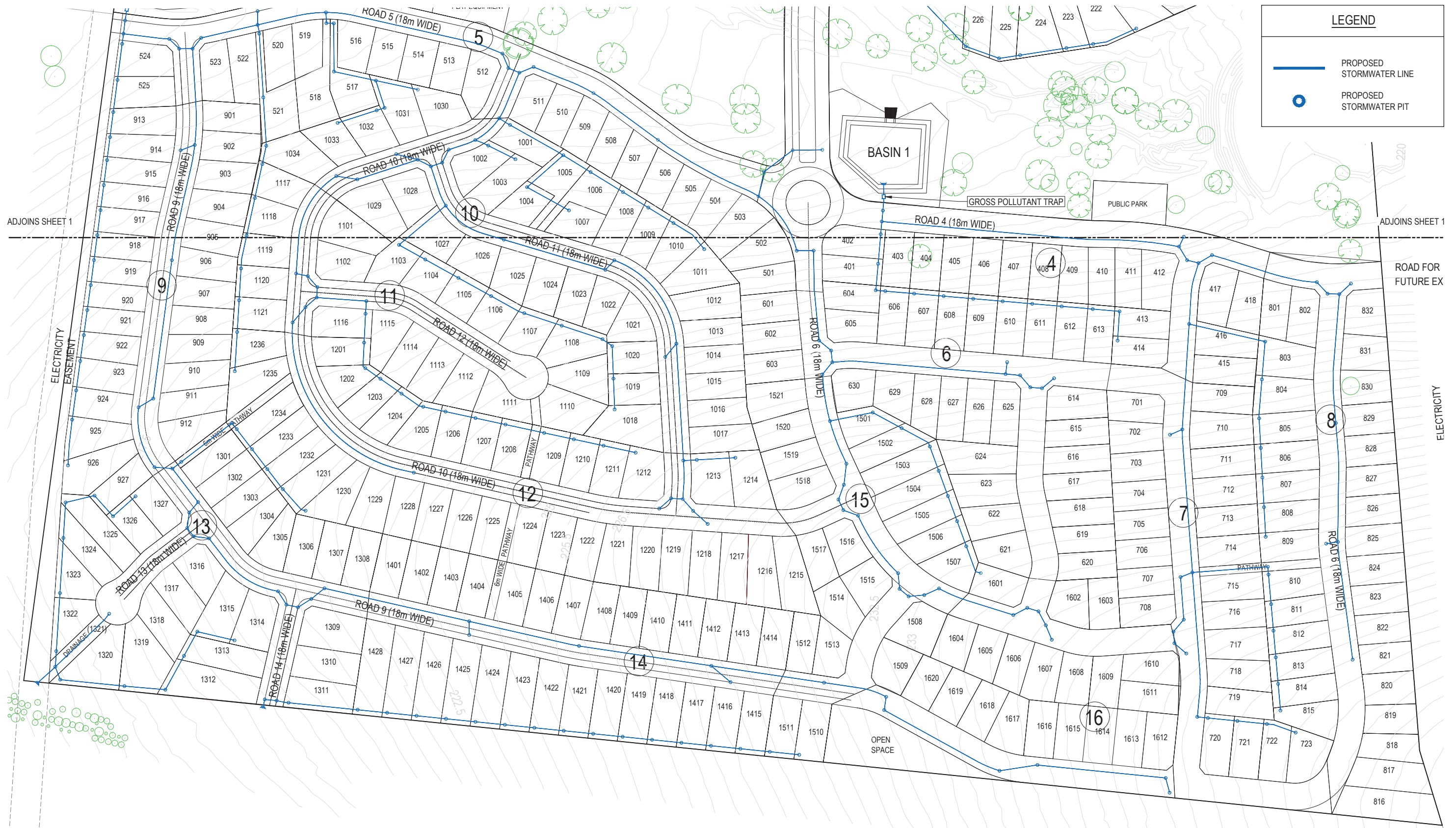
7 Conclusion

The catchment wide modelling undertaken using DRAINS has shown that stormwater detention is not required for the proposed development. Due to the large upstream catchments draining through the existing stream traversing the development site, the post developed flows at the downstream boundary are generally below the predeveloped flows. The proposed installation of the reinforced box culverts under the road crossing between the northern and southern sections of the subdivision also provide some control to the post development flows downstream.

The MUSIC modelling undertaken has shown that the proposed treatment train of rainwater tanks, GPTs and bioretention basins has sufficiently reduced the mean annual pollutants loads from the proposed development. The bioretention basin configuration, levels and inlet/outlet details will need to be confirmed at the Construction Certificate design stage.

During the construction phase of the development, an Erosion and Sediment Control Plan will be implemented to minimise the water quality impacts. Erosion and Sediment Control Plans and details will need to be prepared at the Construction Certificate design stage.

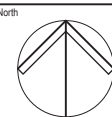
8 FIGURES



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B	ISSUED FOR APPROVAL	19.08.21	ADS	UK
A	NOT ISSUED	-	-	-
Issue	Description	Date	Drawn	Approved



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Project
STORMWATER MANAGEMENT PLAN
LOT 2, DP1169320
GUNDY ROAD, SCONE

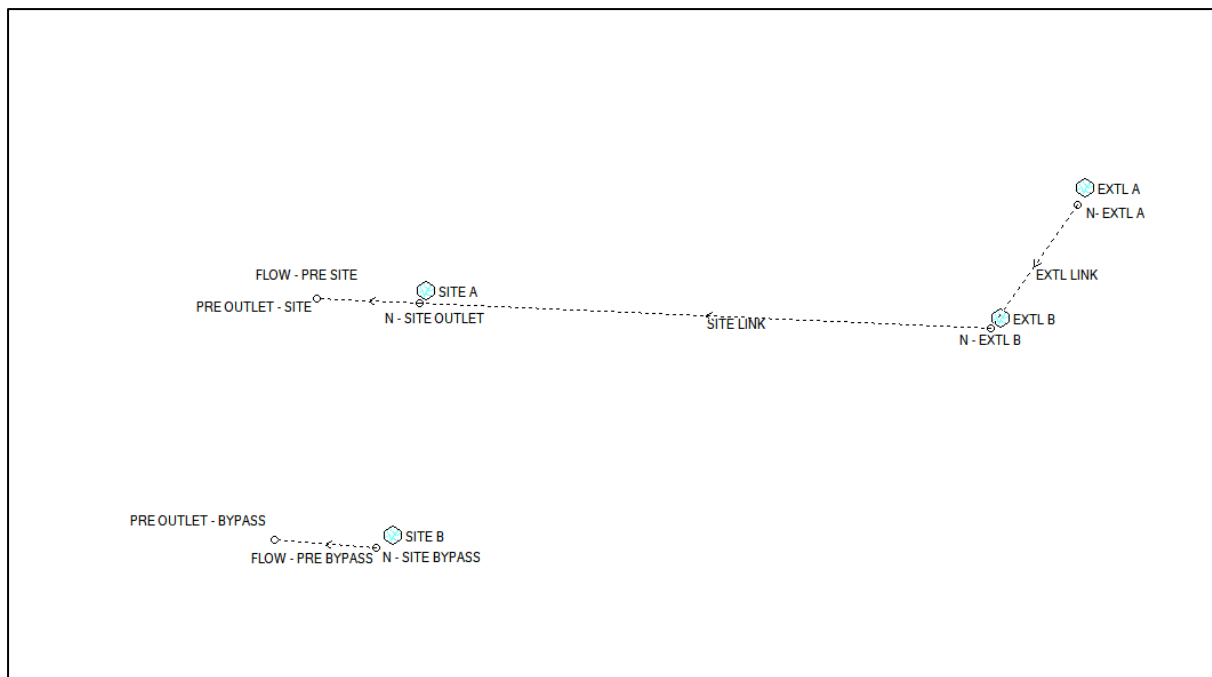
DO NOT REPRODUCE IN GREYSCALE NOT FOR CONSTRUCTION

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Designed UK	Project No. NSW202732	Dwg. No. FIGURE 6	Issue B		

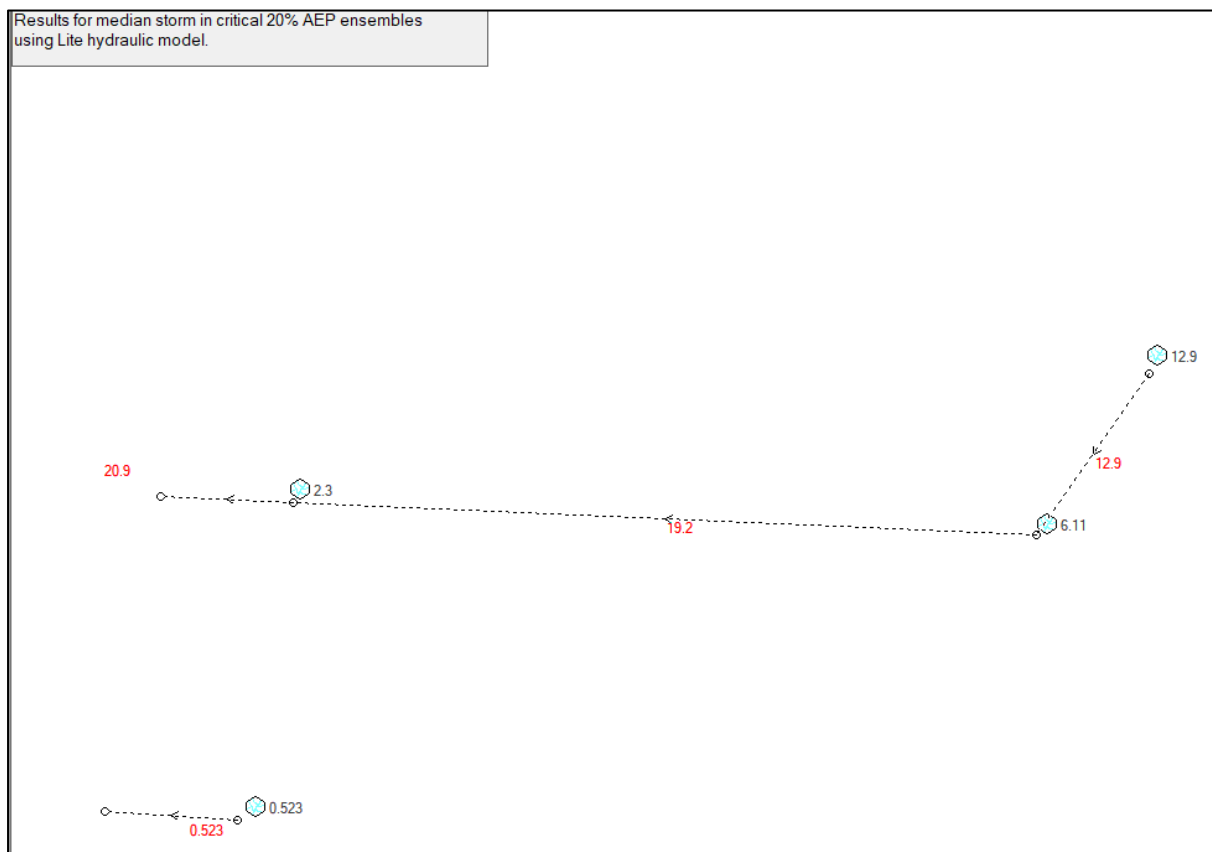
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11550m 11560m 11570m 11580m 11590m 11600m 11610m 11620m 11630m 11640m 11650m 11660m 11670m 11680m 11690m 11700m 11710m 11720m 11730m 11740m 11750m 11760m 11770m 11780m 11790m 11800m 11810m 11820m 11830m 11840m 11850m 11860m 11870m 11880m 11890m 11900m 11910m 11920m 11930m 11940m 11950m 11960m 11970m 11980m 11990m 12000m 12010m 12020m 12030m 12040m 12050m 12060m 12070m 12080m 12090m 12100m 12110m 12120m 12130m 12140m 12150m 12160m 12170m 12180m 12190m 12200m 12210m 12220m 12230m 12240m 12250m 12260m 12270m 12280m 12290m 12300m 12310m 12320m 12330m 12340m 12350m 12360m 12370m 12380m 12390m 12400m 12410m 12420m 12430m 12440m 12450m 12460m 12470m 12480m 12490m 12500m 12510m 12520m 12530m 12540m 12550m 12560m 12570m 12580m 12590m 12600m 12610m 12620m 12630m 12640m 12650m 12660m 12670m 12680m 12690m 12700m 12710m 12720m 12730m 12740m 12750m 12760m 12770m 12780m 12790m 12800m 12810m 12820m 12830m 12840m 12850m 12860m 12870m 12880m 12890m 12900m 12910m 12920m 12930m 12940m 12950m 12960m 12970m 12980m 12990m 13000m 13010m 13020m 13030m 13040m 13050m 13060m 13070m 13080m 13090m 13100m 13110m 13120m 13130m 13140m 13150m 13160m 13170m 13180m 13190m 13200m 13210m 13220m 13230m 13240m 13250m 13260m 13270m 13280m 13290m 13300m 13310m 13320m 13330m 13340m 13350m 13360m 13370m 13380m 13390m 13400m 13410m 13420m 13430m 13440m 13450m 13460m 13470m 13480m 13490m 13500m 13510m 13520m 13530m 13540m 13550m 13560m 13570m 13580m 13590m 13600m 13610m 13620m 13630m 13640m 13650m 13660m 13670m 13680m 13690m 13700m 13710m 13720m 13730m 13740m 13750m 13760m 13770m 13780m 13790m 13800m 13810m 13820m 13830m 13840m 13850m 13860m 13870m 13880m 13890m 13900m 13910m 13920m 13930m 13940m 13950m 13960m 13970m 13980m 13990m 14000m 14010m 14020m 14030m 14040m 14050m 14060m 14070m 14080m 14090m 14100m 14110m 14120m 14130m 14140m 14150m 14160m 14170m 14180m 14190m 14200m 14210m 14220m 14230m 14240m 14250m 14260m 14270m 14280m 14290m 14300m 14310m 14320m 14330m 14340m 14350m 14360m 14370m 14380m 14390m 14400m 14410m 14420m 14430m 14440m 14450m 14460m 14470m 14480m 14490m 14500m 14510m 14520m 14530m 14540m 14550m 14560m 14570m 14580m 14590m 14600m 14610m 14620m 14630m 14640m 14650m 14660m 14670m 14680m 14690m 14700m 14710m 14720m 14730m 14740m 14750m 14760m 14770m 14780m 14790m 14800m 14810m 14820m 14830m 14840m 14850m 14860m 14870m 14880m 14890m 14900m 14910m 14920m 14930m 14940m 14950m 14960m 14970m 14980m 14990m 15000m 15010m 15020m 15030m 15040m 15050m 15060m 15070m 15080m 15090m 15100m 15110m 15120m 15130m 15140m 15150m 15160m 15170m 15180m 15190m 15200m 15210m 15220m 15230m 15240m 15250m 15260m 15270m 15280m 15290m 15300m 15310m 15320m 15330m 15340m 15350m 15360m 15370m 15380m 15390m 15400m 15410m 15420m 15430m 15440m 15450m 15460m 15470m 15480m 15490m 15500m 15510m 15520m 15530m 15540m 15550m 15560m 15570m 15580m 15590m 15600m 15610m 15620m 15630m 15640m 15650m 15660m 15670m 15680m 15690m 15700m 15710m 15720m 15730m 15740m 15750m 15760m 15770m 15780m 15790m 15800m 15810m 15820m 15830m 15840m 15850m 15860m 15870m 15880m 15890m 15900m 15910m 15920m 15930m 15940m 15950m 15960m 15970m 15980m 15990m 16000m 16010m 16020m 16030m 16040m 16050m 16060m 16070m 16080m 16090m 16100m 16110m 16120m 16130m 16140m 16150m 16160m 16170m 16180m 16190m 16200m 16210m 16220m 16230m 16240m 16250m 16260m 16270m 16280m 16290m 16300m 16310m 16320m 16330m 16340m 16350m 16360m 16370m 16380m 16390m 16400m 16410m 16420m 16430m 16440m 16450m 16460m 16470m 16480m 16490m 16500m 16510m 16520m 16530m 16540m 16550m 16560m 16570m 16580m 16590m 16600m 16610m 16620m 16630m 16640m 16650m 16660m 16670m 16680m 16690m 16700m 16710m 16720m 16730m 16740m 16750m 16760m 16770m 16780m 16790m 16800m 16810m 16820m 16830m 16840m 16850m 16860m 16870m 16880m 16890m 16900m 16910m 16920m 16930m 16940m 16950m 16960m 16970m 16980m 16990m 17000m 17010m 17020m 17030m 17040m 17050m 17060m 17070m 17080m 17090m 17100m 17110m 17120m 17130m 17140m 17150m 17160m 17170m 17180m 17190m 17200m 17210m 17220m 17230m 17240m 17250m 17260m 17270m 17280m 17290m 17300m 17310m 17320m 17330m 17340m 17350m 17360m 17370m 17380m 17390m 17400m 17410m 17420m 17430m 17440m 17450m 17460m 17470m 17480m 17490m 17500m 17510m 17520m 17530m 17540m 17550m 17560m 17570m 17580m 17590m 17600m 17610m 17620m 17630m 17640m 17650m 17660m 17670m 17680m 17690m 17700m 17710m 17720m 17730m 17740m 17750m 17760m 177

Appendix A - DRAINS Modelling Inputs and Results

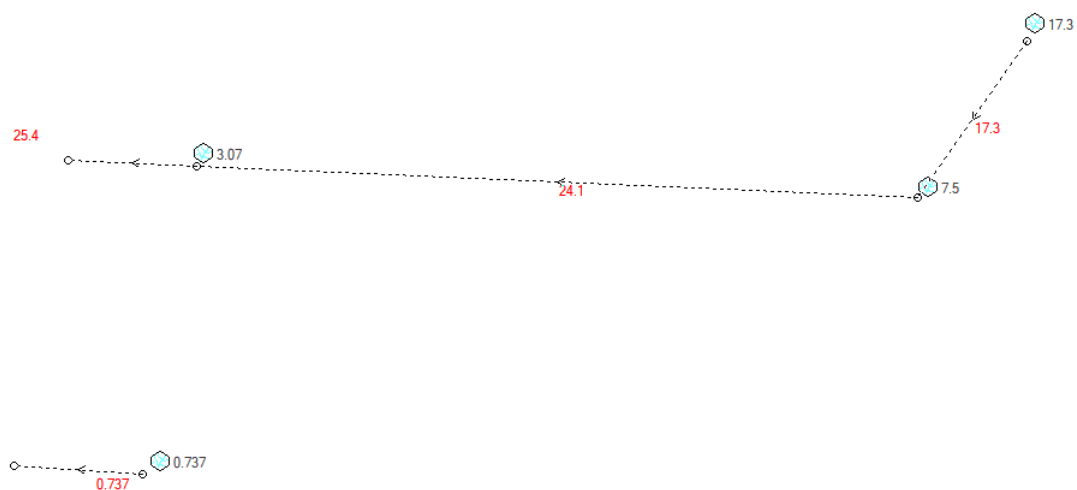
DRAINS PREDEVELOPED SCHEMATICS



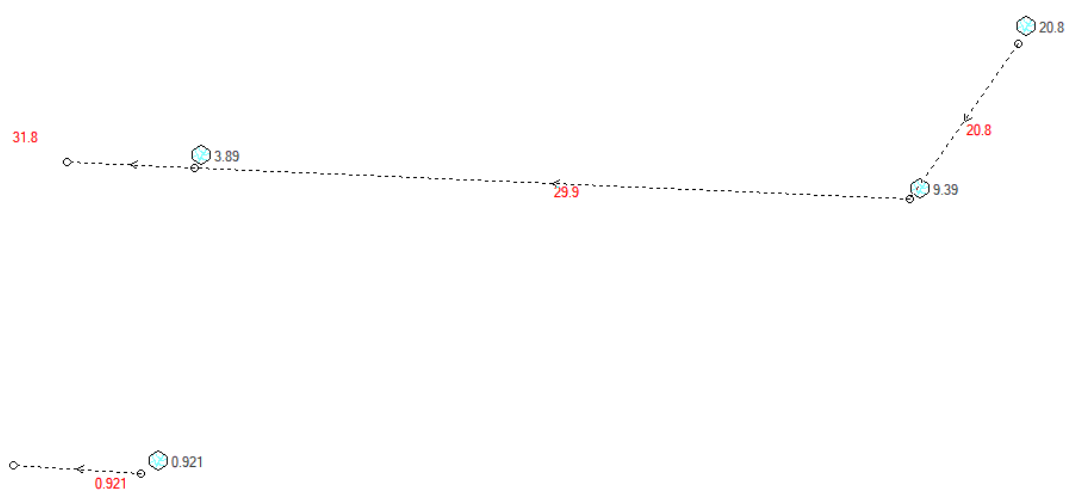
Results for median storm in critical 20% AEP ensembles
using Lite hydraulic model.



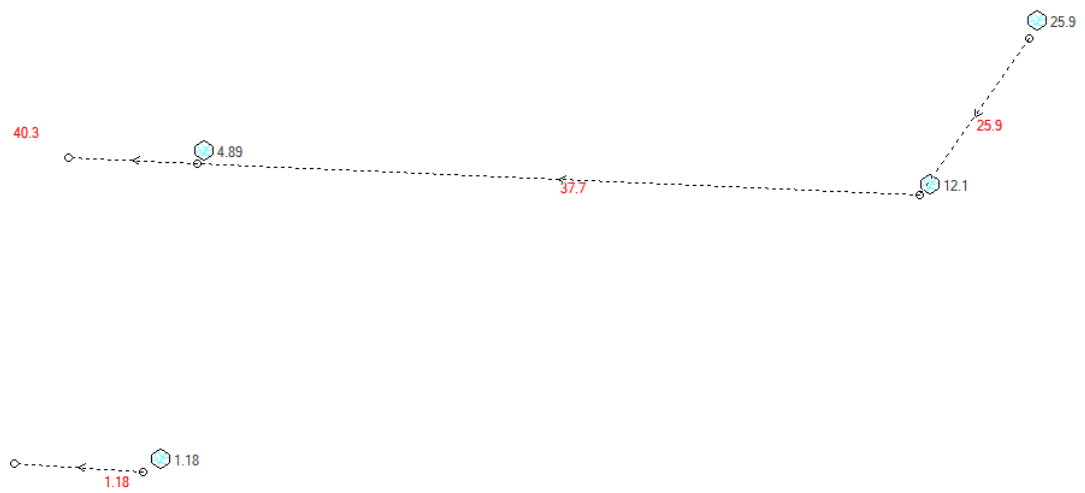
Results for median storm in critical 10% AEP ensembles
using Lite hydraulic model.



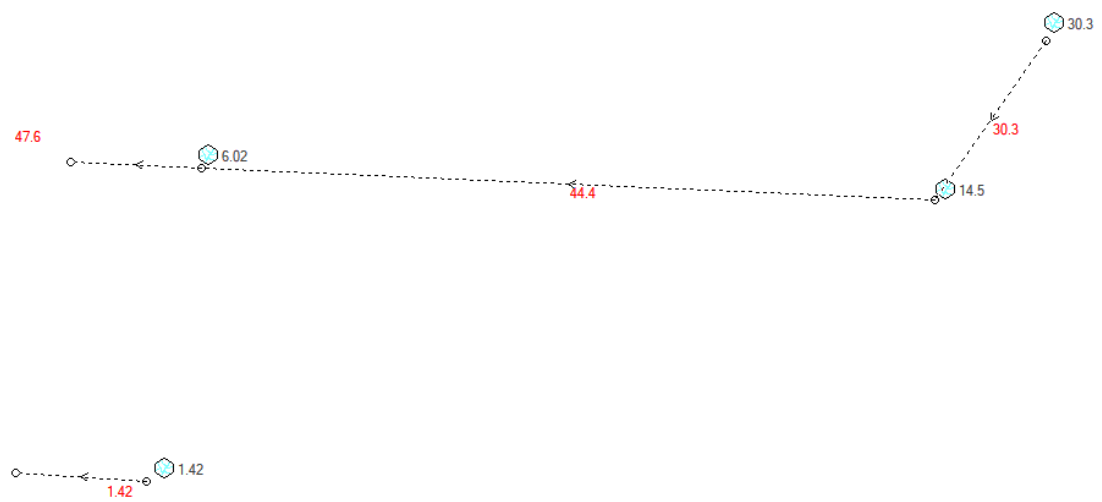
Results for median storm in critical 5% AEP ensembles
using Lite hydraulic model.



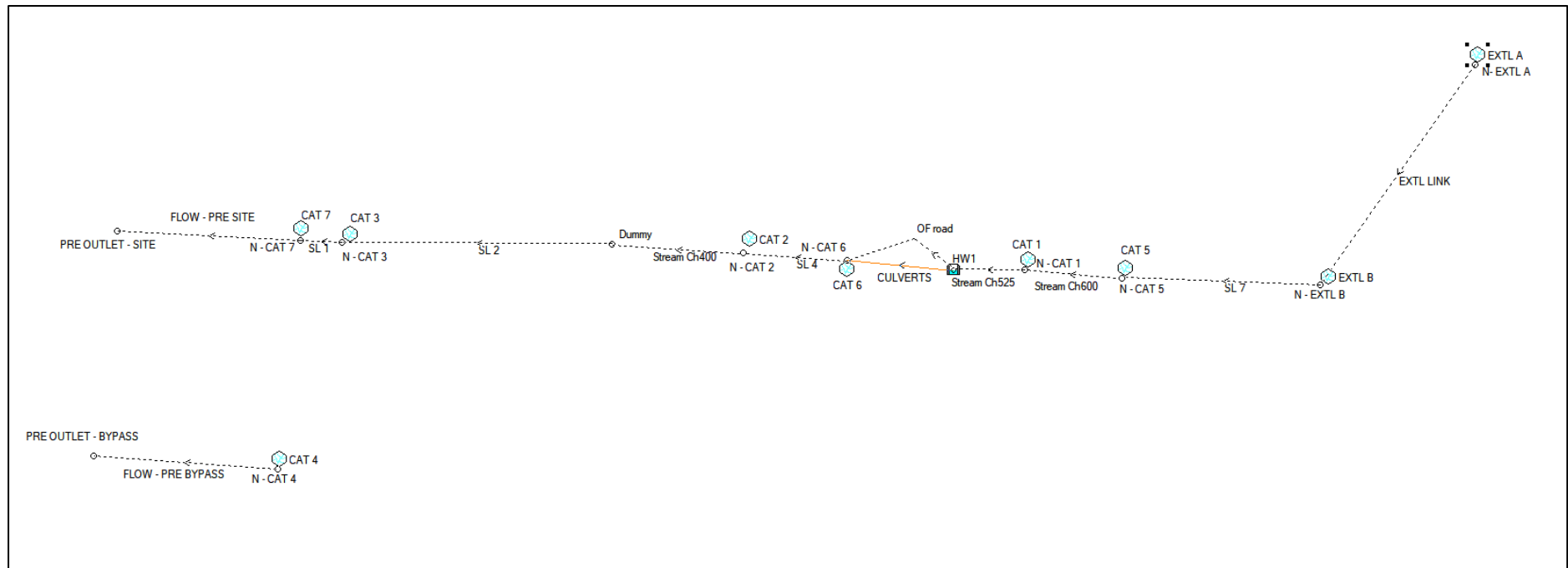
Results for median storm in critical 2% AEP ensembles
using Lite hydraulic model.



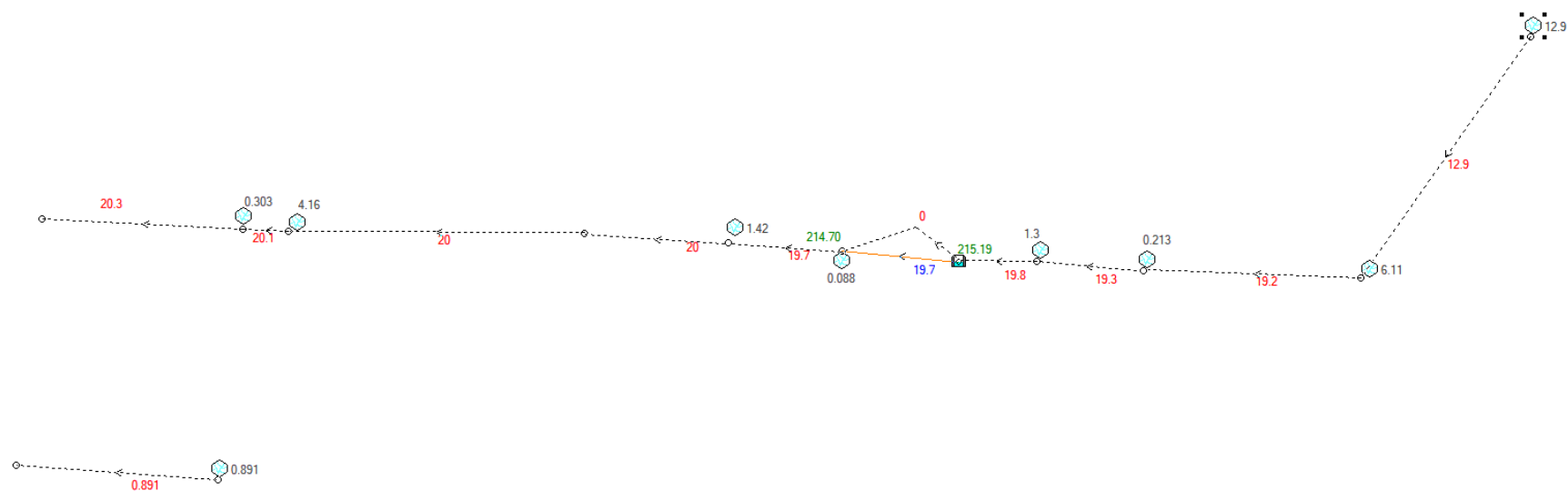
Results for median storm in critical 1% AEP ensembles
using Lite hydraulic model.



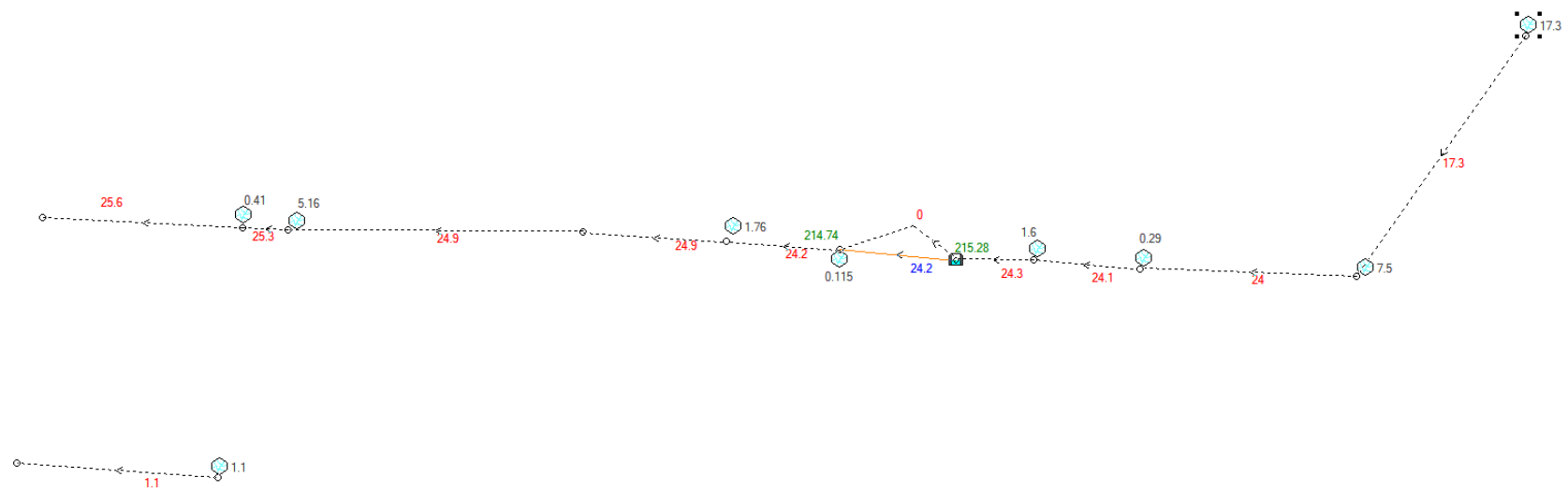
DRAINS POST DEVELOPED SCHEMATICS



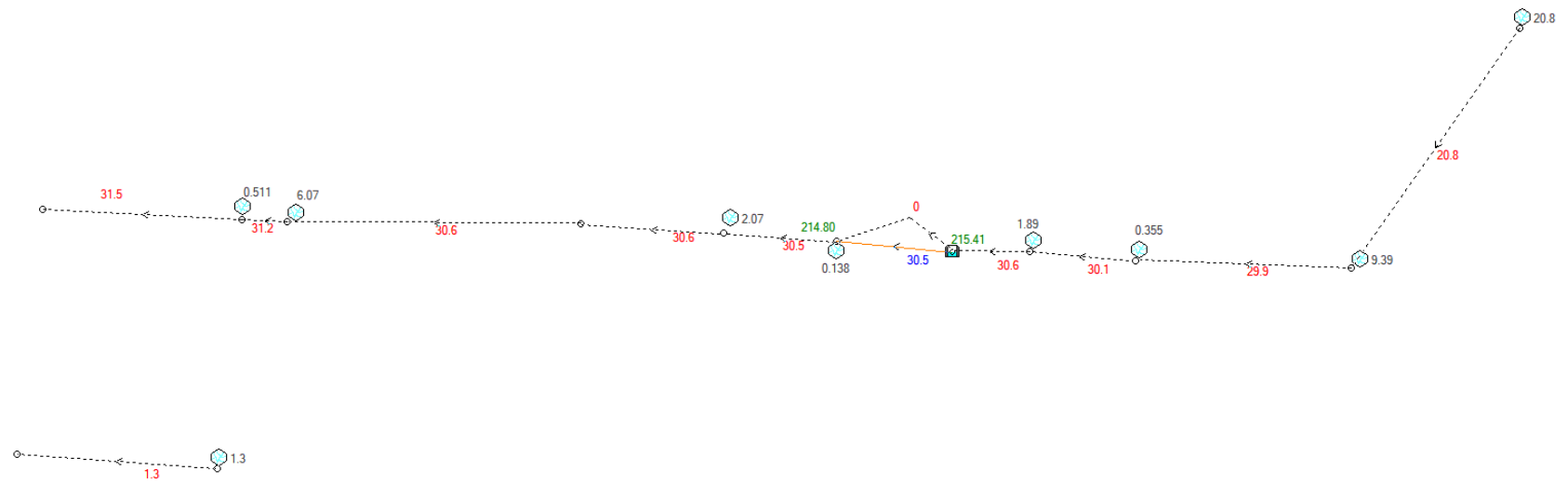
Results for median storm in critical 20% AEP ensembles
using Lite hydraulic model.



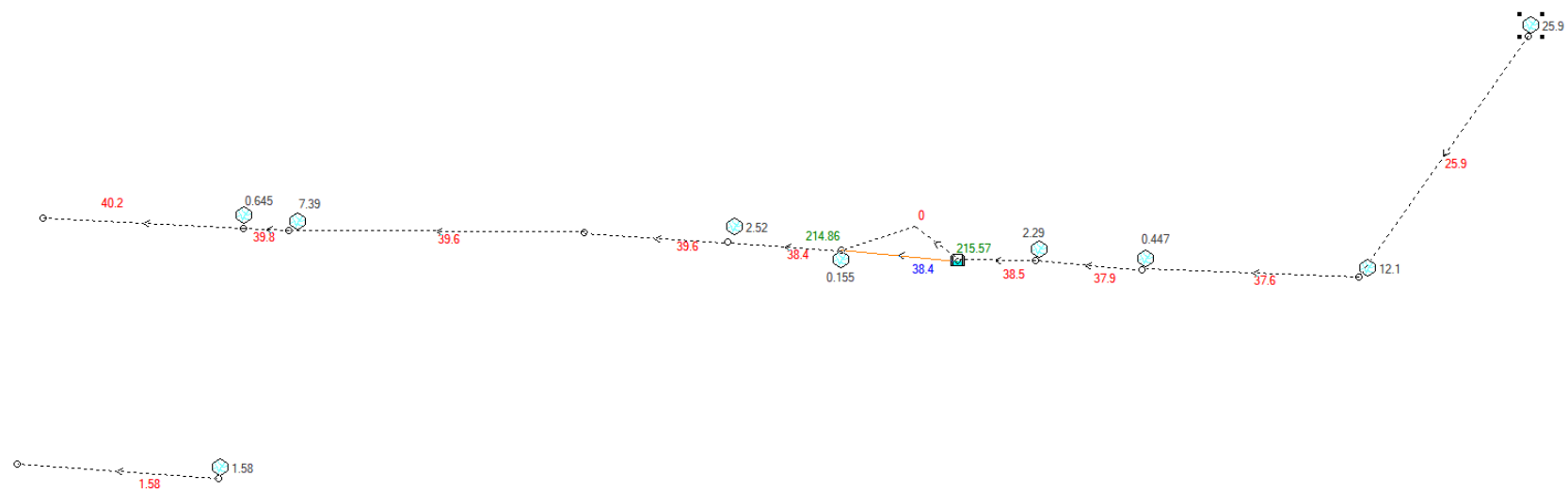
Results for median storm in critical 10% AEP ensembles
using Lite hydraulic model.



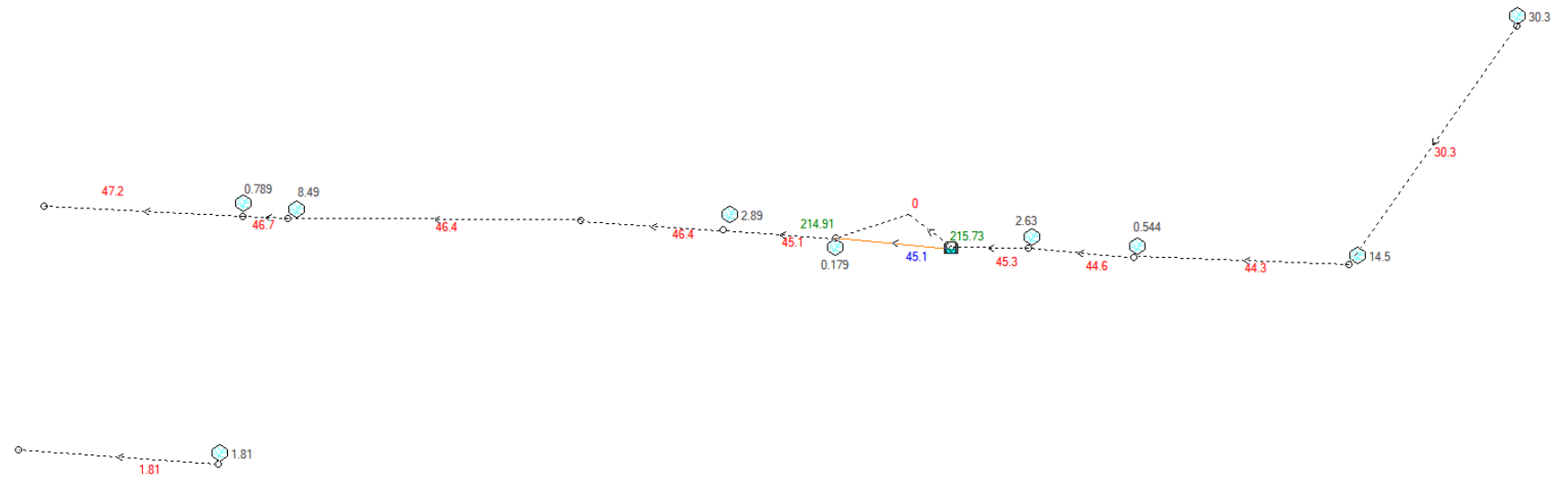
Results for median storm in critical 5% AEP ensembles
using Lite hydraulic model.



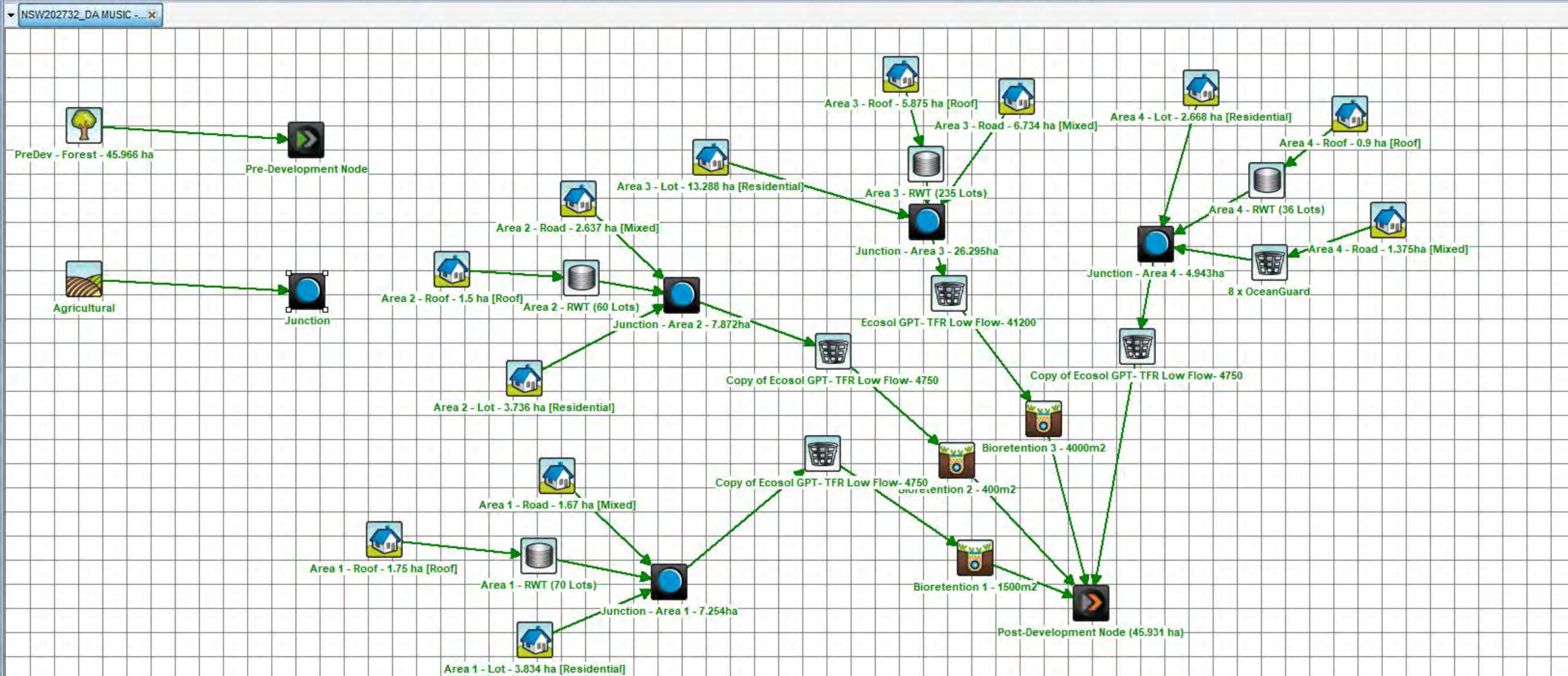
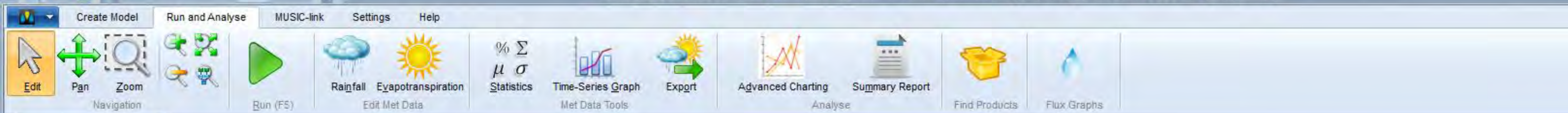
Results for median storm in critical 2% AEP ensembles
using Lite hydraulic model.



Results for median storm in critical 1% AEP ensembles
using Lite hydraulic model.



Appendix B - MUSIC Modelling Report



SCONE SUBDIVISION NSW202732
MUSIC MODEL REPORT - 18 AUGUST 2021

Source nodes

Location,PreDev - Forest - 45.966 ha,Area 1 - Road - 1.67 ha,Area 1 -
Roof - 1.75 ha,Area 1 - Lot - 3.834 ha,Area 2 - Road - 2.637 ha,Area 3 -
Road - 6.734 ha,Area 3 - Roof - 5.875 ha,Area 2 - Roof - 1.5 ha,Area 3 -
Lot - 13.288 ha,Area 2 - Lot - 3.736 ha,Area 4 - Lot - 2.668 ha,Area 4 -
Roof - 0.9 ha,Area 4 - Road - 1.375ha,Agricultural
ID,1,2,3,4,7,8,9,10,11,12,19,20,21,28

Node

Type,ForestSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,Urb
anSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceN
ode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,Agric
ulturalSourceNode

Zoning Surface

Type,,Mixed,Roof,Residential,Mixed,Mixed,Roof,Roof,Residential,Residentia
l,Residential,Roof,Mixed,

Total Area

(ha),45.966,1.67,1.75,3.834,2.637,6.734,5.875,1.5,13.288,3.736,2.668,0.9,
1.375,45.966

Area Impervious

(ha),15.9371668656716,1.33219888059701,1.75,2.47579119402985,2.1135358208
9552,5.3718726119403,5.875,1.5,8.68083223880597,2.42658776119403,1.742960
59701493,0.9,1.10205223880597,15.8805669402985

Area Pervious

(ha),30.0288331343284,0.337801119402985,0,1.35820880597015,0.523464179104
477,1.3621273880597,0,0,4.60716776119403,1.30941223880597,0.9250394029850
74,0,0.27294776119403,30.0854330597015

Field Capacity (mm),58,58,58,58,58,58,58,58,58,58,58,58,58,58

Pervious Area Infiltration Capacity coefficient -

a,135,135,135,135,135,135,135,135,135,135,135,135,135,135

Pervious Area Infiltration Capacity exponent -

b,4,4,3.5,1,4,4,3.5,3.5,1,1,1,4,4,4

Impervious Area Rainfall Threshold

(mm/day),1,1,0.3,1,1,1,0.3,0.3,1,1,1,0.3,1,1

Pervious Area Soil Storage Capacity

(mm),90,90,90,90,90,90,90,90,90,90,90,90,90,90

Pervious Area Soil Initial Storage (% of

Capacity),25,25,25,25,25,25,25,25,25,25,25,25,25,25

Groundwater Initial Depth (mm),10,10,10,10,10,10,10,10,10,10,10,10,10,10

Groundwater Daily Recharge Rate

(%),10,10,10,10,10,10,10,10,10,10,10,10,10,10

Groundwater Daily Baseflow Rate

(%),10,10,10,10,10,10,10,10,10,10,10,10,10,10

Groundwater Daily Deep Seepage Rate (%),0,0,0,0,0,0,0,0,0,0,0,0,0,0

Stormflow Total Suspended Solids Mean (log

mg/L),1.6,2.2,1.3,2.15,2.2,2.2,1.3,1.3,2.15,2.15,2.15,1.3,2.2,2.15

Stormflow Total Suspended Solids Standard Deviation (log

mg/L),0.2,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.3
1

Stormflow Total Suspended Solids Estimation

Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,
Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochas
tic,Stochastic

Stormflow Total Suspended Solids Serial

Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0

Stormflow Total Phosphorus Mean (log mg/L), -1.1, -0.45, -0.89, -0.6, -0.45, -0.45, -0.89, -0.89, -0.6, -0.6, -0.6, -0.89, -0.45, -0.22
 Stormflow Total Phosphorus Standard Deviation (log mg/L), 0.22, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.3
 Stormflow Total Phosphorus Estimation
 Method, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic
 Stormflow Total Phosphorus Serial Correlation, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Stormflow Total Nitrogen Mean (log mg/L), -0.05, 0.42, 0.3, 0.3, 0.42, 0.42, 0.3, 0.3, 0.3, 0.3, 0.3, 0.3, 0.3, 0.42, 0.48
 Stormflow Total Nitrogen Standard Deviation (log mg/L), 0.24, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.19, 0.26
 Stormflow Total Nitrogen Estimation
 Method, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic
 Stormflow Total Nitrogen Serial Correlation, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Baseflow Total Suspended Solids Mean (log mg/L), 0.78, 1.1, 0, 1.2, 1.1, 1.1, 0, 0, 1.2, 1.2, 1.2, 0, 1.1, 1.3
 Baseflow Total Suspended Solids Standard Deviation (log mg/L), 0.13, 0.17, 0, 0.17, 0.17, 0.17, 0, 0, 0.17, 0.17, 0.17, 0, 0.17, 0.13
 Baseflow Total Suspended Solids Estimation
 Method, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic
 Baseflow Total Suspended Solids Serial Correlation, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Baseflow Total Phosphorus Mean (log mg/L), -1.52, -0.82, 0, -0.85, -0.82, -0.82, 0, 0, -0.85, -0.85, -0.85, 0, -0.82, -1.05
 Baseflow Total Phosphorus Standard Deviation (log mg/L), 0.13, 0.19, 0, 0.19, 0.19, 0.19, 0, 0, 0.19, 0.19, 0.19, 0, 0.19, 0.13
 Baseflow Total Phosphorus Estimation
 Method, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic
 Baseflow Total Phosphorus Serial Correlation, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Baseflow Total Nitrogen Mean (log mg/L), -0.52, 0.32, 0, 0.11, 0.32, 0.32, 0, 0, 0.11, 0.11, 0.11, 0, 0.32, 0.04
 Baseflow Total Nitrogen Standard Deviation (log mg/L), 0.13, 0.12, 0, 0.12, 0.12, 0.12, 0, 0, 0.12, 0.12, 0.12, 0, 0.12, 0.13
 Baseflow Total Nitrogen Estimation
 Method, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic, Stochastic
 Baseflow Total Nitrogen Serial Correlation, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Flow based constituent generation - enabled, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off, Off
 Flow based constituent generation - flow file, , , , , , , , , , , , , , , ,
 Flow based constituent generation - base flow column, , , , , , , , , , , , , , , ,
 , , ,
 Flow based constituent generation - pervious flow column, , , , , , , , , , , , , , , ,
 , , , , ,
 Flow based constituent generation - impervious flow column, , , , , , , , , , , , , , , ,
 , , , , , ,
 Flow based constituent generation - unit, , , , , , , , , , , , , , , ,

OUT - Mean Annual Flow
 (ML/yr), 60.0, 4.36, 6.19, 8.25, 6.89, 17.6, 20.8, 5.30, 28.6, 8.04, 5.74, 3.18, 3.59, 60.0
 OUT - TSS Mean Annual Load
 (kg/yr), 2.63E3, 916, 163, 1.53E3, 1.45E3, 3.66E3, 546, 136, 5.23E3, 1.43E3, 1.05E3, 83.0, 749, 10.9E3
 OUT - TP Mean Annual Load
 (kg/yr), 5.36, 1.82, 0.949, 2.41, 2.89, 7.33, 3.12, 0.809, 8.41, 2.34, 1.69, 0.482, 1.51, 44.6
 OUT - TN Mean Annual Load
 (kg/yr), 61.8, 12.6, 13.6, 18.0, 20.0, 50.8, 45.7, 11.6, 62.3, 17.5, 12.6, 7.00, 10.4, 216
 OUT - Gross Pollutant Mean Annual Load
 (kg/yr), 2.48E3, 154, 207, 314, 243, 621, 694, 177, 1.09E3, 306, 218, 106, 127, 2.48E3
 Rain In
 (ML/yr), 170.614, 6.19863, 6.49556, 14.2309, 9.78789, 24.995, 21.8065, 5.56763, 49.3218, 13.8671, 9.90293, 3.34057, 5.10366, 170.614
 ET Loss
 (ML/yr), 110.757, 1.83636, 0.308961, 5.98082, 2.89968, 7.40485, 1.03725, 0.264822, 20.7285, 5.82796, 4.16191, 0.158895, 1.51197, 110.757
 Deep Seepage Loss (ML/yr), 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
 Baseflow Out
 (ML/yr), 0.963763, 0.0107737, 0, 0.1272, 0.0170122, 0.0434434, 0, 0, 0.440854, 0.123949, 0.0885158, 0, 0.00887059, 0.963763
 Imp. Stormflow Out
 (ML/yr), 51.3905, 4.26761, 6.1866, 7.96057, 6.73874, 17.2084, 20.7693, 5.3028, 27.59, 7.75709, 5.53959, 3.18169, 3.51375, 51.3905
 Perv. Stormflow Out
 (ML/yr), 7.6021, 0.0849826, 0, 0.166739, 0.134191, 0.342678, 0, 0, 0.577889, 0.162477, 0.11603, 0, 0.0699707, 7.6021
 Total Stormflow Out
 (ML/yr), 58.9926, 4.35259, 6.1866, 8.1273, 6.87293, 17.5511, 20.7693, 5.3028, 28.1678, 7.91956, 5.65562, 3.18169, 3.58372, 58.9926
 Total Outflow
 (ML/yr), 59.9564, 4.36337, 6.1866, 8.2545, 6.88994, 17.5945, 20.7693, 5.3028, 28.6087, 8.04351, 5.74414, 3.18169, 3.59259, 59.9564
 Change in Soil Storage (ML/yr), -0.0995297, -0.00111261, 0, -0.00447016, -0.00175687, -0.00448646, 0, 0, -0.0154928, -0.0043559, -0.00311069, 0, -0.000916074, -0.0995297
 TSS Baseflow Out
 (kg/yr), 6.08172, 0.146577, 0, 2.17652, 0.231412, 0.59024, 0, 0, 7.54458, 2.12105, 1.51557, 0, 0.120538, 20.1079
 TSS Total Stormflow Out
 (kg/yr), 2625.78, 916.215, 162.662, 1524.27, 1445.27, 3664.05, 546.247, 136.428, 5226.08, 1431.75, 1050.29, 83.0104, 748.878, 10910.4
 TSS Total Outflow
 (kg/yr), 2631.86, 916.362, 162.662, 1526.44, 1445.5, 3664.64, 546.247, 136.428, 5233.62, 1433.87, 1051.81, 83.0104, 748.999, 10930.5
 TP Baseflow Out
 (kg/yr), 0.0304059, 0.00179846, 0, 0.0197638, 0.00283984, 0.00723776, 0, 0, 0.0685476, 0.019237, 0.013762, 0, 0.00147704, 0.0896778
 TP Total Stormflow Out
 (kg/yr), 5.33286, 1.81418, 0.948978, 2.3889, 2.88253, 7.32657, 3.11965, 0.809475, 8.3427, 2.31692, 1.68007, 0.481501, 1.50487, 44.5437
 TP Total Outflow
 (kg/yr), 5.36327, 1.81598, 0.948978, 2.40866, 2.88537, 7.33381, 3.11965, 0.809475, 8.41125, 2.33616, 1.69383, 0.481501, 1.50635, 44.6334

TN Baseflow Out
 (kg/yr),0.303964,0.0233563,0,0,0.170473,0.0369324,0.0943716,0,0,0.590385,0.165819,0.118529,0,0.0192166,1.10461
 TN Total Stormflow Out
 (kg/yr),61.4981,12.527,13.5661,17.7823,19.9739,50.7309,45.6886,11.6094,61.7327,17.3611,12.4956,7.00352,10.3337,214.63
 TN Total Outflow
 (kg/yr),61.8021,12.5503,13.5661,17.9527,20.0108,50.8253,45.6886,11.6094,62.3231,17.5269,12.6141,7.00352,10.3529,215.735
 GP Total Outflow
 (kg/yr),2479.04,154.151,206.707,313.958,243.411,621.589,693.944,177.178,1088.12,305.932,218.477,106.306,126.921,2479.04

No Imported Data Source nodes

USTM treatment nodes

Location,Area 1 - RWT (70 Lots),Area 3 - RWT (235 Lots),Area 2 - RWT (60 Lots),Area 4 - RWT (36 Lots),Bioretention 2 - 400m2,Bioretention 1 - 1500m2,Bioretention 3 - 4000m2
 ID,5,13,14,22,23,24,27

Node

Type,RainWaterTankNode,RainWaterTankNode,RainWaterTankNode,RainWaterTankNode,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4
 Lo-flow bypass rate (cum/sec),0,0,0,0,0,0,0
 Hi-flow bypass rate (cum/sec),0.35,1.175,0.3,0.18,100,100,100
 Inlet pond volume,0,0,0,0, , ,
 Area (sqm),126,423,108,64.8,480,1800,4800
 Initial Volume (m^3),0,0,0,0, , ,
 Extended detention depth (m),0.05,0.05,0.05,0.05,0.3,0.3,0.3
 Number of Rainwater tanks,70,235,60,36, , ,
 Permanent Pool Volume (cubic metres),210,705,180,108, , ,
 Proportion vegetated,0,0,0,0, , ,
 Equivalent Pipe Diameter (mm),837,1533,775,600, , ,
 Overflow weir width (m),10,10,10,10,5,5,5
 Notional Detention Time (hrs),4.79E-3,4.80E-3,4.79E-3,4.80E-3, , ,
 Orifice Discharge Coefficient,0.6,0.6,0.6,0.6, , ,
 Weir Coefficient,1.7,1.7,1.7,1.7,1.7,1.7,1.7
 Number of CSTR Cells,2,2,2,2,3,3,3
 Total Suspended Solids - k (m/yr),400,400,400,400,8000,8000,8000
 Total Suspended Solids - C* (mg/L),12,12,12,12,20,20,20
 Total Suspended Solids - C** (mg/L),12,12,12,12, , ,
 Total Phosphorus - k (m/yr),300,300,300,300,6000,6000,6000
 Total Phosphorus - C* (mg/L),0.13,0.13,0.13,0.13,0.13,0.13,0.13
 Total Phosphorus - C** (mg/L),0.13,0.13,0.13,0.13, , ,
 Total Nitrogen - k (m/yr),40,40,40,40,500,500,500
 Total Nitrogen - C* (mg/L),1.4,1.4,1.4,1.4,1.4,1.4,1.4
 Total Nitrogen - C** (mg/L),1.4,1.4,1.4,1.4, , ,
 Threshold Hydraulic Loading for C** (m/yr),3500,3500,3500,3500, , ,
 Horizontal Flow Coefficient, , , , ,3,3,3
 Reuse Enabled,On,On,On,On,Off,Off,Off
 Max drawdown height
 (m),1.666666666666667,1.666666666666667,1.666666666666667,1.666666666666667, , ,
 , ,
 Annual Demand Enabled,On,On,On,On,Off,Off,Off
 Annual Demand Value (ML/year),24.01,80.605,20.58,12.348, , ,
 Annual Demand Distribution,PET,PET,PET,PET, , ,
 Annual Demand Monthly Distribution: Jan, , , , , , ,
 Annual Demand Monthly Distribution: Feb, , , , , , ,

Annual Demand Monthly Distribution: Mar, , , , , , ,
 Annual Demand Monthly Distribution: Apr, , , , , , ,
 Annual Demand Monthly Distribution: May, , , , , , ,
 Annual Demand Monthly Distribution: Jun, , , , , , ,
 Annual Demand Monthly Distribution: Jul, , , , , , ,
 Annual Demand Monthly Distribution: Aug, , , , , , ,
 Annual Demand Monthly Distribution: Sep, , , , , , ,
 Annual Demand Monthly Distribution: Oct, , , , , , ,
 Annual Demand Monthly Distribution: Nov, , , , , , ,
 Annual Demand Monthly Distribution: Dec, , , , , , ,
 Daily Demand Enabled,On,On,On,On,Off,Off,Off
 Daily Demand Value (ML/day),0.0658,0.2209,0.0564,0.03384, , ,
 Custom Demand Enabled,Off,Off,Off,Off,Off,Off,Off
 Custom Demand Time Series File, , , , , , ,
 Custom Demand Time Series Units, , , , , , ,
 Filter area (sqm), , , , ,400,1500,4000
 Filter perimeter (m), , , , ,80,80,80
 Filter depth (m), , , , ,0.4,0.4,0.4
 Filter Median Particle Diameter (mm), , , , , , ,
 Saturated Hydraulic Conductivity (mm/hr), , , , ,100,100,100
 Infiltration Media Porosity, , , , ,0.35,0.35,0.35
 Length (m), , , , , , ,
 Bed slope, , , , , , ,
 Base Width (m), , , , , , ,
 Top width (m), , , , , , ,
 Vegetation height (m), , , , , , ,
 Vegetation Type, , , , ,Vegetated with Effective Nutrient Removal
 Plants,Vegetated with Effective Nutrient Removal Plants,Vegetated with
 Effective Nutrient Removal Plants
 Total Nitrogen Content in Filter (mg/kg), , , , ,800,800,800
 Orthophosphate Content in Filter (mg/kg), , , , ,55,55,55
 Is Base Lined?, , , , ,Yes,Yes,Yes
 Is Underdrain Present?, , , , ,Yes,Yes,Yes
 Is Submerged Zone Present?, , , , ,No,No,No
 Submerged Zone Depth (m), , , , , , ,
 B for Media Soil Texture,-9999,-9999,-9999,-9999,13,13,13
 Proportion of upstream impervious area treated, , , , , , ,
 Exfiltration Rate (mm/hr),0,0,0,0,0,0,0
 Evaporative Loss as % of PET,0,0,0,0,100,100,100
 Depth in metres below the drain pipe, , , , , , ,
 TSS A Coefficient, , , , , , ,
 TSS B Coefficient, , , , , , ,
 TP A Coefficient, , , , , , ,
 TP B Coefficient, , , , , , ,
 TN A Coefficient, , , , , , ,
 TN B Coefficient, , , , , , ,
 Sfc, , , , ,0.61,0.61,0.61
 S*, , , , ,0.37,0.37,0.37
 Sw, , , , ,0.11,0.11,0.11
 Sh, , , , ,0.05,0.05,0.05
 Emax (m/day), , , , ,0.008,0.008,0.008
 Ew (m/day), , , , ,0.001,0.001,0.001
 IN - Mean Annual Flow (ML/yr),6.19,20.8,5.30,3.18,16.5,14.4,52.2
 IN - TSS Mean Annual Load (kg/yr),163,546,136,83.0,1.27E3,1.07E3,4.07E3
 IN - TP Mean Annual Load (kg/yr),0.949,3.12,0.809,0.482,3.99,3.28,12.3
 IN - TN Mean Annual Load (kg/yr),13.6,45.7,11.6,7.00,40.8,34.4,126
 IN - Gross Pollutant Mean Annual Load
 (kg/yr),207,694,177,106,27.1,20.5,104

OUT - Mean Annual Flow (ML/yr),1.79,6.01,1.53,0.921,15.8,12.3,46.4
 OUT - TSS Mean Annual Load (kg/yr),43.6,147,36.3,22.5,312,67.1,309
 OUT - TP Mean Annual Load (kg/yr),0.272,0.882,0.232,0.137,2.40,1.70,6.42
 OUT - TN Mean Annual Load (kg/yr),3.91,13.2,3.34,2.02,22.9,12.3,48.6
 OUT - Gross Pollutant Mean Annual Load
 (kg/yr),0.317,1.07,0.272,0.163,0.00,0.00,0.00
 Flow In (ML/yr),6.18488,20.7763,5.30389,3.18178,16.4573,14.4,52.1649
 ET Loss (ML/yr),0,0,0,0,0.630399,2.10171,5.80648
 Infiltration Loss (ML/yr),0,0,0,0,0,0,0
 Low Flow Bypass Out (ML/yr),0,0,0,0,0,0,0
 High Flow Bypass Out
 (ML/yr),0.0167255,0.0561499,0.0143361,0.00860168,0,0,0
 Orifice / Filter Out
 (ML/yr),1.7718,5.95154,1.51855,0.910824,9.9694,11.6644,42.3855
 Weir Out
 (ML/yr),0.00176905,0.00255442,0.00165388,0.00129914,5.84958,0.624385,3.93
 3
 Transfer Function Out (ML/yr),0,0,0,0,0,0,0
 Reuse Supplied (ML/yr),4.39749,14.7596,3.7699,2.26142,0,0,0
 Reuse Requested (ML/yr),47.9198,161.986,41.1606,24.8324,0,0,0
 % Reuse Demand Met,9.17678,9.11163,9.15901,9.10676,0,0,0
 % Load Reduction,71.0537,71.0717,71.0676,71.0626,3.87856,14.6613,11.2075
 TSS Flow In
 (kg/yr),162.662,546.25,136.428,83.0103,1271.17,1073.92,4066.59
 TSS ET Loss (kg/yr),0,0,0,0,0,0,0
 TSS Infiltration Loss (kg/yr),0,0,0,0,0,0,0
 TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
 TSS High Flow Bypass Out (kg/yr),0.606496,1.66918,0.231796,0.153861,0,0,0
 TSS Orifice / Filter Out
 (kg/yr),42.9868,145.236,36.0257,22.2853,30.574,38.6256,137.946
 TSS Weir Out
 (kg/yr),0.050705,0.0638998,0.0389031,0.0333229,281.159,28.3748,170.842
 TSS Transfer Function Out (kg/yr),0,0,0,0,0,0,0
 TSS Reuse Supplied (kg/yr),81.8337,274.714,69.2843,41.7958,0,0,0
 TSS Reuse Requested (kg/yr),0,0,0,0,0,0,0
 TSS % Reuse Demand Met,0,0,0,0,0,0,0
 TSS % Load
 Reduction,73.1689,73.0949,73.3952,72.9281,75.4767,93.7611,92.4067
 TP Flow In
 (kg/yr),0.948978,3.11965,0.809476,0.481501,3.98802,3.27613,12.2791
 TP ET Loss (kg/yr),0,0,0,0,0,0,0
 TP Infiltration Loss (kg/yr),0,0,0,0,0,0,0
 TP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
 TP High Flow Bypass Out
 (kg/yr),0.00323844,0.00816684,0.00223317,0.00163247,0,0,0
 TP Orifice / Filter Out
 (kg/yr),0.26872,0.87376,0.229781,0.135371,1.32619,1.59054,5.74669
 TP Weir Out
 (kg/yr),0.000311286,0.000412005,0.000234591,0.000189081,1.06967,0.105761,
 0.666524
 TP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
 TP Reuse Supplied (kg/yr),0.625395,2.08338,0.535264,0.319421,0,0,0
 TP Reuse Requested (kg/yr),0,0,0,0,0,0,0
 TP % Reuse Demand Met,0,0,0,0,0,0,0
 TP % Load
 Reduction,71.3092,71.7167,71.3087,71.5074,39.9237,48.2224,47.7715
 TN Flow In
 (kg/yr),13.5661,45.6884,11.6094,7.00351,40.8108,34.3519,126.155

TN ET Loss (kg/yr),0,0,0,0,0,0,0
 TN Infiltration Loss (kg/yr),0,0,0,0,0,0,0
 TN Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
 TN High Flow Bypass Out
 (kg/yr),0.0333056,0.12295,0.0263195,0.0211619,0,0,0
 TN Orifice / Filter Out
 (kg/yr),3.86845,13.0867,3.3116,2.00071,9.11843,10.9148,39.6175
 TN Weir Out
 (kg/yr),0.00374066,0.00548263,0.00386822,0.00306083,13.7423,1.37399,8.917
 88
 TN Transfer Function Out (kg/yr),0,0,0,0,0,0,0
 TN Reuse Supplied (kg/yr),9.2538,31.0823,7.92315,4.76868,0,0,0
 TN Reuse Requested (kg/yr),0,0,0,0,0,0,0
 TN % Reuse Demand Met,0,0,0,0,0,0,0
 TN % Load
 Reduction,71.2113,71.0756,71.2148,71.087,43.9838,64.2268,61.5272
 GP Flow In
 (kg/yr),206.707,693.944,177.178,106.307,27.1103,20.4569,103.558
 GP ET Loss (kg/yr),0,0,0,0,0,0,0
 GP Infiltration Loss (kg/yr),0,0,0,0,0,0,0
 GP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
 GP High Flow Bypass Out (kg/yr),0.31747,1.06579,0.272118,0.16327,0,0,0
 GP Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0
 GP Weir Out (kg/yr),0,0,0,0,0,0,0
 GP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
 GP Reuse Supplied (kg/yr),0,0,0,0,0,0,0
 GP Reuse Requested (kg/yr),0,0,0,0,0,0,0
 GP % Reuse Demand Met,0,0,0,0,0,0,0
 GP % Load Reduction,99.8464,99.8464,99.8464,99.8464,100,100,100
 PET Scaling Factor, , , , ,2.1,2.1,2.1

Generic treatment nodes

Location,8 x OceanGuard,Copy of Ecosol GPT- TFR Low Flow- 4750 ,Copy of
 Ecosol GPT- TFR Low Flow- 4750 ,Copy of Ecosol GPT- TFR Low Flow- 4750
 ,Ecosol GPT- TFR Low Flow- 41200

ID,26,30,31,32,33

Node Type,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode

Lo-flow bypass rate (cum/sec),0,0,0,0,0

Hi-flow bypass rate (cum/sec),0.08,0.219,0.219,0.219,0.561

Flow Transfer Function

Input (cum/sec),0,0,0,0,0

Output (cum/sec),0,0,0,0,0

Input (cum/sec),10,10,10,10,10

Output (cum/sec),10,10,10,10,10

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

Input (cum/sec), , , , ,

Output (cum/sec), , , , ,

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Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Gross Pollutant Transfer Function
Enabled,True,True,True,True,True
Input (kg/ML),0,0,0,0,0
Output (kg/ML),0,0,0,0,0
Input (kg/ML),14.7808,1000,1000,1000,1000
Output (kg/ML),0,20,20,20,20
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Total Nitrogen Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),10,1000,1000,1000,1000
Output (mg/L),8.5,999,999,999,999
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Total Phosphorus Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),10,1000,1000,1000,1000
Output (mg/L),7.5,710,710,710,710
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,

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Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Total Suspended Solids Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),100,1000,1000,1000,1000
Output (mg/L),45,390,390,390,390
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
TSS Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TSS Flow based Efficiency, , , , ,
TP Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TP Flow based Efficiency, , , , ,
TN Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TN Flow based Efficiency, , , , ,
GP Flow based Efficiency Enabled,Off,Off,Off,Off,Off
GP Flow based Efficiency, , , , ,
IN - Mean Annual Flow (ML/yr),3.59,10.3,16.5,14.4,52.2
IN - TSS Mean Annual Load (kg/yr),749,1.43E3,2.92E3,2.49E3,9.05E3
IN - TP Mean Annual Load (kg/yr),1.51,2.98,5.45,4.50,16.6
IN - TN Mean Annual Load (kg/yr),10.4,23.5,40.9,34.4,126
IN - Gross Pollutant Mean Annual Load (kg/yr),127,220,549,468,1.71E3
OUT - Mean Annual Flow (ML/yr),3.59,10.3,16.5,14.4,52.2
OUT - TSS Mean Annual Load (kg/yr),351,594,1.27E3,1.07E3,4.07E3
OUT - TP Mean Annual Load (kg/yr),1.14,2.15,3.99,3.28,12.3
OUT - TN Mean Annual Load (kg/yr),8.85,23.5,40.8,34.4,126
OUT - Gross Pollutant Mean Annual Load (kg/yr),1.44,7.79,27.1,20.5,104
Flow In (ML/yr),3.5902,10.2481,16.4573,14.4,52.1649
ET Loss (ML/yr),0,0,0,0,0
Infiltration Loss (ML/yr),0,0,0,0,0
Low Flow Bypass Out (ML/yr),0,0,0,0,0
High Flow Bypass Out (ML/yr),0.125624,0.424586,1.30565,1.00622,5.43972
Orifice / Filter Out (ML/yr),0,0,0,0,0
Weir Out (ML/yr),0,0,0,0,0
Transfer Function Out (ML/yr),3.46458,9.82409,15.1523,13.3939,46.7309

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Reuse Supplied (ML/yr),0,0,0,0,0
 Reuse Requested (ML/yr),0,0,0,0,0
 % Reuse Demand Met,0,0,0,0,0
 % Load Reduction,-0.00023845,-0.00525508,-0.00389603,-0.00100612,-
 0.0109207
 TSS Flow In (kg/yr),748.887,1423.97,2913.84,2484.84,9039.53
 TSS ET Loss (kg/yr),0,0,0,0,0
 TSS Infiltration Loss (kg/yr),0,0,0,0,0
 TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0
 TSS High Flow Bypass Out (kg/yr),24.9553,63.0644,220.923,171.887,887.497
 TSS Orifice / Filter Out (kg/yr),0,0,0,0,0
 TSS Weir Out (kg/yr),0,0,0,0,0
 TSS Transfer Function Out (kg/yr),325.771,530.807,1050.3,902.038,3179.33
 TSS Reuse Supplied (kg/yr),0,0,0,0,0
 TSS Reuse Requested (kg/yr),0,0,0,0,0
 TSS % Reuse Demand Met,0,0,0,0,0
 TSS % Load Reduction,53.167,58.2948,56.373,56.7809,55.0106
 TP Flow In (kg/yr),1.50555,2.97333,5.44916,4.49339,16.6149
 TP ET Loss (kg/yr),0,0,0,0,0
 TP Infiltration Loss (kg/yr),0,0,0,0,0
 TP Low Flow Bypass Out (kg/yr),0,0,0,0,0
 TP High Flow Bypass Out
 (kg/yr),0.0594721,0.132595,0.409922,0.296643,1.66924
 TP Orifice / Filter Out (kg/yr),0,0,0,0,0
 TP Weir Out (kg/yr),0,0,0,0,0
 TP Transfer Function Out (kg/yr),1.08463,2.01708,3.57831,2.97989,10.6113
 TP Reuse Supplied (kg/yr),0,0,0,0,0
 TP Reuse Requested (kg/yr),0,0,0,0,0
 TP % Reuse Demand Met,0,0,0,0,0
 TP % Load Reduction,24.0079,27.7017,26.8101,27.0809,26.087
 TN Flow In (kg/yr),10.3451,23.4748,40.8479,34.3842,126.269
 TN ET Loss (kg/yr),0,0,0,0,0
 TN Infiltration Loss (kg/yr),0,0,0,0,0
 TN Low Flow Bypass Out (kg/yr),0,0,0,0,0
 TN High Flow Bypass Out (kg/yr),0.35909,0.995099,3.20427,2.35046,13.1781
 TN Orifice / Filter Out (kg/yr),0,0,0,0,0
 TN Weir Out (kg/yr),0,0,0,0,0
 TN Transfer Function Out (kg/yr),8.49052,22.4571,37.6082,32.0025,112.983
 TN Reuse Supplied (kg/yr),0,0,0,0,0
 TN Reuse Requested (kg/yr),0,0,0,0,0
 TN % Reuse Demand Met,0,0,0,0,0
 TN % Load Reduction,14.4559,0.0962825,0.0867622,0.0909152,0.0854201
 GP Flow In (kg/yr),126.903,219.873,549.287,468.117,1709.64
 GP ET Loss (kg/yr),0,0,0,0,0
 GP Infiltration Loss (kg/yr),0,0,0,0,0
 GP Low Flow Bypass Out (kg/yr),0,0,0,0,0
 GP High Flow Bypass Out (kg/yr),1.4368,3.51999,16.716,11.5081,71.8107
 GP Orifice / Filter Out (kg/yr),0,0,0,0,0
 GP Weir Out (kg/yr),0,0,0,0,0
 GP Transfer Function Out (kg/yr),0,4.2662,10.3943,8.94777,31.7462
 GP Reuse Supplied (kg/yr),0,0,0,0,0
 GP Reuse Requested (kg/yr),0,0,0,0,0
 GP % Reuse Demand Met,0,0,0,0,0
 GP % Load Reduction,98.8678,98.3991,96.9568,97.5416,95.7997

Other nodes

IN - TP Mean Annual Load
(kg/yr), 0.809, 0.232, 2.89, 2.34, 0.949, 1.82, 2.41, 0.272, 1.70, 3.12, 8.41, 0.882, 7.33, 1.69, 0.482, 0.137, 5.36, 1.51, 1.14, 6.42, 2.40, 44.6, 2.98, 2.15, 5.45, 4.50, 16.6, 12.3, 3.99, 3.28

IN - TN Mean Annual Load
(kg/yr), 11.6, 3.34, 20.0, 17.5, 13.6, 12.6, 18.0, 3.91, 12.3, 45.7, 62.3, 13.2, 50.8, 12.6, 7.00, 2.02, 61.8, 10.4, 8.85, 48.6, 22.9, 216, 23.5, 23.5, 40.9, 34.4, 126, 126, 40.8, 34.4

IN - Gross Pollutant Mean Annual Load
(kg/yr), 177, 0.272, 243, 306, 207, 154, 314, 0.317, 0.00, 694, 1.09E3, 1.07, 621, 218, 106, 0.163, 2.48E3, 127, 1.44, 0.00, 0.00, 2.48E3, 220, 7.79, 549, 468, 1.71E3, 104, 27.1, 20.5

OUT - Mean Annual Flow
(ML/yr), 5.30, 1.53, 6.89, 8.04, 6.19, 4.36, 8.25, 1.79, 12.3, 20.8, 28.6, 6.01, 17.6, 5.74, 3.18, 0.921, 60.0, 3.59, 3.59, 46.4, 15.8, 60.0, 10.3, 10.3, 16.5, 14.4, 52.2, 52.2, 16.5, 14.4

OUT - TSS Mean Annual Load
(kg/yr), 136, 36.3, 1.45E3, 1.43E3, 163, 916, 1.53E3, 43.6, 67.1, 546, 5.23E3, 147, 3.66E3, 1.05E3, 83.0, 22.5, 2.63E3, 749, 351, 309, 312, 10.9E3, 1.43E3, 594, 2.92E3, 2.49E3, 9.05E3, 4.07E3, 1.27E3, 1.07E3

OUT - TP Mean Annual Load
(kg/yr), 0.809, 0.232, 2.89, 2.34, 0.949, 1.82, 2.41, 0.272, 1.70, 3.12, 8.41, 0.882, 7.33, 1.69, 0.482, 0.137, 5.36, 1.51, 1.14, 6.42, 2.40, 44.6, 2.98, 2.15, 5.45, 4.50, 16.6, 12.3, 3.99, 3.28

OUT - TN Mean Annual Load
(kg/yr), 11.6, 3.34, 20.0, 17.5, 13.6, 12.6, 18.0, 3.91, 12.3, 45.7, 62.3, 13.2, 50.8, 12.6, 7.00, 2.02, 61.8, 10.4, 8.85, 48.6, 22.9, 216, 23.5, 23.5, 40.9, 34.4, 126, 126, 40.8, 34.4

OUT - Gross Pollutant Mean Annual Load
(kg/yr), 177, 0.272, 243, 306, 207, 154, 314, 0.317, 0.00, 694, 1.09E3, 1.07, 621, 218, 106, 0.163, 2.48E3, 127, 1.44, 0.00, 0.00, 2.48E3, 220, 7.79, 549, 468, 1.71E3, 104, 27.1, 20.5

Catchment Details

Catchment Name, NSW202732_DA MUSIC - LIDELL DATA_UK1_100621

Timestep, 6 Minutes

Start Date, 23/08/1964

End Date, 31/03/1995 11:54:00 PM

Rainfall Station, 61212 LIDDELL

ET Station, User-defined monthly PET

Mean Annual Rainfall (mm), 372

Mean Annual ET (mm), 1606

Attachment 2 – MM Hyndes Bailey Report (2017)

Stormwater Drainage Strategy

PEPPERTREE ESTATE SCONE

LOT 2 IN DP1169320



Ref: 217133

MM Hyndes Bailey November 2017

1 Proposal

It is proposed to develop residential lots to the east of Scone on the Gundy Road. The land abuts the age care facility Strathearn. The location is shown in Figure 1 below.



Location Plan
Figure 1

The area is proposed for development of 423 residential lots.

Urbanisation of this area will impact on the existing stormwater runoff. This report outlines the broad strategy for storm water drainage for the proposed residential development and analyses the impact of urbanization at the point of discharge from the site. The report proposes measures that will be necessary to meet the Council's quantitative requirements of stormwater discharge from the catchment.

Details of the layout and stormwater treatment proposals are shown in Annex 'A'.

2 Topography

The site comprises approximately 57 Has of gently sloping grassland. The existing waterway which traverses through the site is a second order stream with its source in the adjacent hills to the east of the site. The stream is not well defined in places but is generally stable with no significant scouring evident. The proposed development drains into this natural waterway.

A farm dam is located within the site to the east.

3 Subdivision Proposal

It is proposed to develop an urban residential development with roads fully developed with kerb and gutter. A fully developed piped drainage system will also be provided.

3.1 STORMWATER DISCHARGE STRATEGIES

To meet the requirements of Scone Shire Council, it will be necessary to embrace the following objectives:

- Ensure that peak runoff from the developed catchment does not exceed the peak runoff from the existing catchments for all return periods. This includes sub-catchments within the development.;
- Ensure that concentrated flows do not cause an increased number of erosion events in natural waterways.

Using these criteria, the flow data will be examined and any additional interventions recommended as part of the drainage strategy.

To meet these objectives the following strategy is proposed:

1. Provide detention basins at major discharge points from the site;
2. Maintain the natural waterways as drainage reserves and shape these waterways only where erosion is evident or where hydraulic efficiency is required;
3. Where necessary place scour protection at pipe outlets and other areas of flow concentration.

4 Hydrology

4.1 HYDROLOGY ASSUMPTIONS

The proposed development has been analysed using ILSAX hydrological model from “Drains” drainage program, based on rainfall data for Scone. Analysis has been completed for annual exceedance probabilities of 50%, 20%, 5% and 1%, for storm durations of 15minutes, 30 minutes, 1 hour, and 2 hours..

Australian Rainfall and Runoff 2016 has recently been introduced and it is proposed to analyse the catchment using the 2016 rainfall data.

The 2016 Rainfall and Runoff manual places more emphasis on temporal rainfall patterns and several critical rainfall patterns have been used for each return period analysed. The temporal patterns have been adopted for East Coast South region.

“Frequent” patterns have been adopted for 2 year and 5 year return periods, “intermediate” for 20 year return period and “rare” for the 100 year return period, all as recommended by the new manual.

For each return period, a total of 12 cases have been analysed.

The ILSAX hydrological model criteria adopted for the analysis are shown in Figure 3 below.

ILSAX Hydrological Model Input
Figure 2

Impervious areas relate to paved roads.

Supplementary Areas refer to roofs and hardstand areas in properties. The total area assumed is 500m² for normal residential blocks. . A slightly higher depression storage of 1mm has been selected to account for on site water tanks.

Grassed pervious areas refer to lawns, grassed footpaths and open reserves.

“Rather” wet antecedent soil conditions are assumed.

The pervious and impervious areas for each fully developed catchment are shown in the table below:

Catchment	Area Has	Impervious Area %	Pervious Area %
Catchment A	8.4	50.8	49.2
Catchment B	15.6	56	44
Catchment C	22.8	55.9	44.1

Catchment Details
Table 1

To achieve acceptable reductions in peak flows it will necessary to establish a series of detention basins located on the periphery of the natural waterway. The location of these basins is shown in ‘Annex A’.

4.2 FLOW ATTENUATION / WATER QUALITY

The size of each basin modelled in this analysis is tabled below.

In accordance with the water quality plan prepared by Barker Ryan Stewart (MUSIC MODEL) all basins to be bio retention with a gross pollutant trap, sediment trap and be of an impermeable construction, to comply with water quality and salinity requirements (REF: HU170046)

Detention Basin	Crest Width m	Crest RL	Volume of Basin @ max discharge
Basin A	10	214.5	1440
Basin B	10	214.5	4480
Basin C	15	210	9230

**Detention Basin Sizing
Table 2**

4.3 FLOW MODELLING

4.3.1 2016 R&R Analysis

Modelling using the 2016 data gives the following results:

Cat	Q ₂ m ³ /s		Q ₅ m ³ /s		Q ₂₀ m ³ /s		Q ₁₀₀ m ³ /s	
	Exist	Dev	Exist	Dev	Exist	Dev	Exist	Dev
A	0.21	0.22	0.5	0.24	0.96	0.88	1.84	2.28
B	0.26	0.19	0.59	0.23	1.12	0.65	2.18	2.27
C	0.27	0.19	0.62	0.23	1.17	0.25	2.26	1.56

**Pre/post Development Peak Discharges
2016 R&R Analysis
Table 3**

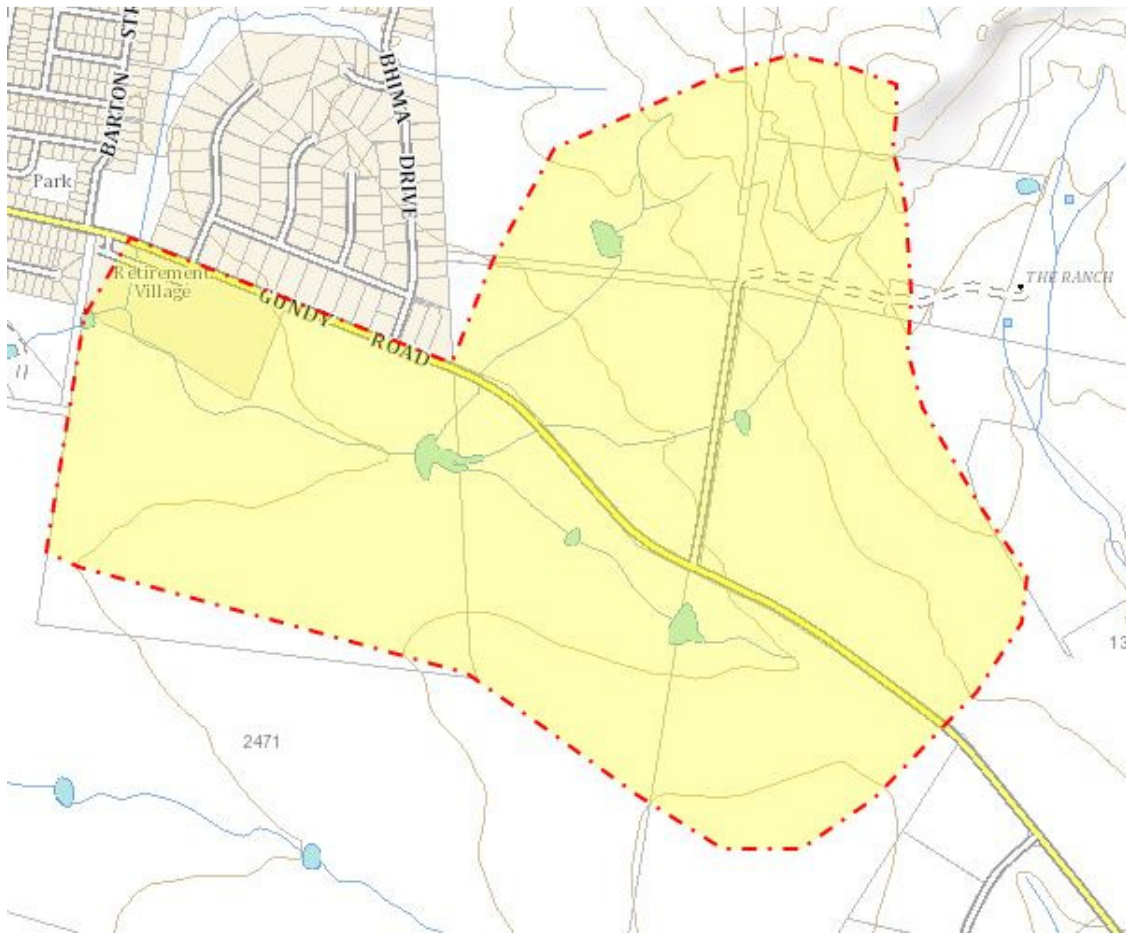
The table above demonstrates that in all cases except the Q100 event, the peak discharges for the post development flows are equal or less than the pre-development flows. Overall at the point of discharge, at the downstream end of the natural channel the Q100 discharge for the developed catchment is less than the existing discharge.

The detailed design may show that some modifications to basin size can be achieved.

5 Natural Waterway

5.1 EXTERNAL CATCHMENT

The natural waterway which traverses through the proposed development has a catchment of 2.3km² at the point of exit from the development as shown in Figure 3 below.



External Catchment Area
Figure 3

Estimates of flow were determined using the Regional Flood Frequency Estimation model developed in the 2016 R&R document. Results of this analysis are tabled below.

AEP %	Discharge m³/s
50	2.86
20	6.56
5	14.8
1	29.8

**2016 Regional Flood Frequency Analysis
Table 4**

5.2 STREAM HYDRAULICS

The 1%AEP flood has been routed through the natural waterway using the HEC RAS model, taking into account the natural contours and the additional constrictions of roads and detention basins located in the waterway.

The levels of flooding for this flood have determined and are shown below. The extent of flooding is also shown in the stormwater treatment proposal in Annex 'A'.

Chainage	RL
50	208.84
150	210.7
250	212
350	213.51
450	214.85
Road crossing*	215.3
550	216.32
650	217.44

*Note: Level of flooding over road causeway with level of 215.1

**1%AEP (1 in 100yr) Flood Levels
Table 5**

At the eastern end of the natural waterway there exists a farm dam. It is proposed to leave this dam in place, however it will be necessary to properly design the bywash of the dam to ensure it has adequate capacity for the 1% AEP flood and at the same time not encroach on proposed residential lots.

5.3 ROAD CAUSEWAY

A detailed analysis of the road crossing the natural waterway has been undertaken. In accordance with Natspec, the causeway has been designed to pass the 5%AEP (1 in 20yr) flood. The causeway has also been designed to pass the 1% AEP flood with a proportion of the flow passing through the culverts and the remaining flow passing over

the causeway with the overflow meeting the following pedestrian safety standards outlined in Natspec.

- Max depth: 200mm
- Depth x Velocity 0.4

To meet these standards the following causeway design is recommended:

Causeway RL	215.1 to 215.3
Causeway Length	60m
Culverts	10/1500x750 RCBC
Floodway depth 1% AEP flood	0.2m
Floodway velocity 1% AEP flood	0.75 m/s

Causeway Details
Table 6

The causeway will need to be protected either by rock or concrete lined embankments with adequate downstream aprons to avoid under-scour.

6 Erosion Events

The urbanisation of catchments creates the potential for increased erosion events because of the additional impervious areas. The criteria for “erosion events” will be determined based on flow velocities and duration of flows.

Scouring in the natural waterway will be controlled by ensuring:

- peak flows (and velocities) are restricted by detention basins;
- the natural waterway will be reinforced where necessary with appropriate turf treatments at the detailed design stage;
- discharges from culverts and piped systems are treated with adequate scour protection.

6.1 VELOCITY- DURATION STANDARD

Table 1.18 of Volume 1 Book VIII of Australian Rainfall and Runoff 1987 gives limiting velocities for the erosion resistance of grasses as follows:

Table 1.18. Limiting velocities for erosion resistance of grasses.

FLOW DURATION (h)	VELOCITIES (m/s) FOR: QUALITY OF COVER		
	Good	Normal	Poor
2	5.0	3.8	2.8
4	3.7	2.9	2.1
6	3.3	2.5	1.8
9	3.0	2.3	1.6
12	2.8	2.1	1.5
18	2.7	2.0	1.3
24	2.6	1.9	1.2
48	2.5	1.7	1.0
72	2.4	1.6	0.9

(Source: Whitehead, 1976)

Limiting velocities for grasses Table 7

Table 5.2 of the publication "Soils and Construction - Managing Urban Stormwater" (the Blue Book), allows the following velocities for couch, Rhodes and carpet grass on highly erodible soil:

Flow Duration (hrs)	Velocity (m/s)
6	1.4
12	1.2
24	1.1
48	0.9

Velocity – Duration Table 8

It is proposed to use the slightly more conservative standards adopted in the "Blue Book".

The maximum velocity for the 1%AEP flood using HEC RAS was 1.38m/s. Because of the relatively small external catchment, the duration of flow at this velocity is likely to be less than an hour, well short of the 6hr criteria given in the Blue Book.

Discharges from overflows from detention basins in the 1% AEP flood can be in the order of an hour for longer duration rainfall events, however the maximum velocities that will occur will be no greater than 1.2m/s, providing overflows are properly dissipated.

7 Conclusion

The stormwater proposals outlined in this report demonstrate that the objectives in Section 3.1 Stormwater Discharge Strategies, can be achieved using detention basins as the main strategy.

- Peak flows for each of the 4 flood frequencies analysed have been demonstrated to be less than the preexisting discharges at the point of discharge from the development, using the recommended detention basins.

- Velocities of flow are well within the accepted scouring velocities set out in the Blue Book.
- The causeway can be constructed as outlined in the report and meet the safety requirements of Natspec with regard to water depth and velocity.

Your faithfully,

Bruce MacFarlane
Consulting Engineer
MM Hyndes Bailey & Co.

Annexure 'A'

Drawing; Drain_001

