BIOME
WATER AND ENVIRONMENTAL CONSULTING

Our Ref: BC-18008
Your Ref: SUB2023/001

15 June, 2023

Clarence Valley Council
Locked Bag 23
Grafton NSW 2460

Attention: James Hamilton

Dear James,

RE: DEVELOPMENT APPLICATION SUB2023/001
PROPOSED 284 LOT RESIDENTIAL SUBDIVISION
RESPONSE TO ADDITIONAL INFORMATION REQUIRED – STORMWATER ITEMS.
52-54 MILES STREET, YAMBA NSW 2464

This letter and supporting documentation have been prepared to address the stormwater items (Items 2-9) raised in the Additional Information Required request issued by Council dated 3 March 2023 (reference: SUB2023/001).

It is noted that a response letter was previously prepared to address the additional items raised by WMAwater who were commissioned as a third-party reviewer of the Stormwater Management Plan and Drainage Assessment (SMP&DA). This response has been included as Attachment A of this letter as supporting information.

A revised report SMP&DAv4 has also been included as supporting information within Attachment B.

If you would like clarification of any of the information included within this Information Request response, please contact the undersigned.

Yours faithfully

BRAD COMLEY
MSc, BAppSc MEngPrac, NER, RPEQ, CPEng.

ENC:
Attachment A – Third Party Review Response
Attachment B – SMP&DAv4

ADDITIONAL INFORMATION REQUEST RESPONSE - STORMWATER

DEVELOPMENT APPLICATION SUB2023/0001
52-54 MILES STREET, YAMBA NSW 2464

ITEM 2

A large number of technical comments made in the WMA Water report 'West Yamba Urban release Area – Yamba Gardens – Flood Impact Assessment Review' dated September 2022, appear to have not been addressed/could not be considered without reviewing the TUFLOW model. Each comment/action made by WMA Water should be responded to by the applicant and the Stormwater Management Plan (SWMP) amended in line with responses/actions.

Response

Refer to Attachment A - Response to Third Party Review, of this letter, which includes a detailed response of the amendments to the Version 2 report to create Version 3 of the SMP based on the WMA comments. These amendments have been retained in the Version 4 report which has been include as Attachment B.

ITEM 3

A concept Soil and Water Management Plan is to be provided to support the proposal.

Response

Following discussions with Chris Dear it is understood that this item pertains to sediment and erosion control management during the construction phase of the project. It is therefore suggested that this item be addressed via a development consent condition and be submitted as part of the application for a construction certificate.

ITEM 4

Gross-pollutant/coarse sediment forebays at inlet of Bio-pods should be provided.

Response

In accordance with Table 13 of the Bioretention Technical Design Guidelines (Version 1.1, Water by Design, 2014), coarse sediment forebays or gross pollutant traps are recommended when contributing catchments to the bioretention measures are greater than 2 ha. Given the proposed contributing catchments to the bio pods are on average around 0.25 ha, based on Table 13, no coarse sediment forebays or gross pollutant traps are required. Rock scour protection has instead been proposed at the inlet points into the bio-pods.

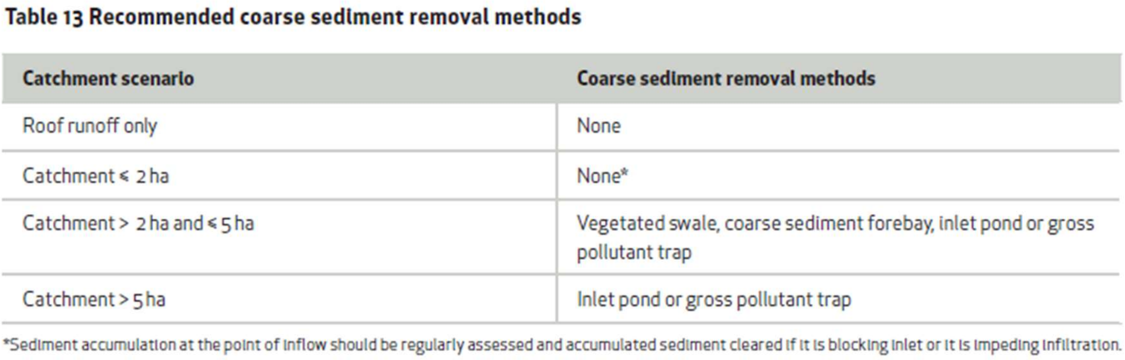

Table 13 Recommended coarse sediment removal methods

Catchment scenario	Coarse sediment removal methods
Roof runoff only	None
Catchment ≤ 2 ha	None*
Catchment > 2 ha and ≤ 5 ha	Vegetated swale, coarse sediment forebay, inlet pond or gross pollutant trap
Catchment > 5 ha	Inlet pond or gross pollutant trap

*Sediment accumulation at the point of inflow should be regularly assessed and accumulated sediment cleared if it is blocking inlet or it is impeding infiltration.

ITEM 5

Pre-developed case to be modelled in MUSIC to compare with post development conditions.

Response

Refer to Section 7 of the revised Stormwater Management Plan & Drinage Assessment (Version 4) attached to this letter. Pre-development stormwater quality modelling was undertaken in MUSIC based on the existing soil types and a rural land use.

The results of modelling including a comparison between the pre-developed, developed (untreated), and developed (treated) scenarios are summarised in the table below. Treatment measures have been sized to achieve the water quality targets specified within Table H2 of the DCP and will ensure that surface water pollutant loads are reduced by at least 85%, 60% and 45% for TSS, TN and TP respectively of the devloped flow.

In comparision to the pre-development scenario, whilst increases in nutrient loads (TN and TP) are expected as a result of urbanisation of the site, sediment loads are generally expected to largely decrease due to the inclusion of stormwater treatment measures whithin the development. To achieve a reduction in nutient loads that would meet with pre-developed conditions an 80% reduction in TP and 75% reduction in TN would be required from the untreated developed flow.

Table 1 Pre-Development vs Developed (Untreated) vs Developed (Treated) Nutrient & Sediment Loads

Catchment ID	Pollutant	Pre-Development (kg/yr)	Developed (Untreated) (kg/yr)	Developed (Treated H2 requirments) (kg/yr)
Overall Site (TOTAL)	TSS	11,041	34,510	3,619
	TP	13	66	21.6
	TN	107	435	236

As discussed in Section 5.3.1 of the Water Sensitive Urban Design Technical Design Guidelines for South East Queensland (Version 1, June 2006, Healthy Waterways Partnership) referred to as ‘WSUD Guidelines’, bioretention performance as a ratio of biroetention treatment area exhibits a non-linear relationship comparable to a logarithmic regression. This relationship implies that treatment perfomance increases rapidly with treatment area size then reaches a point of ‘diminishing performance’ where incremental increases in basin size result in only marginal increases in bioretrention performance. This is represented graphically within Figures 5-4, and 5-5 of the WSUD Guidelines and is also provided in the figures below.

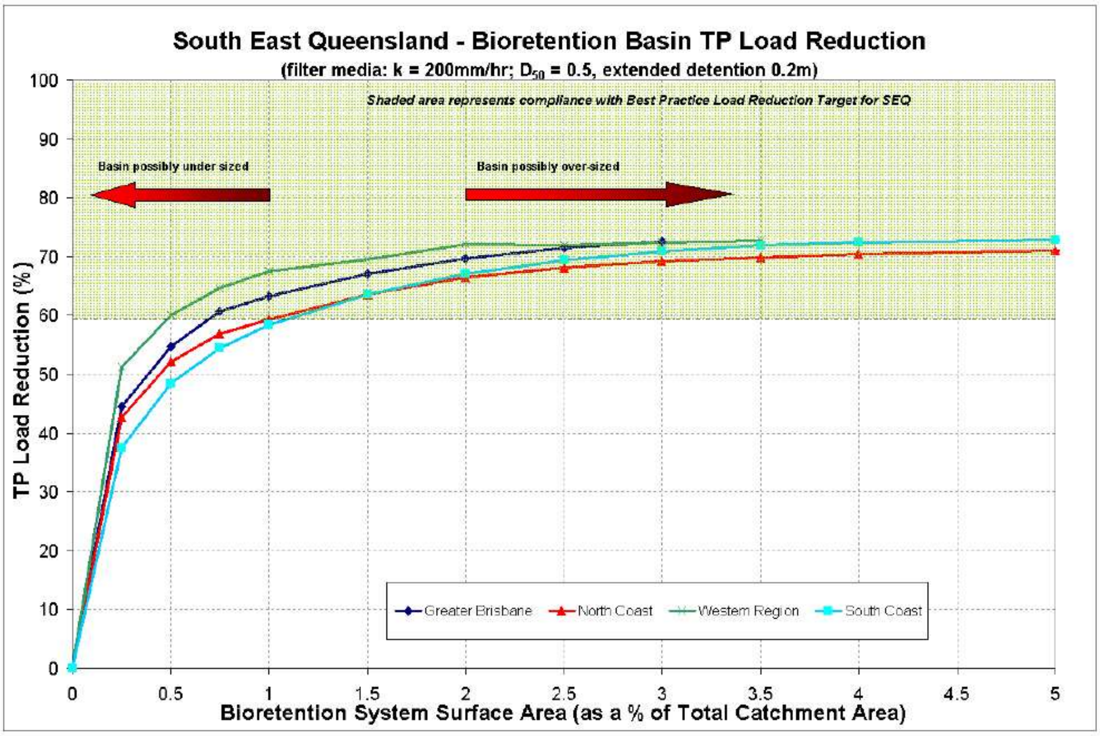

Figure 5-4: Bioretention Basin TP Removal Performance

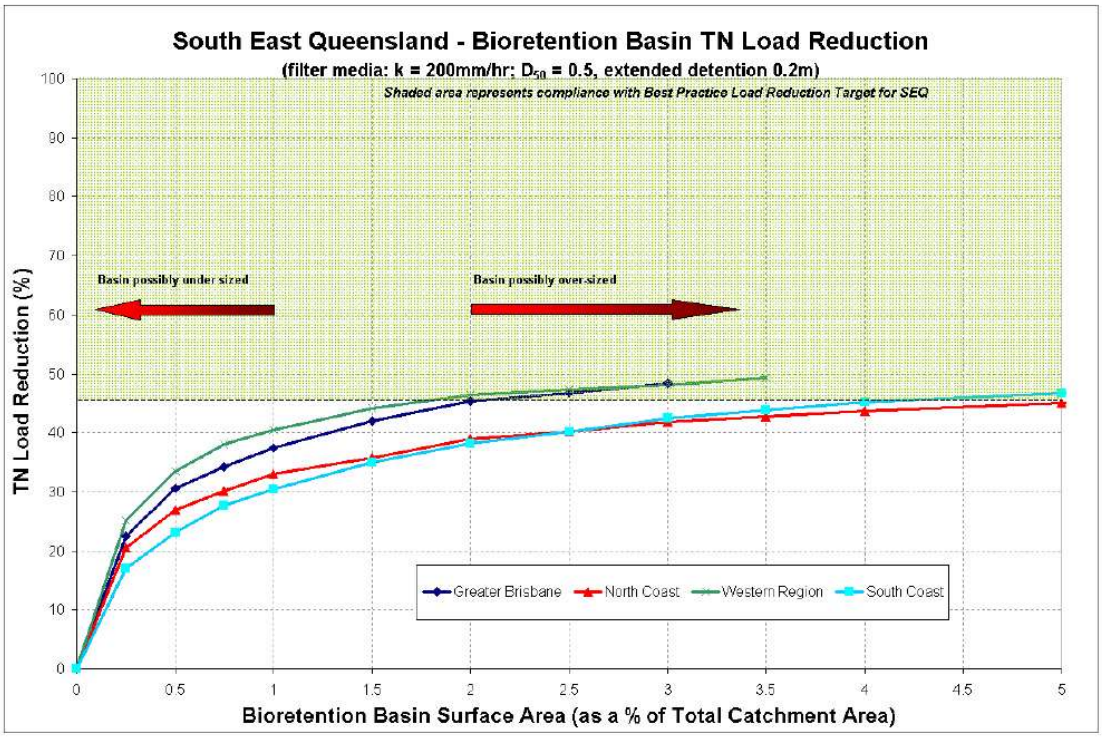

Figure 5-5: Bioretention Basin TN Removal Performance

As can be seen in the graphs above, the most optimal treatment area is 1-2% of the total contributing catchment area. It is noted that whilst the information provided above represents catchments modelled within Queensland climates, it is deduced that a similar relationship would be prevelant for catchments within the site locality.

The bioretention treatment measures for the proposed development have been sized to achieve the required load based reductions specified in Table H2 of the DCP. The resultant filter treatment areas equate to approximately 1.1% of the developed contributing catchment. It is therefore considered that the optimal treatment basin size has been provided for each catchment. Furthermore, increasing the size of the basins would likely not offer a material change in of treatment efficiency but would result in large assets delivered to Council and therefore increase maintenance costs.

ITEM 6

A more detailed sensitivity assessment on key assumptions is recommended, including key parameters such as the roof/road/ground percentage, soil properties, percent of roof area reporting to rainwater tanks, key bioretention basin parameters, exfiltration rate, pollution generation parameters, rainfall and evaporation estimates, etc.

Email April 12, 2023 2:24 PM

Key assumptions in the pre-developed case should be reviewed with findings from geotechnical investigations over the site – specifically, soil properties, evaporation estimates and infiltration rates.

Response

Refer to Sections 6.2.4 and 7.5.4 of the report. Sensitivity analyses have been included for both the quantity and quality assessments. The requested sensitivity scenarios are discussed further below.

Stormwater Quantity Sensitivity

- Basin Blockage: Consideration has been given to consequences of fully blocked outlet pipes for both basins. Modelling indicates that water levels would increase within the basins with all flows discharging over the high flow weir structures. Peak water levels are not expected to exceed the top of bund level in all modelled events up to the 1% event.

- Very Rare Events: Consideration has been given to very rare events including the PMF and 0.05% AEP (or 1 in 2000 AEP).

  Modelling indicates that in a very rare event (defined within the report as the 0.05% AEP) water levels would increase within the basins with all flows discharging over the high flow weir structures. Peak water levels are not expected to exceed the top of bund level in this event.

  Modelling indicates that during the PMF the detention basin bund will overtop by up to 200 mm. Velocities on the downstream face of the bund are expected to be > 2 m/s and therefore it has been recommended that scour protection be provided.

- Changes in imperviousness (existing case): As requested by Council, the existing impervious area within Catchment C was removed from the existing case model. This has not materially altered the reported flows at the nominated point of discharge (PD-C) given the impervious area represents approximately 0.4% of the contributing catchment to this discharge location. Table 2 below presents the peak discharge comparison at PD-C.

Table 2 - Peak Discharge Comparison (m^3/s) – PD-C

Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
		39.3%	18.1%	10%	5%	2%	1%
Existing	24.49	0.91	1.32	1.84	2.30	2.83	3.30
Developed (Unmitigated)	26.87	1.94	2.34	2.85	3.30	3.94	4.63
Developed (Mitigated)		0.91	1.27	1.83	2.20	2.68	3.26
Difference (Existing vs Developed)		**0.0**	**-0.05**	**-0.01**	**-0.1**	**-0.15**	**-0.04**

- Soil properties: Council have requested that consideration be given to the geotechnical findings over the subject site.

  Infiltration from pervious areas within the xpstorm model have been based on a uniform loss methodology. As described in Section 3.4 of the SMP, losses were obtained from the Australian Rainfall and Runoff Data Hub tool based on the geographical location of the site, then adjusted based on Approach 5 described in 'Floodplain Risk Management – Incorporating 2016 Australian Rainfall and Runoff in studies', 2019).

  It is noted that loss within a catchment is not only a product of soil composition, but also depression storage, vegetated interception, and transmission loss through stream beds and banks (Hill, P & Thomson, R, ARR Book 5, Chapter 3, 2019). It is difficult to estimate storm losses based solely on geotechnical information within the site. As described in Section 3.3.3 of ARR Book 5 (Hill, P & Thomson, R 2019) the broad approaches to estimating losses include empirical analysis of at site rainfall and streamflow records, information from regional analysis of data, and reconciliation of design values with independent flood frequency estimates.

  The analysis contained within Book 5 has provided the consideration as requested by Council. Therefore the recommendations within ARR Book 5 Chapter 3 (Hill, P & Thomson, R 2019) based on regional studies of loss values have been adopted.

- Evaporation: In xpstorm modelling, evaporation has a near negligible effect on single event simulation. This is due to the relatively short time frames for a rainfall event which are of interest in stormwater quantity modelling. Evaporation generally occurs at a much slower rate over a longer time frame.

Stormwater Quality Sensitivity (MUSIC model)

- Changes in imperviousness: As requested by Council, consideration was given to changes in imperviousness within the catchment and treatment effectiveness modelled within MUSIC. In this modelling scenario, the road imperviousness was increased from 60% to 100%, and the ground imperviousness increased from 20% to 50%. Results of modelling indicate increases in the imperviousness of the road and ground areas will not worsen the treatment train effectiveness of the bioretention systems. Refer to Section 7.5.4 of the attached report for modelling results and further information.

- Changes in source node splits (roof/road/ground): As requested by Council, consideration was given to alterations in roof/road/ground splits within the catchment and treatment effectiveness modelled within MUSIC. In this scenario the 2,500 m^2 catchment was split based on three lots with a minimum lot size of 450 m^2 and a road area of 1,150 m^2. Roof areas were assumed as 250 m^2 per lot with the remainder of the lot represented as ground area. This equates to a split of 46% road, 30% roof, and 24% ground. Results of modelling indicate increasing the road catchment split will improve the treatment effectiveness of the bioretention system. Refer to Section 7.5.4 of the attached report for modelling results and further information.

- Soil Properties. Council have requested that consideration be given to the geotechnical findings over the subject site.

  As discussed in Item 5, and also Section 7.2.1 of the attached report, the existing soil properties have been considered in the pre-development case MUSIC model with rainfall runoff parameters split based on the existing soil type. In the developed and mitigated scenarios soil types have been based on a silty clay soil type which represents a more compacted fill material likely to be used onsite.

- Rainfall/Evaporation. The Grafton South station (58076) has been used for modelling purposes, as this is the closest rainfall station with available and accurate pluviograph data to the site.

- Pollution Generation Parameters. The adopted pollutant export parameters for each sub catchment are based on data from the Water by Design MUSIC v6 Modelling Guidelines (2010).

- Bioretention Basin Parameters. The adopted bioretention parameters have been based on Type 3 – Conventional bioretention systems as described in the Bioretention Technical Design Guidelines (Water By Design 2014). Whilst liners are not specified for Type 3 drainage profile systems, an exfiltration rate of 0.0 mm/hr has been adopted for modelling purposes in accordance with BMT WBM 2015, and Clarence Valley Council Guideline in Preparing MUSIC Model v6 (DRAFT). This is to enable water quality objectives to be tested.

ITEM 7

The Stormwater management and water quality section of Part X of the DCP outlines 5 objectives and 5 controls for the West Yamba Urban Release Area. This section also makes reference to Part H (primarily s1 and Table H1 and H2) and Part J (primarily s10). The applicant shall explicitly address each of these stormwater quality related requirements in the documents supporting their development application.

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6. Part X, H and J:

a. Investigation of downstream infrastructure and impacts of the post development peak flows on capacity due to changes in natural drainage paths and catchments – Part X C3. C. p220
b. Ensure that stormwater discharge from residential subdivisions does not compromise the health of nearby natural waterways or the integrity of nearby endangered ecological communities (EECs) or other vegetation communities – investigate
c. The drainage network must plan, design and implement infrastructure in recognition of connectivity, restrictions and impacts upstream, neighbouring and downstream infrastructure and environment which extends beyond the boundaries of the proposed development. Council needs to be aware of the impacts on the existing natural drainage paths and it must be demonstrated that the external drainage will function as intended/not be impacted in the post development case. – Item 4 in Table H1
d. Retention and restoration of natural drainage systems/flow paths – J10.2 b)
e. Stormwater management to include vegetation management, in particular the planting of local indigenous plant species – J10.2 e)

Response

Please refer to Appendix H of the attached report for assessment against Parts X, H, and J of the DCP specific to Stormwater Management.

ITEM 8

The Northern Rivers Handbook of Stormwater Drainage Design requires the assessment of the Probable Maximum Flood for detention basins (Section 9, Point 8) – it is unclear if this has been addressed in the latest report.

Response

Consideration has been given to very rare events. Version 4 now includes an additional Section 6.2.4 in which an analysis of the PMF and 0.05% AEP (or 1 in 2000 AEP) event has been undertaken.

Modelling indicates that in 0.05% AEP event, water levels would increase in both the detention basins with all flow discharging over the high flow weir structures. Based on the existing basin and weir configurations, peak water levels would not be expected to exceed the Top of Bund during the 0.05% AEP.

Modelling indicates that during the PMF the detention basin bund will overtop by up to 200 mm. Velocities on the downstream face of the bund are expected to be > 2 m/s and therefore it has been recommended that scour protection be provided.

ITEM 9

Please clarify what design criteria was used for sizing the stormwater network (culverts, kerbs and pits).

Response

Refer to Section 6.1.2 of the attached report. The stormwater network within the internal road is designed for the 18.1% AEP. Major flows (up to the 1% AEP) above the piped network capacity are to be conveyed within the road reserves to the proposed detention basins within Catchments B and C.

Attachment A

Third Party Review Response

RESPONSE TO THIRD PARTY REVIEW

DEVELOPMENT APPLICATION SUB2019/030
52-54 MILES STREET, YAMBA NSW 2464

Local – Regional Integrated Assessment

Section 4.2.1.1. Integrated assessment of local flooding and riverine flooding

The BIOME TUFLOW model which was developed for assessing stormwater management options investigates local runoff and flooding without considering any impact from riverine flooding. Therefore, it is recommended to add detail of local runoff generation behaviour in the model and provide an integrated assessment the joint probability of local flooding and riverine flooding for short and long duration design storms.

4.2.2.2. Riverine Flooding

The BIOME TULOW model does not consider the impact of runoff/ flooding from the neighboring catchment outside of the study area as well as riverine flooding from major river systems. The 1% AEP stormwater inundation would be potentially higher if riverine flood levels were included in the modelling. This is of importance for the assumptions made about the water level at outlet of stormwater system.

There is no need for a full joint probability assessment of these systems. We recommend including riverine flood levels from 20% AEP design event as boundary condition for 1% AEP local flood assessment. Similarly, 1% AEP riverine flooding should be considered for modelling 20% AEP local flooding.

Response

Refer to Section 6.3.5 of the revised Stormwater Management & Downstream Drainage Assessment Report (Version 4).

To analyse local flood during a regional tailwater additional modelling has been undertaken.

In accordance with Section 5.5 of the Northern Rivers Local Government Handbook of Stormwater Drainage Design a tailwater equal to the River Half-Tide Level is to be used for receiving tidal waters. Based on Appendix D of the Handbook this level for Gauge 1a would be 0.89 m (Chart Data) - 0.91 m = -0.02 m AHD.

As the site outlet is above this level (0.8 m AHD), consideration was given to coincident flooding (local vs regional events). Based on a catchment ratio of 10,000 to 1 and with reference to QUDM table BN 8.3.4.1 – Suggested ARIs for coincidental occurrence (Figure below), an following event combinations have been considered:

- local 1% AEP on a regional 39.3% AEP; and
- regional 1% on a 39.3% local.

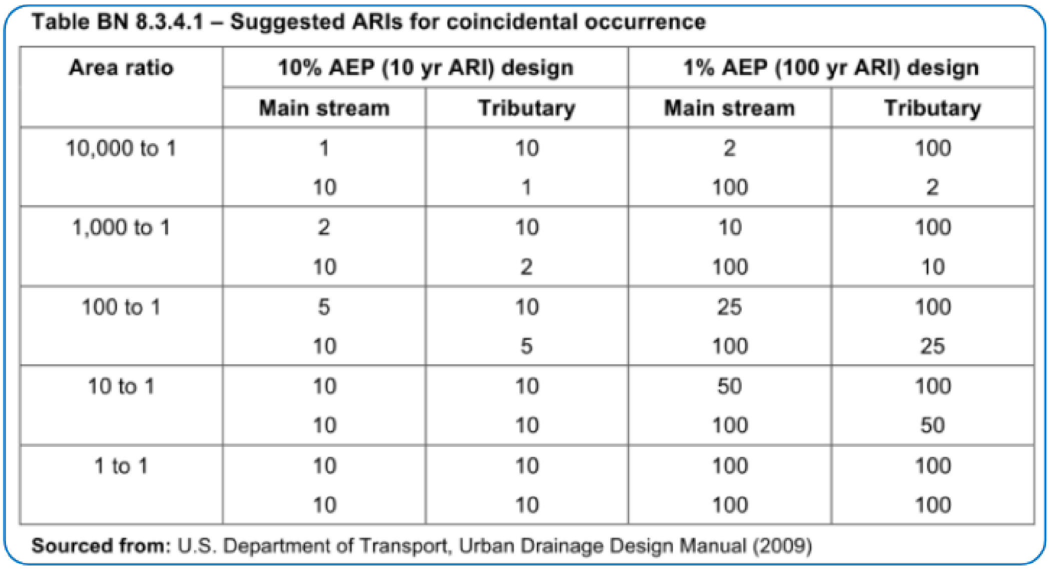


Table BN 8.3.4.1 – Suggested ARIs for coincidental occurrence

Area ratio	10% AEP (10 yr ARI) design		1% AEP (100 yr ARI) design	
	Main stream	Tributary	Main stream	Tributary
10,000 to 1	1	10	2	100
	10	1	100	2
1,000 to 1	2	10	10	100
	10	2	100	10
100 to 1	5	10	25	100
	10	5	100	25
10 to 1	10	10	50	100
	10	10	100	50
1 to 1	10	10	100	100
	10	10	100	100

Sourced from: U.S. Department of Transport, Urban Drainage Design Manual (2009)

BMT have undertaken regional modelling over the West Yamba study area. The 1% AEP flood level recorded at the site is RL 2.0 m AHD. Whilst no information is provided within the report for a 39.3% event. The results of the regional flood modelling show the subject site as flood free during a regional 18.13% AEP. As such the 39.3% regional tailwater case initial water level has been set equal to the proposed outlet of RL 0.8 m AHD.

Table 3 – Item 1

1. An objective for the stormwater discharged from the site is that the design achieves the specified load-based reduction targets in accordance with Clarence Valley Council's Residential Zone Development Control Plan. For the development site relevant targets of 85% for TSS, 65% for TP, and 45% for TN have been adopted (based on LANDCOM's Water Sensitive Urban Design Strategy (2009)).

   The adopted water quality targets are consistent with the LANDCOM 2009 baseline performance target for pollution control. (Noted LANDCOM also has 1.5 yr peak discharge objective and stream erosion index = 2.0). Table H2 in the Clarence Valley Council DCP also provides a similar set of targets. Compared to the objectives given in Table H2 in the Clarence Valley Council DCP, the values used are conservative except for the Total N target, 45% adopted while the Clarence Valley Council DCP requires 50%. However, Table 7.10 and 7.11 indicate both options result in reductions for TN of over 50%, meeting the higher Clarence Valley Council DCP 2011 objective.

   It is noted that Table H2 in the Clarence Valley Council DCP also provides oil and grease and pH objectives, which are not addressed in the report. It is noted that s7.2 of the report adds a 90% gross pollutants target. This target is also conservative compared to the 80% Clarence Valley Council DCP objective.

Response

When preparing the MUSIC modelling presented within the report, advice was sought from Council in relation to water quality targets. BIOME was informed that targets contained within TABLE H2 were in the process of being revised to better align with LANDCOM requirements. Council informed BIOME that modelling should therefore achieve the most stringent of either guideline.

The current version of the Clarence Valley Council DCP as sourced from the link below specified the current water quality targets within TABLE H2.

https://www.clarence.nsw.gov.au/files/assets/public/building-and-development/files/development-control-plans/residential-dcp_29_july_2022.pdf

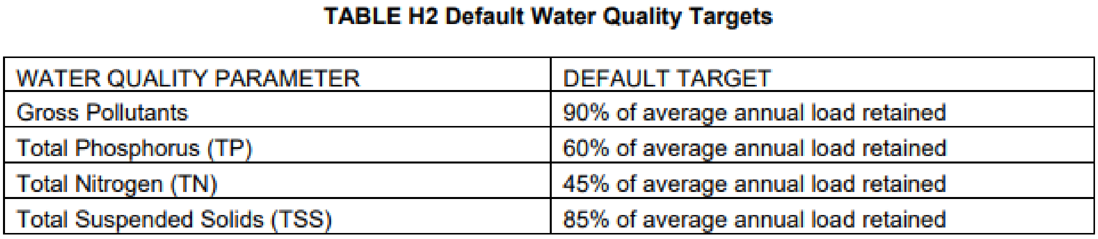


TABLE H2 Default Water Quality Targets

WATER QUALITY PARAMETER	DEFAULT TARGET
Gross Pollutants	90% of average annual load retained
Total Phosphorus (TP)	60% of average annual load retained
Total Nitrogen (TN)	45% of average annual load retained
Total Suspended Solids (TSS)	85% of average annual load retained

MUSIC modelling presented within Section 7.0 of the attached SMP&DAv4 demonstrates that the current targets can be achieved within the proposed treatment train.

Please note oil and grease and pH objectives have been removed from Table H2.

Table 3 -Item 2

2. Please indicate which version of ARR was used.

Response

IFD, storm losses and temporal patterns were sourced from the Australian Rainfall and Runoff Datahub (Babister et al, 2016). Section 2.1 within the amended report has been updated to include this reference.

Table 3 -Item 3

3. There is a mismatch between the tabulated IFD in report and Appendix C. Please make reference to Appendix C for the full IFD list if not tabulated in the main report (only up to 3 hours).

Response

Table 2.1 has been amended to include all modelled durations. Reference has now been included for Appendix C refering to the full list of IFD data.

Table 3 -Item 4

4. It is unclear if the developed case hydrology model includes the basin. It would be helpful to clarify if this section is modelling the unmitigated state. Otherwise, basins should be included in the modelling.

Response

Section 5 of the report is the *unmitigated* hydrological assessment of the development. This section establishes the extent to which development will affect peak discharge to the site's point of discharge. It is also used to validate the post development catchment flows. Where peak discharge is increased, mitigation measures are required. In cases where catchment reduction result in a reduction in peak discharge no detention is necessary.

Modelling of proposed mitigation measures (detention) is outlined within Section 6 of the report titled 'Stormwater Quantity Management – Operational Phase' of the report.

The title of Section 5 of the report has been amended within the attached SMP&DAv4 to 'Developed Case Unmitigated – Hydrological Assessment' to avoid confusion.

Table 3 -Item 5

5. Please state the design event for the stormwater drainage by Morton's Urban Solutions.

Response

The minor event for the stormwater pipe drainage by Morton's Urban Solutions is the 18.1% AEP. Section 6.1.2 has been amended to clarify this.

Table 3 -Item 6

6. The model boundary located along Golding Lane and Sullivans road are at a close proximity to the culverts along these roads. The model boundary should be extended to properly model the flow behaviour through culverts. This will most likely not change the modelling outcomes but ideally it would minimise the impact of outlet.

Response

The model boundary has been extended a further 50 m downstream. The model has been rerun and no material changes have occurred to the results. Refer to Figure 6.7 of the attached SMP&DAv4.

Table 3 -Item 7

7. Please define HAT where it is stated first within the report. The WYURA model is located at a certain distance away from the river. Including description on how the HAT level was translated to the model boundary would help with analysing the results. The TUFLOW model indicated an initial water level of 0.8 m AHD was adopted, which is also the pipe outlet invert level for the basin. Please provide some description in the report why this value was selected. Also considering the flood levels for the design event from the regional model could potentially impact the stormwater system performance (as described in 4.2.2.2 and 4.2.1.1).

Response

Version 4 of the report has included the definition of the acronym HAT where it is first used (Section 7.2.2).

In relation to tailwater assessment and adoption of 0.8 m AHD please refer to the response prepared above addressing Local – Regional Integrated Assessment.

Table 3 - Item 8

8. This methodology for tailwater conditions may not be consistent with the Handbook of Stormwater Drainage Design Northern Rivers Local Government. The downstream model should be a constant water level (HT) as opposed to HQ. Checking the water level at the boundary might be able to provide assurance with meeting this criterion.

Response

Section 6.3 of the attached SMP&DAv4 has been amended to include a Local – Regional Integrated Assessment based on a constant tailwater. Please refer to the response prepared above addressing Local – Regional Integrated Assessment.

Table 3 -Item 9

9. The list of landuses and respective Manning's coefficient were not reflected in the TUFLOW model which has a constant roughness value of 0.03 commented for roads. For example, S6.3.4 indicates a value of 0.015 for concrete/roads, which is different to the value used in the model. The TUFLOW model might need to be updated to account for these values.

Response

Modelling was undertaken for two cases. The design case was based on the Manning's values listed in the report. A second case (sensitively) was undertaken with roads assessed with an increased Mannings n of 0.03 to test road depths.

It appears that BIOME Consulting may only have issued the result files for the sensitively analysis and not included the design case files.

Please note that the result plots contained within all issued reports are for the design case. If necessary, the design case can be provided.

Table 3 -Item 10

10. Please document the structure types and locations incorporated in the model. If any missing structures (not a part of the survey completed) were identified from the drainage paths, which may be critical to the assessment these should be documented. This would be very helpful for the future users of the model.

Response

Figure 6.7 within Section 6.3.3 of the revised report (V4) has been amended to include the modelled drainage structures.

Table 3 -Item 11

11. Please clarify if the hardstand areas are considered as impervious areas.

Response

It is confirmed that hardstand areas have been considered to be impervious areas.

Table 3 -Item 12

12. Please comment on the storm duration adopted for the modelling. For the 1% AEP event, only the 45 minute storm was modelled – Does this captures the critical duration across the development area? If not, it might be necessary to model a range of durations.

Response

An analysis of flows through the catchment was undertaken for all durations, for an ensemble of 10 temporal patterns. Statistical analysis of the peak flow results at the points of interest within the catchment were used to identify the critical design storm for each AEP at the downstream point of interest (culvert at Carrs Drive). The 45-minute storm event was found to be the critical duration for the 1% AEP peak flow to this location.

Section 6.3.7 has been added to the Version 4 report to detail the above.

Table 3 -Item 13

13. To be compliant with DCP Section D7.5, the report would likely need to include figures for flood parameters listed.

Response

The parameters listed within Section D7.5 of the DCP better relate to regional flood assessment as this modelling determines regional flood levels and therefore sets building floor levels. This assessment has been undertaken BMT.

Table 3 -Item 14

14. Section 1.1 states an objective to maintain a Lawful Point of Discharge (LPD) for all site catchments in accordance with QUDM (2016). Please provide commentary on this based on the TUFLOW model results. It would be useful to add flow directions figures.

Response

As described in Section 6.3.9 of the report, results of TUFLOW modelling indicate that the proposed development will not impact on the extent or depth of flood inundation within private property. Minor isolated impacts were noted around the new headwalls to the north-west of the site due to the upgrading of Miles Street (which is within a Council maintained road reserve).

Additionally, the results of *xpstorm* modelling (refer to Section 6.2.2 of attached report) indicate that the inclusion of the detention basins along with the proposed catchment delineation will mitigate the expected increases in peak discharge at the nominated points of discharge location during all nominated AEP events.

Section 6.4 of the report establishes the criteria for determining a lawful point of discharge. It has been demonstrated through TUFLOW and *xpstorm* modelling that:

(i) The proposed development will not alter the site's stormwater discharge characteristics in a manner that could substantially damage a third-party property;

It is therefore considered that a lawful point of discharge can be obtained for the development site.

Section 6.4 of the report has been updated to included additional figures illustrating flow direction arrows during the 1% AEP for the pre and post development case.

Table 3 -Item 15

15. The green line is not described in the legend. Perhaps reducing width of the green lines could better show the velocity impact along the roads.

Response

A legend has been added to Figure 6.13 (refer to attached report) to identify the green lines as "stormwater pipe network". The post development result plots (Figures 6.14 to 6.16) have been amended to remove the pipe network so as to more clearly indicate flooding depth and velocity.

Table 3 -Item 16

16. It is important to understand the flood hazard around the inlet of the stormwater pipes towards the basin as the velocities along the roads reach up to 0.75 m/s - although the private properties are not inundated.

Response

Whilst the velocities along the road my reach 0.75 m/s, the depth of flow is below 200 mm. The resulting d.V product is less than 0.15.

Both the peak flood depth and d.V product are in accordance with QUDM Table 7.4.4 and 7.4.5. Figure 6.16 has been included which present a d.V plot in the post-development case.

Both the peak flood depth and d.V product are in accordance with the Development Design Specification D5 Stormwater Drainage Design D5.12.

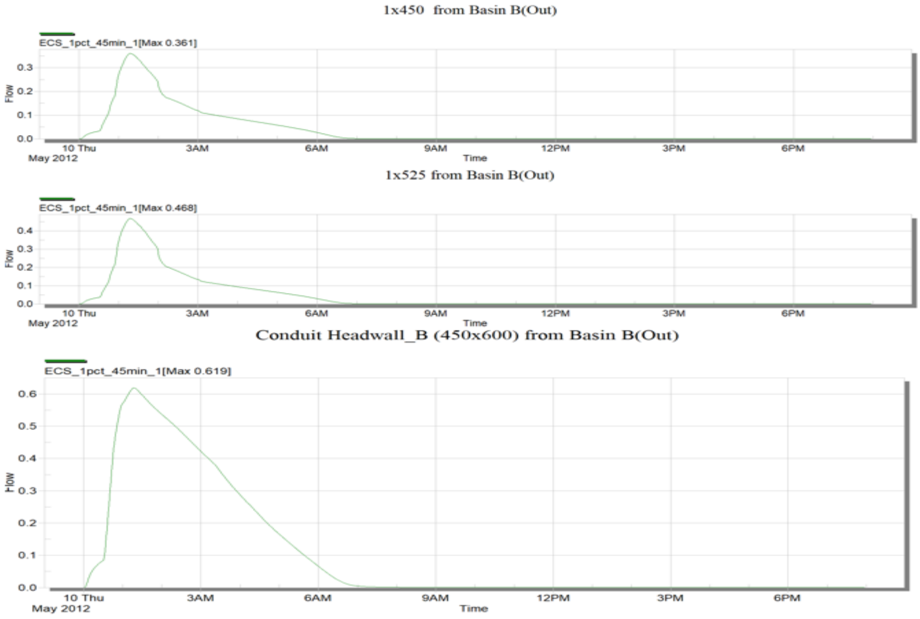
Table 3 -Item 17

17. It would be beneficial to check if the modelled flow rates in the stormwater pipes and basin is consistent with the hydrology model? Do the flow rates at the basin outlet remain above 1 m³/s for a long period of time after the storm event, was this expected?

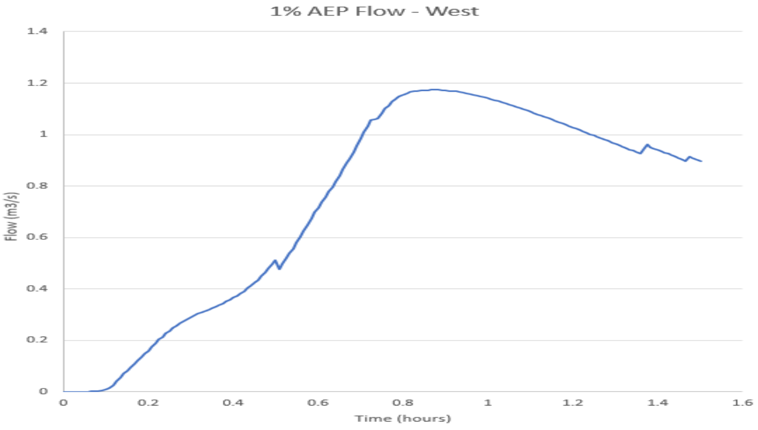
Response

The below hydrographs have been extracted from the *xpstorm and TUFLOW* modelling files. During the 45 minute 1% AEP the combined flows within the outlet pipes from Basin B are expected to the greater than 1 m^3/s for a period of up to 2 hours. Both models predict a similar duration. Given the pipes have been sized to mitigate peak flow and detain increasing in runoff volume, it is not unexpected that duration of the peak flow will increase in the post development case. This is the primary function of a detention basin.

Xpstorm Basin B

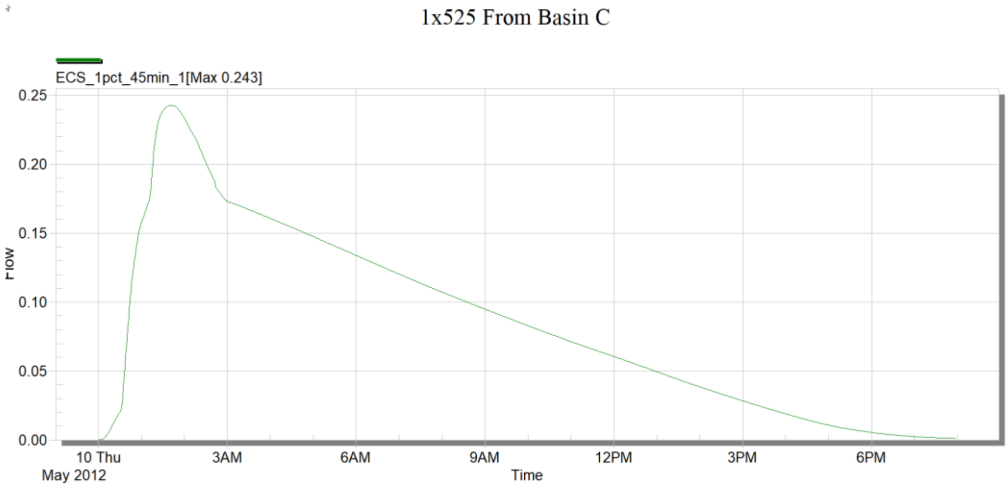


TUFLOW Basin B



Xpstorm Basin C

During the 45 minute 1% AEP the flows within the outlet pipe from Basin C is not expected to the greater than 1 m^3/s at any time. Both models predict a similar result.



TUFLOW Basin C

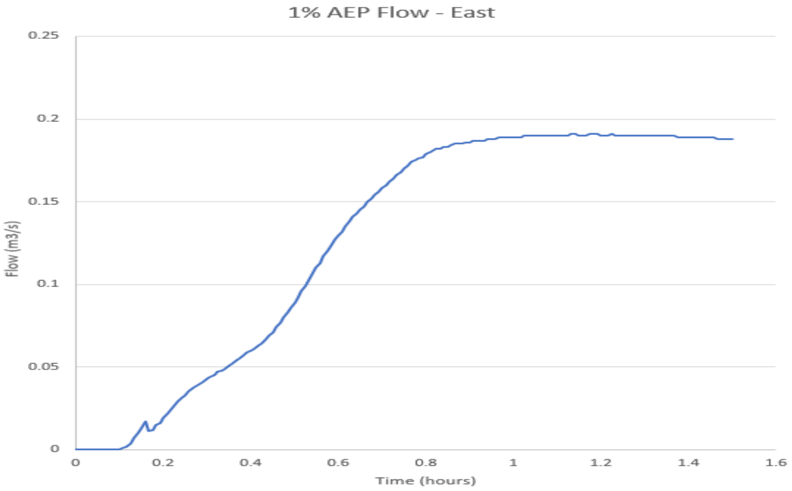


Table 3 -Item 18

18. Please check if the roads near the basin are overtopped in the 1% AEP event and if the stormwater infrastructure sizing is adequate. Please provide comments associated with risk as a result of the proposed drainage system. This is required as per the Handbook of Stormwater Drainage Design by Northern Rivers Local Government (Section 1.02, Point 4b).

Response

It should be noted that the review undertaken by WMAwater was of the Version 1 report dated 13 May 2022. A second report was prepared (Version 2) dated 18 August 2022 and to respond to the Information Request issued by Council dated 28 April 2022.

This report included an assessment of a revised road design and internal stormwater pit and pipe system. The revised design was prepared to reduce road ponding depths to a maximum of 200 mm as per Development Design Specification D5 Stormwater Drainage Design D5.12. The previous design was adopted maximum road depth as per QUDM Table 7.4.4 and 7.4.5.

The version of the SMP&DAv4 (Attachment) maintains the D5.12 requirements. Refer to Section 6.3.9.

The internal roads near the basins do not overtop during the 1% AEP event.

Table 3 -Item 19

19. The report outlines parameters for the developed case, but does not include modelling of the pre-development case. Without comparison to the pre-development, it is difficult to evaluate any change from pre-development conditions to assist in evaluation of, for example, Control C2 on pg. 219 of the CVC DCP. It is recommended that the pre-development case is modelled to allow evaluation of changes from pre-development conditions.

Response

The stormwater management measures to be included with the development have been designed to meet the default water quality targets contained within Table H2 of the DCP.

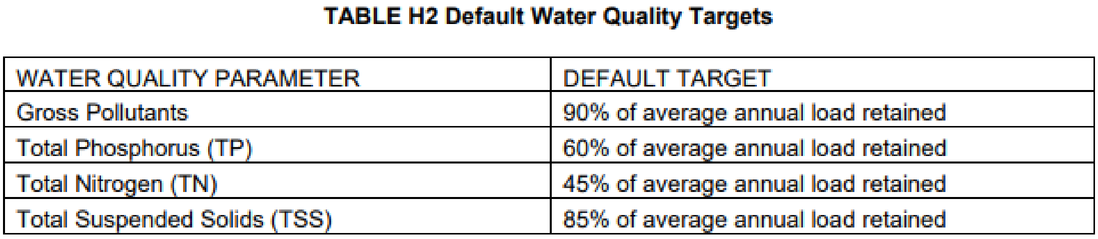


TABLE H2 Default Water Quality Targets

WATER QUALITY PARAMETER	DEFAULT TARGET
Gross Pollutants	90% of average annual load retained
Total Phosphorus (TP)	60% of average annual load retained
Total Nitrogen (TN)	45% of average annual load retained
Total Suspended Solids (TSS)	85% of average annual load retained

Table 3 -Item 20

20. The text indicates Fraction Impervious was sourced from BMT WBM 2015 report or from CVC advice. It is noted that the values used are consistent with those specified in the Healthy Land and Water MUSIC Modelling Guidelines (HLW 2018) Table 3.6 and 3.7. However fraction impervious is a critical parameter, and Table 3.5 of HLW 2018 makes it clear that fraction impervious should be determined based on the proposed development layout plans except for broadscale master planning, i.e. it is generally not applicable for development applications. In particular, it is likely that the 55% lumped catchment imperviousness, and the 60% road imperviousness are unconservative and low.

    It is recommended that fraction impervious is computed from the development plan and standard lot layout, and additionally that sensitivity analysis is carried out on this critical parameter, as part of this assessment.

Response

The reference to BMT WBM 2015 report and CVC advice relates to Table 7.3 and 7.4 not to fraction impervious values.

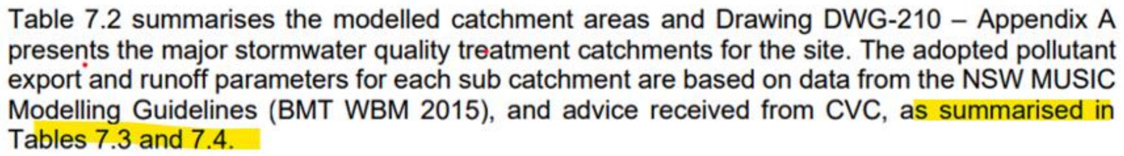


Table 7.2 summarises the modelled catchment areas and Drawing DWG-210 – Appendix A presents the major stormwater quality treatment catchments for the site. The adopted pollutant export and runoff parameters for each sub catchment are based on data from the NSW MUSIC Modelling Guidelines (BMT WBM 2015), and advice received from CVC, as summarised in Tables 7.3 and 7.4.

The imperviousness applied within each source node was based on Table 3.6 of the Water By Design Guidelines (2018).

Given the proposed at source treatment and the number of treatment devices (over 100), the modelling approach has been based on a typical 2,500 m^2 catchment. Each typical catchment includes 3 lots and road frontage. Catchments consist of 3 x 250 m^2 roof areas, 3 x 330 m^2 ground areas and 750 m^2 of road. Each catchment has been represented by an individual source node.

The proposed road reserve is 17 m wide with a 7.5 m wide carriage way. This equates to a 44% impervious surface per liner length. Considering driveways and foot paths the adopted 60% impervious values is therefore not considered unconservative or low.

Increasing the imperviousness within the catchment to a bioretention measure effectively increases the pollutant load with the runoff. Given MUSIC is based on a % reduction basis, this has the effect of making each m^2 of bioretention surface more effective.

A sensitivity analysis has been undertaken and included within section 7.5.4 of the revised report with the road surfaces increased to 100% imperviousness. The results show that load-based reduction is increased with increased imperviousness.

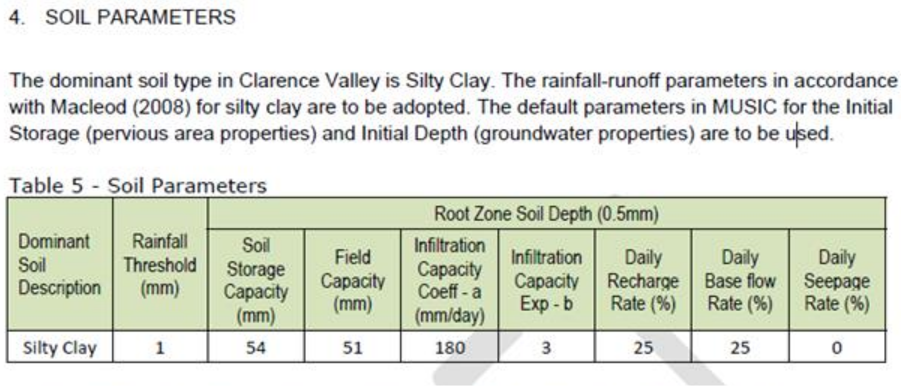
Table 3 -Item 21

21. The soil parameters in this table appear to be drawn from the silty clay row of Table 5-5 in BMT WBM 2015. Also it is understood that fill material will likely be imported from elsewhere. Please include some local information in the report to support this choice of soil conditions for the subject site, and consider the likely variability of soil conditions from likely fill source areas. If significant variability is feasible, a sensitivity assessment would be appropriate.

Response

The values of the soil parameters for the developed catchments contained within Table 7.6 of the report and used within the MUSIC model for the site have been based on advice and documentation received by Clarence Valley Council (see extract below taken from documentation ‘Guideline in Preparing MUSIC Model v6’ sent to BIOME Consulting by Clarence Valley Council).

Within this documentation a ‘Silty Clay’ type is recommended for use within Clarence Valley. A sensitivity analysis is therefore not considered appropriate.



4. SOIL PARAMETERS

The dominant soil type in Clarence Valley is Silty Clay. The rainfall-runoff parameters in accordance with Macleod (2008) for silty clay are to be adopted. The default parameters in MUSIC for the Initial Storage (pervious area properties) and Initial Depth (groundwater properties) are to be used.

Table 5 - Soil Parameters

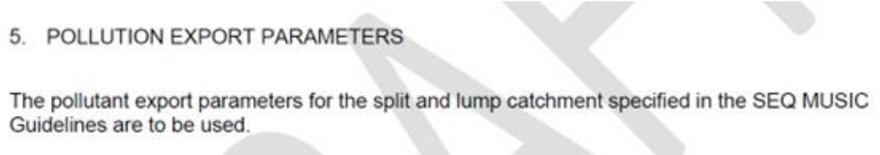
Dominant Soil Description	Rainfall Threshold (mm)	Root Zone Soil Depth (0.5mm)						
		Soil Storage Capacity (mm)	Field Capacity (mm)	Infiltration Capacity Coeff - a (mm/day)	Infiltration Capacity Exp - b	Daily Recharge Rate (%)	Daily Base flow Rate (%)	Daily Seepage Rate (%)
Silty Clay	1	54	51	180	3	25	25	0

Table 3 -Item 22

22. There are some differences between values of pollutant export parameters in Table 7.4 and those in BMT WBM 2015 Table 5.6 and 5.7, for example the report's base flow sealed roads TSS mean is 1.0 compared to 1.2 in the BMT WBM guideline. The values appear to better match those in Table 3.8 and 3.9 of HLW 2018. Assuming that these were specified by Clarence Valley Council, there is no issue.

Response

The values of the pollutant export parameters contained within Table 7.7 (formerly Table 7.4) of the report and used within the MUSIC model for the site have been based on the Water by Design MUSIC guidelines as advised by Clarence Valley Council (see extract below taken from documentation ‘Guideline in Preparing MUSIC Model v6’ sent to BIOME Consulting by Clarence Valley Council).



5. POLLUTION EXPORT PARAMETERS

The pollutant export parameters for the split and lump catchment specified in the SEQ MUSIC Guidelines are to be used.

Table 3 -Item 23

23. It is noted that there is an updated (draft) Water By Design Guideline (2018). While it appears that many of the values in this report are consistent with the 2018 draft guideline, it is recommended that the report considers any implications of the updated guideline on the proposed approach for this site.

Response

Noted. The MUSIC parameters applied to each source treatment node are consistent with the 2018 draft guidelines.

Table 3 -Item 24

24. The invert constrained rainwater tanks are specified as 9kL each, which appears to conflict with the 3kL tanks used elsewhere. Please check if this is a written mistake.

Response

Reference has been removed. All tanks are 3 kL within each modelled scenario. Please refer to Table 7.10 within attached SMP&DAv4.

Table 3 -Item 25

25. Refers to Table 4.6, but no Table 4.6 appears to be in this report?.

Response

Reference has been removed (refer to attached SMP&DAv4).

Table 3 -Item 26

26. Type 3 convention bioretention systems are not lined as per Water By Design 2014. This table indicates Yes to lining, and indicates an Exfiltration rate of 0 mm/hr. This was perhaps done to enable water quality objectives to be tested as per BMT WBM 2015 (Also see discussion on Exfil in s4.1.1 in HLW 2018)? Recommend add some explanation that this is a modelling assumption only, e.g. it is not an instruction to install a liner on the Type 3 basins.

Response

Liner requirements for Type 3 bioretention basins have been updated within Table 7.13 (refer to attached SMP&DAv4). Whilst liners are not specified for Type 3 drainage profile systems, an exfiltration rate of 0.0 mm/hr has been adopted for modelling purposes in accordance with BMT WBM 2015, and Clarence Valley Council Guideline in Preparing MUSIC Model v6 (DRAFT).

Table 3 -Item 27

27. The invert constrained bioretention systems have an extended detention depth of 0.1m in Table 7.8 and 0.2m on Table 7.9. Why the difference?

Response

Table 7.13 (formerly 7.8) has been amended (refer to attached SMP&DAv4). All extended detention depths have been modelled as 0.2 m within the bioretention systems.

Table 3 -Item 28

28. All four types of basin in Fig 14 of WBD 2014 have a 50-75mm mulch layer. Will mulch be included in the specified Type 3 and Type 1 basins? If so, how will the mulch layer impact the Extended Detention compartment? If not, how will the function of the mulch layer be addressed?

Response

The intention of the mulch layer is to help *establish* the plants within the bioretention surface. The mulch layer is therefore temporary for the establishment phase of the bioretention systems, and not a permanent layer during the operational life of the basin. For further details refer to Section 3.6.6 of the Water By Design Bioretention Technical Design Guidelines (Version 1.1, 2014)

Table 3 -Item 29

29. The proposal includes some grassed swales and detention basins as listed in this table, but they have not been included in the MUSIC modelled treatment train in this report. (From perusal of DWG-300 it appears grassed swales are not applied on a street level, rather they are only proposed in selected areas around the edge of the proposed development). While the results from only modelling the bio-pods are likely to be conservative, it is recommended that the detailed design phase considers modelling the proposed site in more detail, including any potential benefits from other design features such as buffer strips, swales, and detention basins.

Response

The intention of Table 8.3 is to recommend maintenance requirements for stormwater management devices, including conveyance, treatment and detention measures. Hence the measures listed do not necessarily reflect the treatment train for the subject site.

Grassed swales are proposed for conveyance of flows from the upstream catchments of Miles Street and flows from Carrs Drive. Whilst they would provide some treatment benefits in terms of sediment removal from external flows, they do not form part of the internal treatment train for the subject site and are hence not included within the MUSIC model of the subject site.

Detention basins were excluded from MUSIC modelling as they are intended for stormwater quantity management and to create storage for mitigation of peak flows, not quality treatment. In accordance with the Water By Design MUSIC modelling guidelines (2010, and draft 2018 versions) flood storage, and retardation volumes available above extended detention depths within basins is generally not recommended for inclusion for water quality assessment.

It is noted as suggested, that the detention measures may have some potential benefit for treating stormwater quality. As such during the detailed design phase detailed modelling which includes modelling of the detention basins and any buffer areas will be undertaken to determine the overall benefit from the stormwater management system. It is further noted that the current sizing for the stormwater treatment measures represents a conservative assessment.

Table 3 -Item 30

30. Please use consistent terminology for the storm events.

Response

Storm events have been reported as AEP (%) within the revised report.

Table 3 -Item 31

31. Please comment on any scour protection/energy dissipation required at outlets of the basin or other stormwater infrastructure.

Response

Scour protection has been proposed at all detention basin outlets (piped and weir). Scour protection has also been proposed at the inlet location of the proposed bioretention measures, The location of scour protection is shown on several drawings including:

- Drawings 300, 310, 311, 312, and 320 of the attached SMP&DAv4; and
- Drawing 33801-PR2-663-B of the Mortons Urban Solutions civil design drawings (included within Appendix B of the SMP&DAv4).

Details including sizing of scour protection measures is to be included as part of the detailed design documentation to accompany a construction certificate application.

Table 3 -Item 32

32. The Stormwater management and water quality section of Part X of the CVC DCP 2011 outlines 5 objectives and 5 controls for the WYURA. This section also makes reference to Part H (primarily s1 and Table H1 and H2) and Part J (primarily s10). It is recommended that the proponent explicitly addresses each of these stormwater quality related requirements in the documents supporting their development application.

Response

The stormwater management measures to be included with the development have been designed to meet the default water quality targets contained within Table H2 of the DCP.

Responses to Part X, Part H, and Part J of the CVC DCP 2011 have also been provided within Appendix H of SMP&DAv4.

Table 3 - Item 33

33. In addition to carrying out sensitivity assessment on fraction impervious, sensitivity assessment on other key assumptions is also recommended. This should include roof/road/ground percentage, soil properties, percent of roof area reporting to rainwater tanks, key bioretention basin parameters, exfiltration rate, pollution generation parameters, rainfall and evaporation estimates, etc.

Response

An additional sensitivity assessment has been included within Section 7.5.4 of the attached report.

Assumptions within the BIOME report have been based on best practice guidelines and industry standards, and advice sought from Council. The designs contained within the report are therefore considered suitable for development assessment.

Table 3 -Item 34

34. The Northern Rivers Handbook of Stormwater Drainage Design requires the assessment of the PMF for detention basins (Section 9, Point 8) - this has not been presented in the stormwater management plan report developed by BIOME.

Response

Consideration has been given to very rare events. Version 4 now includes an additional Section 6.2.4 in which an analysis of the PMF and 0.05% AEP (or 1 in 2000 AEP) event has been undertaken.

Modelling indicates that in 0.05% AEP event, water levels would increase in both the detention basins with all flow discharging over the high flow weir structures. Based on the existing basin and weir configurations, peak water levels would not be expected to exceed the Top of Bund during the 0.05% AEP.

Modelling indicates that during the PMF the detention basin bund will overtop by up to 200 mm. Velocities on the downstream face of the bund are expected to be > 2 m/s and therefore it has been recommended that scour protection be provided.

Table 3 -Item 35

35. Please clarify what design criteria was used for sizing the stormwater network (culverts, kerbs and pits). Note that the stormwater network modelled in TUFLOW by BIOME may not be sized up to the 1% AEP event. No other events have been modelled.

Response

The stormwater network modelled within TUFLOW has been designed for conveyance of the 18.1 % AEP event. This is the designated minor event referred to within the SMP&DAv4 (refer to Sections 5.2 and 6.1.2 of the attached revised report).

Attachment B

Stormwater Management Plan & Downstream Drainage Assessment (Version 4)

Stormwater Management Plan & Downstream Drainage Assessment

Yamba Gardens – Stages 1-10

Kahuna No.1 Pty Ltd

May 2023
BC-18008

BIOME
WATER AND ENVIRONMENTAL CONSULTING

Document Control

Project Name	Yamba Gardens
Project Number	BC-18008
Report Title	Stormwater Management Plan & Downstream Drainage Assessment
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Executive Summary

This report has been prepared on behalf of Kahuna No.1 Pty Ltd and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase of the development. Additionally, this report also includes a hydraulic impact assessment (velocities and peak depths) to ensure the development does not impose any hydraulic impacts upon the western downstream drainage network (relevant to Lot 46) as requested by Clarence Valley Council.

This report (Version 4) has been prepared to address the additional information request issued by Clarence Valley Council dated March 3, 2023 (reference: SUB2023/001), and also the further request items received via email correspondence from James Hamilton (sent April 12, 2023 2:24 PM). In particular this report addresses the items relating to stormwater management.

Version 3 was prepared to address the additional items raised within the review undertaken by WMAwater titled ‘West Yamba Urban Release Area – Yamba Gardens – Flood Impact Assessment Review’ (dated September 2022).

Version 2 (dated 18 August 2022) was prepared to respond to the Information Request issued by Council dated 28 April 2022.

In order to address the management of stormwater quantity during the operational phase of the development, two (2) formal stormwater detention basins have been proposed. These basins include purpose-built outlet structures and detention volumes to control discharge from the site. In addition to the basins, detention storage will also be provided within the drainage swale along the northern boundary of the site adjacent to Miles Street. Modelling of the proposed detention measures and their associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A, PD-B and PD-C. It is estimated that a total detention volume of 20,420 m^3 (for the 1% AEP) is required and has been provided to mitigate peak flows from the site.

TUFLOW modelling of the downstream discharge locations of Lot 46 has demonstrated that the proposed development will not adversely affect neighbouring properties or materially change the hydraulic impacts on the downstream drainage structures of Carrs Drive. It is noted the impacts associated with the eastern floodway (Lot 47) and general filling of the West Yamba development area has previously been investigated as part of the Hydraulic Impact Assessment undertaken by BMT. As such this report will not cover these items.

In order to address the management of stormwater quality for Stages 1-10 of the development, numerous streetscape bioretention systems (pods) have been proposed for incorporation within the road reserve areas of the development. This design concept will promote at source treatment of runoff from the road network.

Rainwater tanks have been included for the beneficial reuse of stormwater and are to be connected to the roof catchment area within each allotment. Overflows are to be directed to the dedicated inter allotment pipe network contained with a 3 m drainage easement.

MUSIC v6 modelling indicates that the inclusion of bioretention pods and rainwater tanks within each allotment will achieve the required pollutant removal efficiencies of 85%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively. These results demonstrate that the Default Water Quality Targets include in Table H2 of the Clarence Valley Council DCP can be achieved.

The level of detail provided within this report is suitable for development assessment only and should not be relied upon for construction purposes. A Detailed Stormwater Management Plan containing detailed engineering designs will be needed to finalise the stormwater concepts presented in this report. Detailed design documentation should be prepared in conjunction with civil operational works.

Contents

Tables

Figures

Appendix

1 Introduction

This conceptual stormwater management plan (Version 3) has been prepared so as to be considered as part of a Development Application for a Material Change of Use (MCU) and Reconfiguration of a Lot (ROL) over Lot 46 and Lot 47 on DP751395 at 52-54 Miles St, Yamba. (the subject site).

This report includes revisions to address the additional information request issued by Clarence Valley Council dated March 3, 2023 (reference: SUB2023/001), and also the further request items received via email correspondence from James Hamilton (sent April 12, 2023 2:24 PM). In particular this report addresses the items relating to stormwater management

The report has been prepared on behalf of Kahuna No.1 Pty Ltd and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase. Additionally, the report includes a hydraulic impact assessment (velocities and peak depths) to ensure the development does not impose any hydraulic impacts upon the western downstream drainage network (relevant to Lot 46) as requested by Clarence Valley Council.

The level of detail provided within this report is suitable for development assessment only. It is not to be relied upon for construction purposes. A Detailed Stormwater Management Plan will be needed to finalise the concepts presented in this report. Detailed design documentation should be prepared in conjunction with civil operational works.

1.1 Objectives

The overarching objective of this report is to present practical conceptual stormwater designs which can be integrated into the development proposal so as to ensure that the development does not cause an unacceptable impact or nuisance which could result in actionable damage to downstream properties and receiving environments during the operational phase of development.

The following objectives are to be achieved.

Operational Phase Objective (Quantity)	Maintain a Lawful Point of Discharge (LPD) for all site catchments in accordance with QUDM (2016).
Operational Phase Objective (Quality)	Stormwater discharged from the site achieves the specified load based reduction targets in accordance with Table H2 of Clarence Valley Council's Residential Zone Development Control Plan (CVC DCP. For the development site relevant targets of 85% for TSS, 60% for TP, 45% for TN, and 90% for Gross Pollutants have been adopted (Table H2 CVC DCP).

Additionally this report is to investigate the hydraulic impacts associated with the proposed development of the site. The objectives of the hydraulic impact assessment are to:

- Ensure the development does not result in impacts to the water levels upstream and downstream of the site (Lot 46) during events up to and including the 1% AEP; and
- No worsening of peak flows and velocities external to the site (Lot 46).

2 Site Location

The subject site is located within the Clarence Valley Council local area at 52-54 Miles St, Yamba and comprises two rectangular allotments, Lot 46 and 47 on 751395. The site has a total area of 42.53 ha, with street frontage to Carrs Road (West), Miles Street (North), and Golding Street (East).

There are currently two (2) existing residential dwellings located within the north eastern portion of the site. The remainder of the site consists of grassed areas, two main (2) drainage lines within the east and south west portion of the site, and existing denser vegetated areas associated with the drainage lines.

Based on existing survey information, the site is low lying and flat with elevations varying between 0.4-1.5 m AHD and average grades varying between 0.1-0.5%. The existing drainage lines convey flows from the site generally in a southerly direction ultimately discharging into Oyster Channel.

Refer to Figure 2.1 below which presents an aerial image depicting the site's location and surrounding road network.

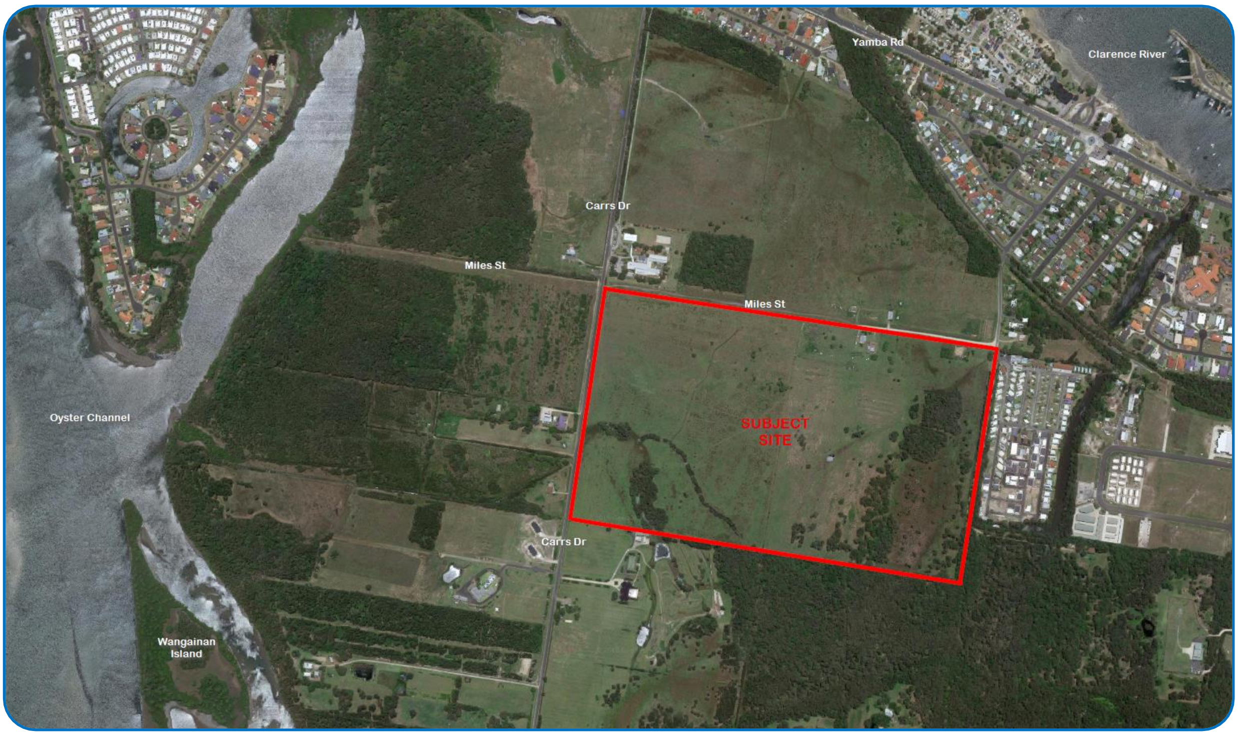


Figure 2.1 Site Location (sourced from NSW Six Maps)

2.1 Rainfall

The hydrologic analysis undertaken in this report will rely on Australian Rainfall and Runoff (ARR) temporal patterns and IFD data obtained for the site from the ARR Data Hub (Babister et al, 2016) and the BOM (Table 2.1 refers to modelled durations, for full list of IFD data for other durations please refer to Appendix C).

Table 2.1 Adopted Intensity Frequency Data (mm/hr)

Storm Duration	Annual Exceedance Probability (AEP)					
	39.3%	18.1%	10%	5%	2%	1%
5 minute	139.0	167.0	191.0	219.0	257.0	287.0
10 minute	112.0	135.0	155.0	178.0	208.0	232.0
15 minute	94.3	114.0	131.0	149.0	175.0	194.0
20 minute	81.8	98.7	113.0	129.0	151.0	168.0
25 minute	72.5	87.3	99.9	114.0	134.0	149.0
30 minute	65.3	78.6	89.9	103.0	120.0	134.0
45 minute	51.0	61.2	70.0	80.2	94.2	105.0
60 minute	42.3	50.9	58.3	66.8	78.7	88.3
90 minute	32.4	39.0	44.8	51.5	61.0	68.8
120 minute	26.7	32.3	37.2	43.0	51.1	57.8
180 minute	20.4	24.9	28.9	33.5	40.2	45.7
270 minute	15.7	19.4	22.7	26.5	32.0	36.5
360 minute	13.1	16.4	19.2	22.6	27.4	31.4

3 Existing Case – Hydrological Assessment

xpstorm was utilised to assess the site's existing hydrology and generate hydrographs to represent the stormwater flows expected within each catchment and at the site's existing points of discharge (PD). Modelling was based on existing catchment areas and surface characteristics. Peak discharge rates for nominated Annual Exceedance Probabilities (AEPs) were derived from the output hydrographs. The following sections detail the input parameters used in the *xpstorm* modelling. Catchments have been delineated on Drawing DWG-200 – Appendix A.

3.1 Existing Case – Discharge Locations

Flows from the subject site currently discharge at five (5) Points of Discharge (PD), north west, south west, and south to the following locations:

PD-A The stormwater infrastructure at the intersection of Miles Street & Carrs Drive. Flows from a small portion of Lot 46 discharge north to the existing drainage swale which runs west along Miles Street. Flows from the drainage swale are then conveyed west underneath Carrs Drive via a set of existing culverts (2 x 1200 x 300 RCBC) which discharge to an existing drainage channel which runs west along the Miles Street road reserve. The channel ultimately discharges to Oyster Channel.

PD-B The existing drainage line and stormwater infrastructure of Carrs Drive. Flows from the western portion of the site currently discharge to the existing drainage line within the south western portion of the site. From here flows discharge both west to the existing culverts and drainage channel of Carrs Drive and also south to the neighbouring freehold allotment (Lot 9 on DP 1251010) where the drainage line continues south and discharges to an existing dam. Flows which are conveyed west underneath Carrs Drive via the culverts discharge into an existing channel located within Lot 2 on DP 733507 which ultimately discharges to Oyster Channel.

PD-C The southern freehold allotment Lot 4 on DP63341. Flows from the eastern portion of the site are conveyed within an existing floodway that continues across the southern boundary of the site into freehold allotment, Lot 4 on DP63341.

PD-D The southern freehold allotment Lot 5 on DP1210129. Flows from a small portion of Lot 47 discharge south to the southern neighbouring allotment. Flows discharge at this location as both sheet and channel flow. It is understood that discharge is ultimately conveyed to the existing floodway which continues through this allotment (Lot 5) from Lot 4 (identified as PD-C).

PD-E The southern freehold allotment Lot 9 on DP 1251010. A portion of flows from the existing south western drainage line and also sheetflow from the south western corner of the site discharge along the southern boundary of the site. Flows discharge via the drainage line which continues south within Lot 9 to an existing dam and also via sheet flow across the site boundary.

PD-F The existing drainage channel of Carrs Drive. A small portion of flows from Lot 46 discharge to the existing roadside drainage channel south of the cross-drainage culverts. Flows at this discharge location continue south within the channel.

The existing discharge locations are shown on Drawing DWG-200 – Appendix A.

For detention sizing and peak mitigation purposes, flows presented for PD-B in the 1D assessment (XPSTORM) are the combined discharge to the existing south-western drainage line. Given flows are split within this drainage line to two points of discharge, a 2D assessment has been constructed to further assess downstream impacts at PD-B and PD-E (refer to Section 6.3).

3.2 Existing Case – External Catchments

There are two (2) external upstream catchments that contribute flows directly onto the subject site. These catchments are predominantly associated with the northern neighbouring allotments north of Miles Street. The external catchment characteristics are summarised in Table 3.1 below and are delineated on Drawing DWG-200- Appendix A.

Table 3.1 Existing Case – External Catchment Characteristic

Catchment ID	Area (ha)	Cover (%)	Discharge Condition	PD ID
Ext A(1)	6.89	75 – Grassed/Cleared 25 - Dense Veg.	Sheet & Channel	PD-A
Ext C(1)	7.22	90 – Grassed/Cleared 10 – Dense Veg.	Sheet & Channel	PD-C

3.3 Existing Case – Internal Catchments

The subject site has been divided into eight (8) internal catchment areas. The characteristic of the site’s catchments are detailed in Table 3.2 below and have been delineated on Drawing 200 – Appendix A.

Table 3.2 Existing Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal	A	1.02	100 – Grassed/Cleared	Sheet & Channel	PD-A
	B1	1.01	100 – Grassed/Cleared	Sheet & Channel	PD-B
	B2	16.90	95 – Grassed/Cleared 5 – Dense Veg.	Sheet & Channel	
	B3	0.77	30 – Dense Veg. 70 – Grassed/Cleared	Sheet & Channel	
	C	17.28	79.6 – Grassed/Cleared 20 - Dense Veg. 0.4 - Dwelling	Sheet & Channel	PD-C
	D	2.35	85 – Grassed/Cleared 15 - Dense Veg.	Sheet & Channel	PD-D
	E	3.31	70 – Grassed/Cleared 30 - Dense Veg.	Sheet & Channel	PD-E
	F	0.62	100 – Grassed/Cleared	Sheet & Channel	PD-F

3.4 Existing Case – *xpstorm* Runoff

The "Laurenson" routing method was applied to *xpstorm* for hydrological calculation and hydrograph generation. The contributing catchment was split into pervious (with 0% impervious fraction) and impervious (with 100% impervious fraction) areas. Adopted parameters for the Laurenson routing method include a Manning's roughness coefficient (n) for impervious and pervious areas respectively. Infiltration uniform losses have been applied to the hydrologic model based on information obtained from the Australian Rainfall and Runoff Data Hub tool (reference: https://data.arr-software.org). It is noted that as the site is within NSW, ARR losses have been adjusted by a factor of 0.4 (consistent with Approach 5 described in 'Floodplain Risk Management – Incorporating 2016 Australian Rainfall and Runoff in studies', 2019).

Temporal Patterns and Rainfall Data

Site specific rainfall and temporal pattern data used in modelling was sourced from the Australian Rainfall and Runoff (ARR) Data Hub (2020). Refer to Appendix C for a summary of the data obtained.

Critical Storm Duration Assessment

The critical storm duration for each catchment was determined utilising the Ensemble Statistics Utility in *xpstorm*. From the critical storm duration, the median storm ensemble was utilised to determine peak flows for each respective catchment. In order to determine the peak flow at the sites point of discharge, the critical duration and median ensemble was selected Table 3.3 presents the critical storm duration and chosen median storm ensemble for each of the modelled catchments. Box and Whisker Plots showing the 1% AEP peak flows for the range of durations modelled is contained within Appendix D.

Table 3.3 Existing Case – Critical Storm Assessment

Catchment ID		Annual Exceedance Probability (AEP)	Critical Duration (minute)	Median Ensemble Storm No.
External	Ext A(1)	1%	120	2
		2%	180	9
		5%	180	2
		10%	180	6
		18.1%	180	2
		39.3%	180	6
	Ext C(1)	1%	180	9
		2%	180	9
		5%	180	6
		10%	180	6
		18.1%	180	6
		39.3%	180	6
	A	1%	120	2
		2%	180	4
		5%	120	2
		10%	180	7
		18.1%	270	2
		39.3%	180	2
		1%	120	9
		2%	120	9

Internal	B1	5%	180	9
		10%	120	7
		18.1%	120	5
		39.3%	120	7
	B2	1%	180	9
		2%	180	9
		5%	180	3
		10%	180	6
		18.1%	180	4
		39.3%	270	7
	B3	1%	45	6
		2%	45	6
		5%	60	3
		10%	60	7
		18.1%	120	4
		39.3%	120	7
	C	1%	120	2
		2%	180	2
		5%	180	2
		10%	180	6
		18.1%	180	2
		39.3%	180	6
	D	1%	90	10
		2%	90	10
		5%	180	6
		10%	180	9
		18.1%	120	9
		39.3%	180	2
	E	1%	90	10
		2%	90	10
		5%	180	6
		10%	180	9
		18.1%	120	9
		39.3%	180	2
	F	1%	120	9
		2%	120	4
		5%	120	5
		10%	120	7
		18.1%	120	9
		39.3%	120	2
	PD-A	1%	120	2
		2%	120	2
		5%	180	3
		10%	180	6

Point of Discharge		18.1%	180	2
		39.3%	180	6
	PD-B	1%	180	9
		2%	180	9
		5%	180	3
		10%	180	6
		18.1%	180	4
		39.3%	180	4
	PD-C	1%	180	9
		2%	180	9
		5%	180	3
		10%	180	6
		18.1%	180	6
		39.3%	180	6

The tables below contain the modelling parameters relied upon and present the resulting peak discharges expected for each catchment. The flows reported at PD-A and PD-C represent the combined external and internal catchment inflows at these points. PD-B represents the combined inflows for the internal 'B' catchments.

Table 3.4 Existing Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
External	Ext A(1)	-	-	6.888	0.25
	Ext C(1)	-	-	7.219	0.21
Internal	A	-	-	1.020	0.23
	B1	-	-	1.007	0.27
	B2	-	-	16.899	0.34
	B3	-	-	0.767	1.22
	C	0.070	0.40	17.205	0.40
	D	-	-	2.351	0.29
	E	-	-	3.307	0.37
	F	-	-	0.617	0.23

Table 3.5 Existing Case – Adopted Initial and Continuing Losses

Impervious Area			Pervious Area			
IL (mm)	CL (mm/hr)	Manning's n	AEP	IL (mm)	CL (mm/hr)	Manning's n
0	0	0.014	0.393-0.01	24	1.44*	0.040

*CL(from ARR) x 0.4 ARR (consistent with Approach 5 described in 'Floodplain Risk Management – Incorporating 2016 Australian Rainfall and Runoff in studies', 2019)

Table 3.6 Existing Case – *xpstorm* Peak Discharge (m^3/s)

Catchment/Point of Discharge	Annual Exceedance Probability (AEP)					
	39.3%	18.1%	10%	5%	2%	1%
Ext A(1)	0.28	0.40	0.56	0.69	0.79	0.93
Ext C(1)	0.27	0.39	0.54	0.68	0.80	0.92
A	0.05	0.10	0.12	0.15	0.18	0.18
B1	0.06	0.09	0.11	0.13	0.17	0.20
B2	0.59	0.88	1.20	1.51	1.82	2.11
B3	0.07	0.10	0.13	0.16	0.19	0.22
C	0.71	1.02	1.42	1.73	1.98	2.36
D	0.12	0.17	0.22	0.26	0.33	0.39
E	0.17	0.24	0.31	0.38	0.48	0.57
F	0.04	0.05	0.06	0.08	0.10	0.12
PD-A	*0.33*	*0.47*	*0.65*	*0.80*	*0.92*	*1.09*
PD-B	*0.70*	*0.98*	*1.37*	*1.73*	*2.11*	*2.46*
PD-C	*0.91*	*1.32*	*1.84*	*2.30*	*2.83*	*3.30*
PD-D	*0.12*	*0.17*	*0.22*	*0.26*	*0.33*	*0.39*
PD-E	*0.17*	*0.24*	*0.31*	*0.38*	*0.48*	*0.57*
PD-F	*0.04*	*0.05*	*0.06*	*0.08*	*0.10*	*0.12*

3.5 Existing Case – Model Validation (Rational Method)

For validation purposes, peak discharge values were calculated for 0.01 AEP using Rational Method and compared to those generated using *xpstorm.* The comparison is shown in Table 3.7 below and Rational calculations, which are in accordance with QUDM 2016 Section 4, are detailed within Appendix E.

Table 3.7 Existing Case – Peak Flow Validation *xpstorm* vs Rational

Catchment & Point of Discharge ID		*xpstorm* (m^3/s)	Rational (m^3/s)	Difference (%)
External	Ext A(1)	0.93	0.87	6.5
	Ext C(1)	0.92	1.04	-13.0
Internal	A	0.18	0.19	-5.6
	B1	0.20	0.20	0.0
	B2	2.11	2.48	-17.5
	B3	0.22	0.19	13.6
	D	0.39	0.38	2.6
	E	0.57	0.52	8.8
	F	0.12	0.11	8.3

*for modelling purposes B (Ext 2) has been included as a sub-catchment of B1.

The peak discharge calculated using Rational method is within 20% of the value generated using *xpstorm* for the 1% AEP. The modelling is therefore considered to be appropriately validated.

4 Proposed Development

The proposal is for the reconfiguration of Lot 46 and 47 into 291 residential allotments ranging in size from 400-1,000 m^2. In addition to these allotments the development will also include:

- A single medium density allotment (Lot 293);
- A sing commercial allotment (Lot 292);
- An internal road network with pedestrian footpath;
- Streetscape stormwater treatment areas incorporated within the road reserves;
- Two (2) Stormwater detention basins for quantity management (located within drainage reserves); and
- Vegetated riparian zones.

The proposed lot layout plan is presented within Figure 4.1 and 4.2 (below).

Figure 4.1 Lot Layout Plan (Mortons Urban Solutions)

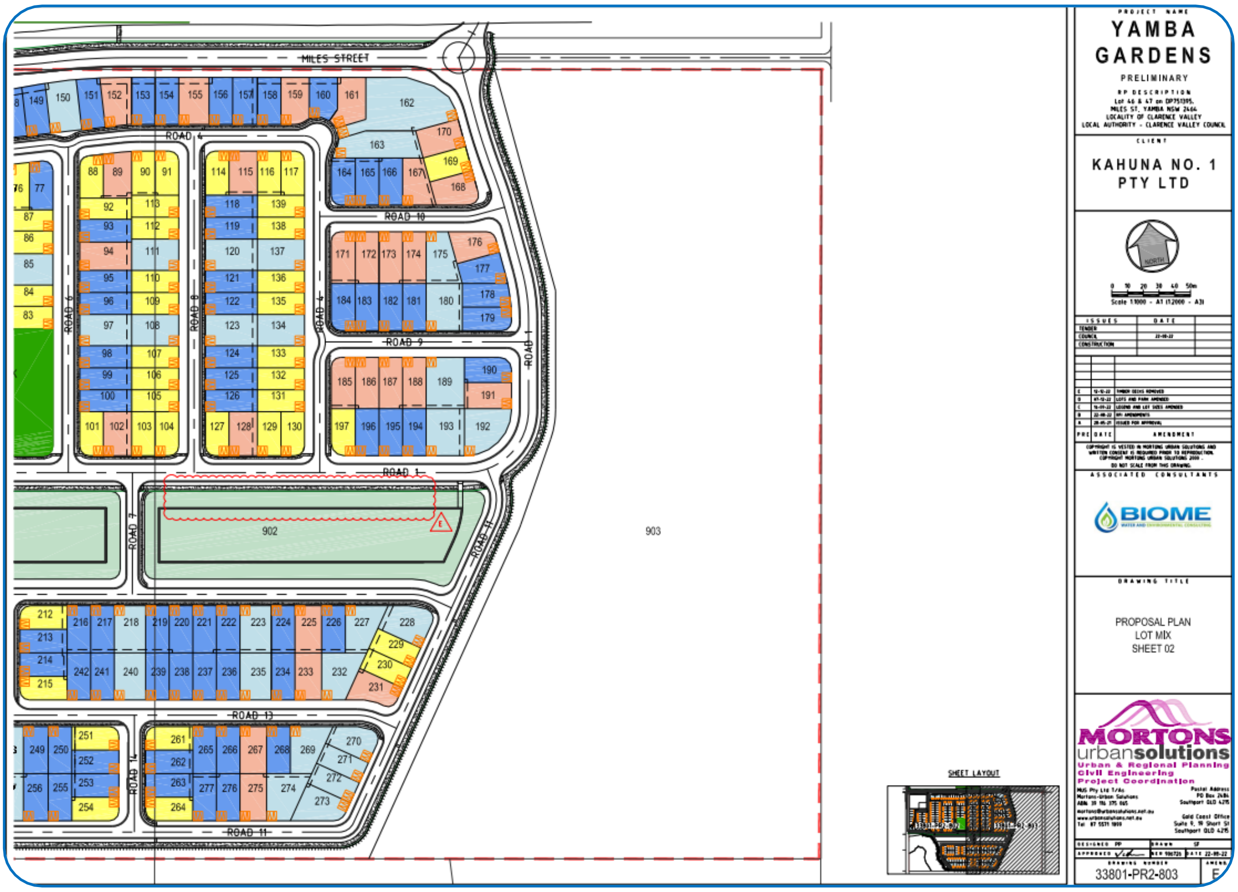


Figure 4.2 Lot Layout Plan (Mortons Urban Solutions)

5 Developed Case Unmitigated – Hydrological Assessment

xpstorm was utilised to assess the site's developed hydrology and generate hydrographs and peak discharge rates for the site catchments and at each PD. The following sections detail the parameters used in the *xpstorm* modelling. Catchments have been delineated on Drawing DWG-201 – Appendix A.

5.1 Developed Case – External Catchments

In the developed case two (2) of the external catchments; Ext A(1) and Ext C(1), will be altered due to the construction and improvement of Miles Street which bounds the northern boundary of the site. The external catchment characteristics of the altered catchments in the developed case are summarised in Table 5.1 below.

Table 5.1 Developed Case – External Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
External	Ext A(1)	7.44	21 – Impervious 79- Grassed	Point & Sheet	PD-A
	Ext C(1)	7.34	9 – Impervious 91 - Grassed	Point & Sheet	PD-C

5.2 Developed Case – Internal Catchments

The site will undergo substantial earthworks (fill) to profile the development area and raise the level of the land 2-3m to the 1% AEP design flood level. Underground piped drainage will be installed to collect minor stormwater flows (up to 18.1% AEP), with major flows (up to 1% AEP) conveyed via the internal road network.

Four (4) major post development catchments (A, B, C1 and C2) have been delineated within the developable area based on the preliminary civil designs by Mortons Urban Solutions (Refer to Appendix B). Outside the developable area, a further five (5) catchments have been delineated within the site boundary and included within this assessment. Whilst the topography of these site catchments will remain consistent with the existing case, minor alterations in catchment areas and diversions will occur as a result of earthworks within the developable area of the site. The characteristic of the site's catchments are detailed in Table 5.2 below and have been delineated on Drawing 201 – Appendix A.

Table 5.2 Developed Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal (Development Area)	A	0.30	100 – Res Dev	Pipe – Road	PD-A
	B	17.53	100 – Res Dev	Pipe – Road	PD-B
	B (Access Road)	0.13	100-Road	Pipe-Road	PD-B
	C1	0.41	100 – Res Dev	Pipe – Road	PD-C
	C2	8.07	100 – Res Dev	Pipe – Road	PD-C
Internal (Remainder of	B2	0.51	15 – Batter 25 – Dense Veg. 60 - Grassed/Cleared	Sheet & Channel	PD-B
	B3	0.77	30 – Dense Veg.	Sheet & Channel	PD-B

			70 – Grassed/Cleared		
Site Area)	C3	11.04	80 – Grassed/Cleared 20 - Dense Veg.	Sheet & Channel	PD-C
	D	0.58	90 – Grassed/Cleared 10 – Grassed Batter	Sheet & Channel	PD-D
	E	2.61	10 – Batter 30 – Dense Veg. 60 - Grassed/Cleared	Sheet & Channel	PD-E
	F	0.62	100 – Grassed/Cleared	Sheet & Channel	PD-F

5.3 Developed Case – *xpstorm* Runoff

The “Laurenson” routing method was applied to *xpstorm* for hydrological calculation and hydrograph generation. The contributing catchment was split into pervious (with 0% impervious fraction) and impervious (with 100% impervious fraction) areas. Adopted parameters for the Laurenson routing method include a Manning’s roughness coefficient (n) for impervious and pervious areas respectively. Infiltration uniform losses have been applied to the hydrologic model. The tables below contain the modelling parameters relied upon and present the resulting peak discharges expected for each catchment. The flows reported at each PD represent the combined catchment inflows at this point.

Table 5.3 Developed Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
External	Ext A(1)	1.59	0.50	5.85	0.25
	Ext C(1)	0.63	0.21	6.72	0.21
Internal (Developable Area)	A	0.21	0.50	0.09	0.50
	B	12.27	0.50	5.26	0.50
	B(Road Access)	0.09	1.50	0.04	1.50
	C1	0.29	0.50	0.12	0.50
	C2	5.10	0.50	2.19	0.50
Internal (remainder of site area)	B2	-	-	0.51	0.23
	B3	-	-	0.77	0.31
	C3	-	-	11.04	0.40
	D	-	-	0.58	0.50
	E	-	-	2.61	0.37
	F	-	-	0.62	0.23

Table 5.4 Developed Case – Adopted Initial and Continuing Losses

Impervious Area			Pervious Area			
IL (mm)	CL (mm/hr)	Manning’s n	AEP	IL (mm)	CL (mm/hr)	Manning’s n
0	0	0.014	0.393-0.01	24	1.44*	0.040

*CL(from ARR) x 0.4 ARR (consistent with Approach 5 described in ‘Floodplain Risk Management – Incorporating 2016 Australian Rainfall and Runoff in studies’, 2019)

Table 5.5 Developed Case – *xpstorm* Peak Discharge (m^3/s)

Catchment/Point of Discharge	Annual Exceedance Probability (AEP)					
	39.3%	18.1%	10%	5%	2%	1%
Ext A(1)	0.60	0.82	0.85	0.99	1.09	1.68
Ext C(1)	0.30	0.47	0.58	0.72	0.86	1.00
A	0.08	0.11	0.11	0.13	0.14	0.22
B	4.52	6.17	6.40	7.31	8.27	12.19
B(Access Road)	0.04	0.05	0.05	0.06	0.06	0.10
B2	0.03	0.05	0.06	0.07	0.08	0.12
B3	1.79	2.18	2.54	2.92	3.51	3.91
C1	0.11	0.15	0.16	0.18	0.20	0.30
C2	2.09	2.88	2.99	3.43	3.84	5.64
C3	0.49	0.68	0.95	1.13	1.40	1.66
D	0.03	0.06	0.07	0.08	0.10	0.12
E	0.14	0.21	0.27	0.33	0.40	0.46
F	0.04	0.05	0.06	0.08	0.10	0.12
PD-A	*0.29*	*0.40*	*0.51*	*0.59*	*0.67*	*0.77*
PD-B	*4.23*	*5.12*	*6.12*	*7.06*	*8.43*	*9.42*
PD-C	*1.94*	*2.34*	*2.85*	*3.30*	*3.94*	*4.63*
PD-D	*0.03*	*0.06*	*0.07*	*0.08*	*0.10*	*0.12*
PD-E	*0.13*	*0.21*	*0.27*	*0.33*	*0.40*	*0.46*
PD-F	*0.04*	*0.05*	*0.06*	*0.08*	*0.10*	*0.12*

5.3.1 Validation of Flows

Table 5.6 illustrates that the peak discharges generated using both methods compare moderately well for the 1.0 % AEP as both hydrological methods are within 20% of each other for the 1% AEP. The modelling is considered to be appropriately validated.

Table 5.6 Developed Case – Peak Flow Validation *xpstorm* vs Rational

Catchment/Point of Discharge		*xpstorm* (m^3/s)	Rational (m^3/s)	Difference (%)
External	Ext A(1)	1.68	1.45	14.3
	Ext C(1)	1.00	1.24	-19.8
Internal	A	0.22	0.20	8.9
	B	12.19	10.42	14.5
	B(Access Road)	0.10	0.09	11.5
	B2	0.12	0.11	5.1
	B3	3.91	0.19	13.6
	C1	0.30	0.25	18.1
	C2	5.64	5.13	9.1
	C3	1.66	1.49	10.2
	D	0.12	0.11	5.1
	E	0.46	0.41	11.1
	F	0.12	0.11	8.3

5.3.2 Peak Discharge Comparison (m^3/s) – Existing vs Developed (Unmitigated)

Table 5.7 presents a comparison of the peak discharges expected at each PD. Results indicate decreases in peak discharge are expected a PD-A, PD-D, and PD-E due to contributing catchment area reductions. Storage has also been created within the swales proposed for the upgrade of Miles Street and has contributed to the reduction of flows at PD-A.

Increases in peak discharge to PD-B and PD-C are expected due to an increase in contributing catchment and impervious area.

Catchment F (discharge location PD-F) will not be altered as a result of the development therefore flows will remain as per the existing condition (refer to Table 3.6).

Table 5.7 Peak Discharge Comparison (m^3/s)

PD	Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
			39.3%	18.1%	10%	5%	2%	1%
PD-A	Existing	7.91	0.33	0.47	0.65	0.80	0.92	1.09
	Developed (Unmitigated)	7.74	0.29	0.40	0.51	0.59	0.67	0.77
	Difference		**-0.04**	**-0.07**	**-0.14**	**-0.21**	**-0.25**	**-0.32**
PD-B	Existing	18.67	0.70	0.98	1.37	1.73	2.11	2.46
	Developed (Unmitigated)	18.93	4.23	5.12	6.12	7.06	8.43	9.42
	Difference		**+3.53**	**+4.14**	**+4.76**	**+5.33**	**+6.32**	**+6.96**
PD-C	Existing	24.49	0.91	1.32	1.84	2.30	2.83	3.30
	Developed (Unmitigated)	26.87	1.94	2.34	2.85	3.30	3.94	4.63
	Difference		**+1.03**	**+1.02**	**+1.01**	**+1.00**	**+1.11**	**+1.33**
PD-D	Existing	2.35	0.118	0.17	0.22	0.26	0.33	0.39
	Developed (Unmitigated)	0.58	0.03	0.06	0.07	0.08	0.10	0.12
	Difference		**-0.088**	**-0.11**	**-0.15**	**-0.18**	**-0.23**	**-0.27**
PD-E	Existing	3.31	0.17	0.24	0.31	0.38	0.48	0.57
	Developed (Unmitigated)	2.61	0.04	0.05	0.06	0.08	0.10	0.12
	Difference		**-0.13**	**-0.19**	**-0.25**	**-0.30**	**-0.38**	**-0.45**

6 Stormwater Quantity Management – Operational Phase

In order to ensure that the operational phase objectives outlined within Section 1.1 of this report can be achieved, a network of stormwater management measures are proposed for inclusion within the development.

To achieve these objectives, both external and internal flows will need to be adequately managed prior to discharge to the site's points of discharge.

6.1 Schematic Design Plan

With consideration given to the existing site characteristics, the proposed development configuration and the range of available stormwater management control measures, a set of conceptual stormwater management designs have been proposed and detailed within the drawing set contained within Appendix A.

6.1.1 Upstream Flow Diversion and Conveyance

There are several upstream catchments north of the Miles Street road reserve which are to be conveyed through or diverted around the development area in association with the upgrade of Miles Street. The preliminary designs for the roadside channels and cross drainage culverts are contained within Mortons Civil design drawings (refer to Appendix B). The western portion of the Miles Street upgrade has also been included within the 2D Hydraulic Model Assessment contained within Section 6.3 of this report.

6.1.2 Internal Drainage

The site's internal catchments will be developed as residential allotments which will be graded to allow stormwater flows to be collected within the internal road network of the development. Preliminary stormwater drainage designs have been prepared by Mortons Urban Solutions and are contained within Appendix B of this report.

Runoff collected within the kerb and channel of the internal roads during minor events (up to 18.1% AEP), is to be treated within street scape quality treatment measures. Flows will enter these measures via openings within the kerb. These measures have been designed to encourage 'at source treatment' of flows within the road reserves and to limit earthworks (fill) associated with a traditional piped network.

Post treatment stormwater flows from each streetscape measure will enter the underground piped network. Highflows above the piped network capacity are to be conveyed within the road reserves to the proposed detention basins within Catchments B and C.

6.2 Quantity Control – Detention

The proposed development will result in an increase in impervious/hardstand area and therefore an increase in peak discharge to PD-B and PD-C. Two (2) detention basins have been proposed to detain stormwater flows so as to ensure that there is no increase in discharge to downstream properties for all nominated AEP's at PD-B and PD-C.

The basins are to be located within the western and eastern portion of the site.

6.2.1 *xpstorm* Modelling Parameters

xpstorm has been relied upon to size the required detention basin and develop appropriate outlet configurations. *xpstorm* requires a depth area relationship to be defined when modelling an onsite detention (OSD). A summary of the total depth-area relationship applied to the storage nodes of the *xpstorm* model in the post-development (mitigated) scenario is contained in Table 6.1. The dimensions and proposed levels of the outlet structures used to mitigate the developed case peak discharge and achieve the required detention volumes are detailed in Table 6.2. The proposed outlet configurations were then utilised in the 2D assessment for the site (Section 6.3).

Table 6.1 Depth Area Relationship

Detention ID	RL (m AHD)	Depth (m)	Surface Area (ha)
Basin B	0.8	0	0.0010
	0.9	0.1	0.0940
	1	0.2	0.3784
	1.1	0.3	0.7488
	1.2	0.4	0.9422
	1.3	0.5	0.9942
	1.4	0.6	1.0388
	1.5	0.7	1.0861
	1.6	0.8	1.1458
	1.7	0.9	1.2115
	1.8	1	1.2788
	1.9	1.1	1.3435
	2	1.2	1.4284
	2.1	1.3	1.4885
	2.2	1.4	1.5332
	2.3	1.5	1.5743
	2.36	1.56	1.5981
Basin C	0.8	0	0.0010
	0.9	0.1	0.1050
	1	0.2	0.3724
	1.1	0.3	0.6612
	1.2	0.4	0.7519
	1.3	0.5	0.7839
	1.4	0.6	0.8163
	1.5	0.7	0.8491
	1.6	0.8	0.8822
	1.7	0.9	0.9157
	1.8	1	0.9494
	1.9	1.1	0.9832
	2	1.2	1.0167
	2.1	1.3	1.0497
	2.2	1.4	1.0813
	2.3	1.5	1.1136
	2.36	1.56	1.1310
C1 (Miles Street Swale – East)	1.38	0	0.0011
	1.48	0.1	0.0081
	1.58	0.2	0.0193
	1.68	0.3	0.0265

Table 6.2 Outlet Structures

	Low Flow Outlet		High Flow
Detention Basin ID	**Pit Orifice**	**Pit & Pipe Outlet**	**High Flow Weir**
Basin B	2x0.2mx0.35m rectangular orifice @ RL 0.8 m AHD 2x0.2mx0.4m rectangular orifice @ RL 1.4 m AHD	2 x 600x900 Pits, Crests @ RL 1.60 m AHD with 1x450mm & 1 x 525mm RCP Pipe outlets (US IL @ RL 0.8 m AHD) 1x450mm x 600mm high RCBC Headwall outlet (US IL @ RL 0.8 m AHD)	1 x 18 m wide weir, crest @ RL 1.95 m AHD
Basin C	1x0.2mx0.5m rectangular orifice @ RL 0.8 m AHD	1 x 900x900 Pits, Crests @ RL 1.55 m AHD with 1x525 mm RCP outlet (US IL @ RL 0.8 m AHD)	4 x 900x900 Pits & 1 x 900x600, crest @ RL 1.96 m AHD 3 x 600mm RCP Outlets (USIL @ 0.8 m AHD)
C1 – Miles Street Swale (East)	-	-	1x450 (USIL @ 1.38, 0.6%)

6.2.2 Modelling Results

The results of *xpstorm* modelling indicate that the inclusion of the detention basins along with the proposed catchment delineation will mitigate the expected increases in peak discharge at the nominated points of discharge location during all nominated AEP events.

Table 6.3 to 6.4 presents a comparison between the expected peak discharges during nominated ARI events for the pre- and post-development mitigated cases at PD-B, and PD-C. Figures 6.1 to 6.2 illustrates a comparison of the outlet hydrograph at PD-B and PD-C.

Table 6.3 Peak Discharge Comparison (m^3/s) – PD-B

Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
		39.3%	18.1%	10%	5%	2%	1%
Existing	18.67	0.70	0.98	1.37	1.73	2.11	2.46
Developed (Unmitigated)	18.93	4.23	5.12	6.12	7.06	8.43	9.42
Developed (Mitigated)		0.70	0.95	1.35	1.63	1.89	2.43
Difference (Existing vs Developed)		**0.00**	**-0.03**	**-0.02**	**-0.1**	**-0.22**	**-0.03**

Table 6.4 Peak Discharge Comparison (m^3/s) – PD-C

Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
		39.3%	18.1%	10%	5%	2%	1%
Existing	24.49	0.91	1.32	1.84	2.30	2.83	3.30
Developed (Unmitigated)	26.87	1.94	2.34	2.85	3.30	3.94	4.63
Developed (Mitigated)		0.91	1.27	1.83	2.20	2.68	3.26
Difference (Existing vs Developed)		**0.0**	**-0.05**	**-0.01**	**-0.1**	**-0.15**	**-0.04**

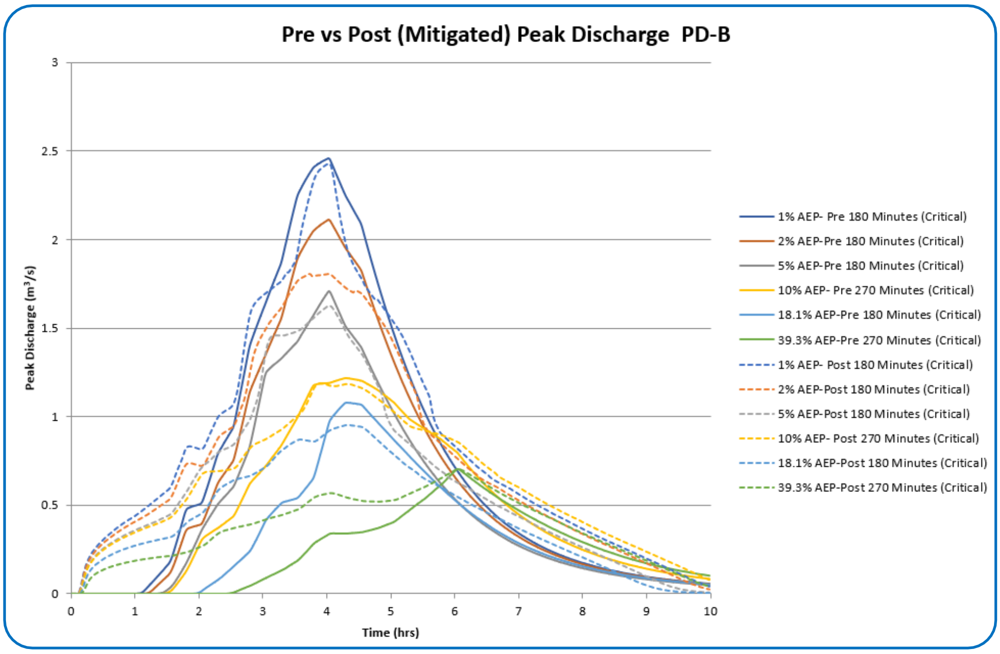


Figure 6.1 Comparison 39.3 to 1 %AEP Hydrography at PD-B (Critical Duration)

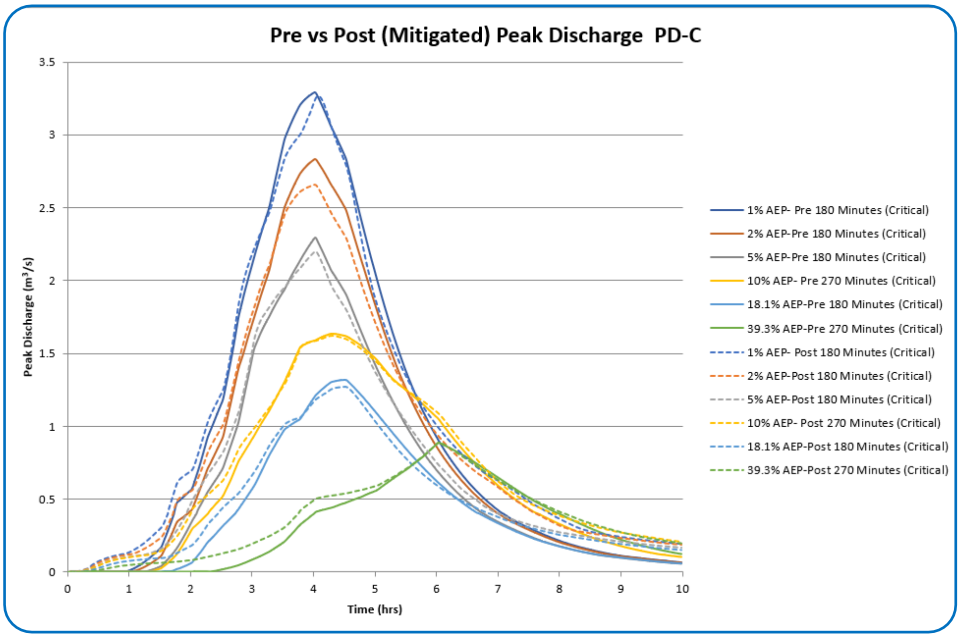


Figure 6.2 Comparison 39.3 to 1 %AEP Hydrography at PD-C (Critical Duration)

6.2.3 Detention Depths and Volumes

Table 6.5 and 6.6 presents the peak water levels, depths and volumes expected within the detention basins during both the 20 year ARI and 100 year ARI.

Table 6.5 Detention Storage Details, Depths and Volumes (Basin B)

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	0.8	0.8
Top of Bund Level (m AHD)	2.36	2.36
Weir Level (m AHD)	1.95	1.95
Peak Water Surface (m AHD)	1.80	2.02

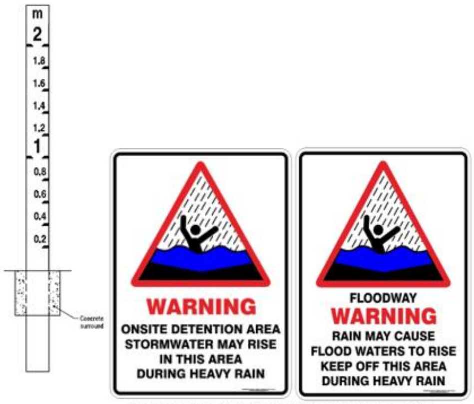
Peak Depth of Water (m)	1.0	1.22
Peak Volume (m^3)	8,038	11,200
Freeboard Achieved (m)	0.56	0.342
Depth of Weir Flow (m)	-	0.068

Table 6.6 Detention Storage Details, Depths and Volumes (Basin C)

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	0.8	0.8
Top of Bund Level (m AHD)	2.36	2.36
High Flow Pit Level (m AHD)	1.96	1.96
Peak Water Surface (m AHD)	1.86	2.06
Peak Depth of Water (m)	1.06	1.26
Peak Volume (m^3)	7,181	9,186
Freeboard Achieved (m)	0.51	0.30
Depth of Weir Flow (m)	-	0.10

Basin Safety in Design

As water depths are expected to rise above 1.0 m within the detention basin during major events, in accordance with QUDM Section 5.12 it is recommended that a depth indicator be installed within the basin with its zero level relative to the lowest point in the basin floor. Warning signs are also recommended to deter access during rainfall events (refer to Figure 6.3 below).



Source: Department of Traffic and Main Roads

Figure 6.3 Typical Detention Basin Depth Indicator & Warning Signs

6.2.4 Sensitivity Analysis

Blockage

Consideration has been given to the consequences of fully blocked outlet pipes for both basins. Table 6.7 illustrates the expected peak water levels within the basins if the proposed low flow pipe outlets became fully blocked. In this event, water levels would increase in the basins with all flow discharging over the high flow structures.

Table 6.7 Sensitivity Analysis (Blockage) Results for 1% AEP

Basin ID	Peak Water Level (m AHD)	Top of Bund (m AHD)	Depth of Weir Flow (m)
Basin B	2.13	2.36	0.18
Basin C	2.14	2.37	0.18

Based on the existing basin and weir configurations, peak water levels would not be expected to exceed the Top of Bund during the 100 year ARI. The expected maximum depth of flow over the weir has been modelled at less than 0.3 m.

Very Rare Events
Consideration has been given to the consequences of a very rare event for both basins and the likelihood of basin failure (overtopping of the bund). Table 6.8 illustrates the expected peak water levels within the basins based on a 0.05% AEP (or 1 in 2000 AEP). In this event, water levels would increase in the basins with all flow discharging over the high flow structures.

Table 6.8 Sensitivity Analysis (Very Rare Event) Results for 0.05% Event

Basin ID	Peak Water Level (m AHD)	Top of Bund (m AHD)	Depth of Weir Flow (m)
Basin B	2.26	2.36	0.31
Basin C	2.19	2.37	0.23

Based on the existing basin and weir configurations, peak water levels would not be expected to exceed the Top of Bund during the 0.05% AEP.

Probable Maximum Flood (PMF) Assessment
In accordance with the Northern Rivers Handbook of Drainage Design – D5- Stormwater Drainage Design (Amendment 17, 2019) Section 9.8 consideration has been given to the consequences of a PMF.

In order to assess the PMF, the Probable Maximum Precipitation (PMP) was calculated based on the Generalized Short Duration Method (GSDM) for durations up to 6hrs (BOM, 2003). The PMP was then applied to the TUFLOW. model for the site (refer to section 6.3 for details of the TUFLOW model setup).

Figures 6.4-6.6 present the results of TUFLOW modelling for the PMF. Modelling indicates that during the PMF the detention basin bund will overtop by up to 200 mm. Velocities on the downstream face of the bund are expected to be > 2 m/s and therefore it has been recommended that scour protection be provided.

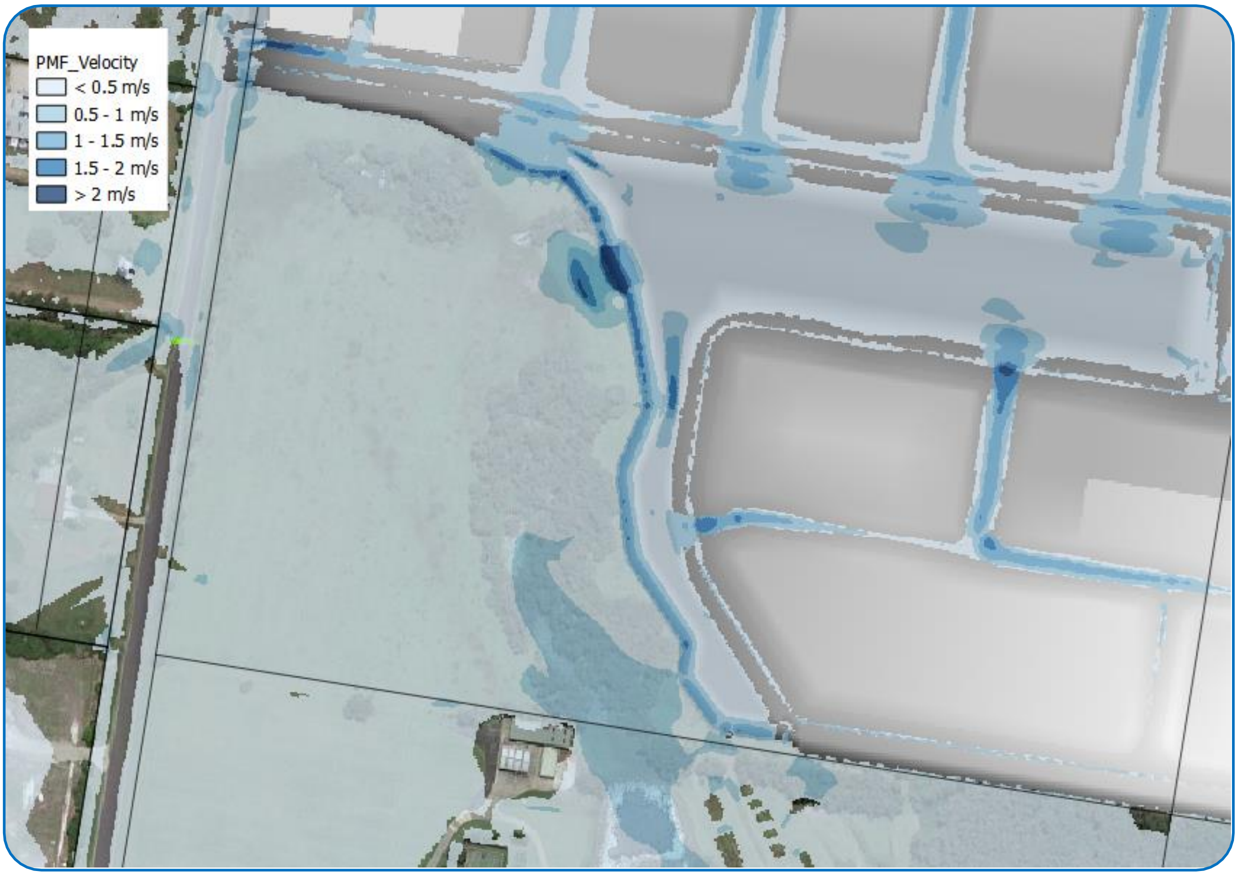


Figure 6.4 PMF- Post Development Peak Flood Velocity

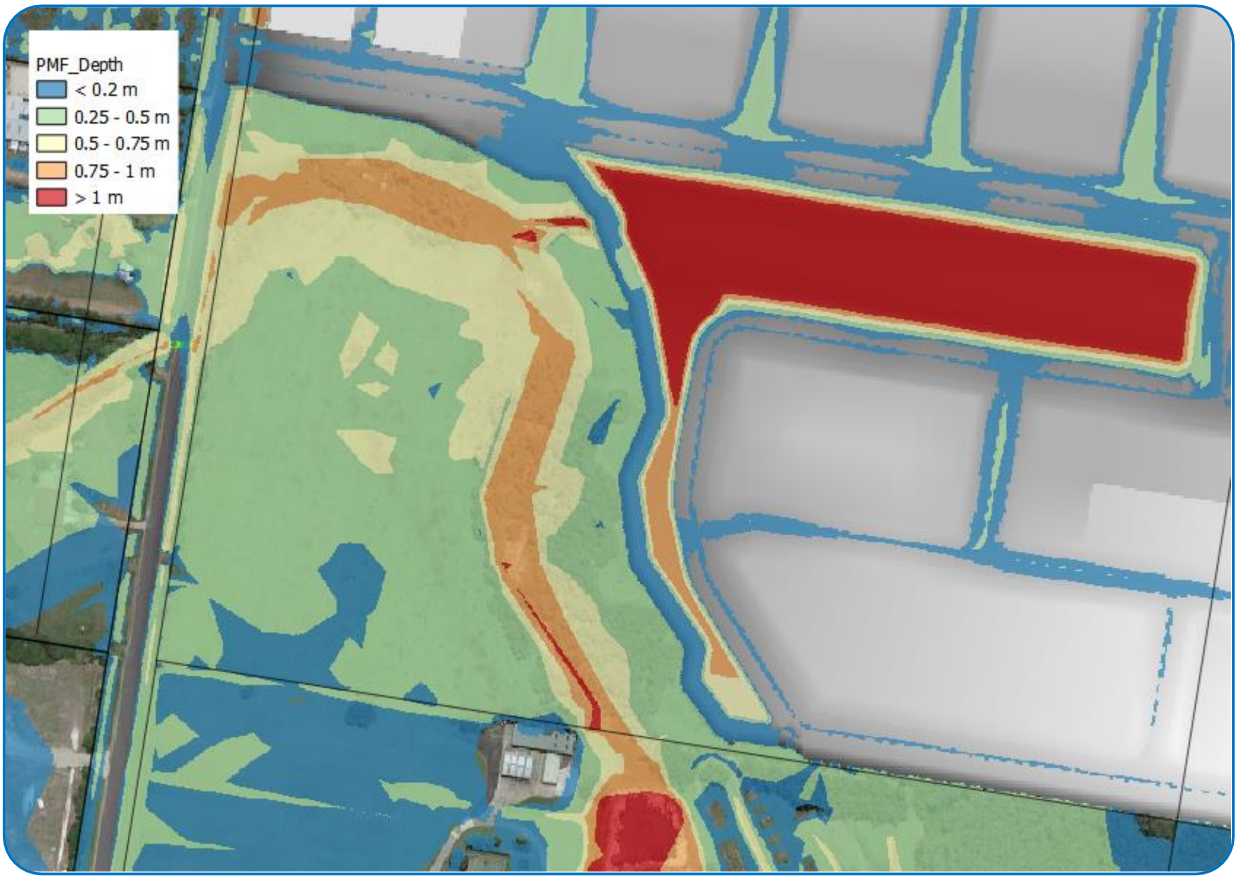


Figure 6.5 PMF- Post Development Peak Flood Depth

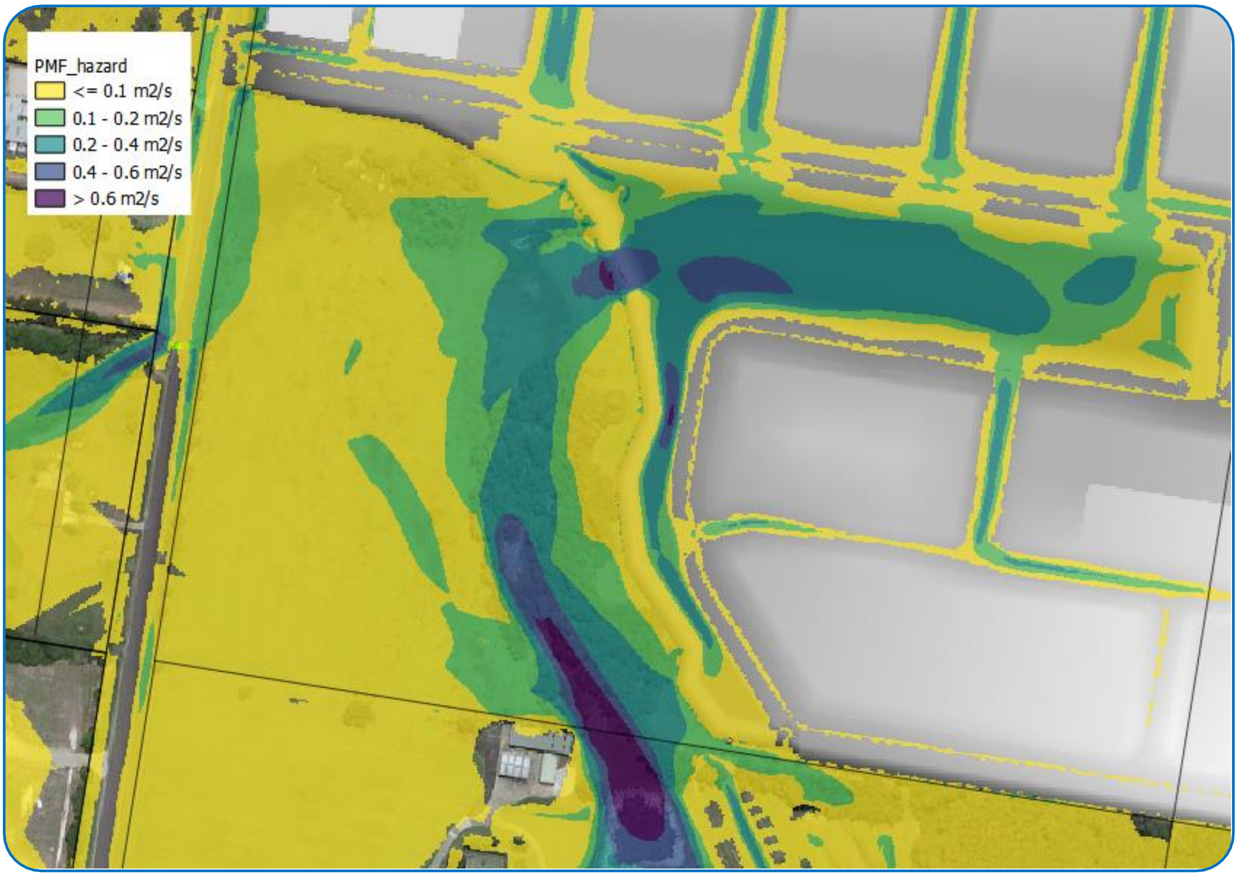


Figure 6.6 PMF- Post Development Peak Flood Hazard

6.3 Hydraulic Assessment – TUFLOW

In order to determine whether the discharge conditions resulting from the development will lead to unacceptable impacts to downstream properties to the west, a *TUFLOW* 1D/2D hydraulic assessment has been undertaken. *TUFLOW* is capable of simulating flow for both small and large study areas using both 2-Dimensional and 1-Dimensional flow based on topography.

Data used to construct the 2D hydraulic model includes:

- Survey of the site and surrounds;
- LiDAR of the wider catchment;
- design surfaces of proposed works by Mortons Urban Solutions; and
- existing pipe network data from survey.

Flows from the western portion of the site discharge to culverts under Carrs Drive and into a table drain leading to the Clarence River.

6.3.1 Digital Terrain Model

The digital terrain model (DTM) forms the basis of the topography of the assessment area. This study has relied upon LiDAR data obtained from the Department of Natural Resources and Mines to construct the DTM, with survey overlaid where available. To accurately represent this DTM within the TUFLOW model, a grid size of 1 m has been utilised which is fine enough to capture the detail within the smaller flowpaths within the model extent. For the post-development scenario the model has been modified to include the design surface by Mortons Urban Solutions.

6.3.2 Model Extent

The extent of the TUFLOW model has been selected to accurately represent flood behaviour at the site, and ensure all contributing flows are captured. The model extends approximately 800 m downstream of Carrs Drive and encompasses the entire upstream catchment. The TUFLOW model extent is illustrated in Figure 6.7.

6.3.3 Structures

The existing pipe network downstream of the site has been represented in the model as 1D elements. Information on this network has been sourced from site survey.

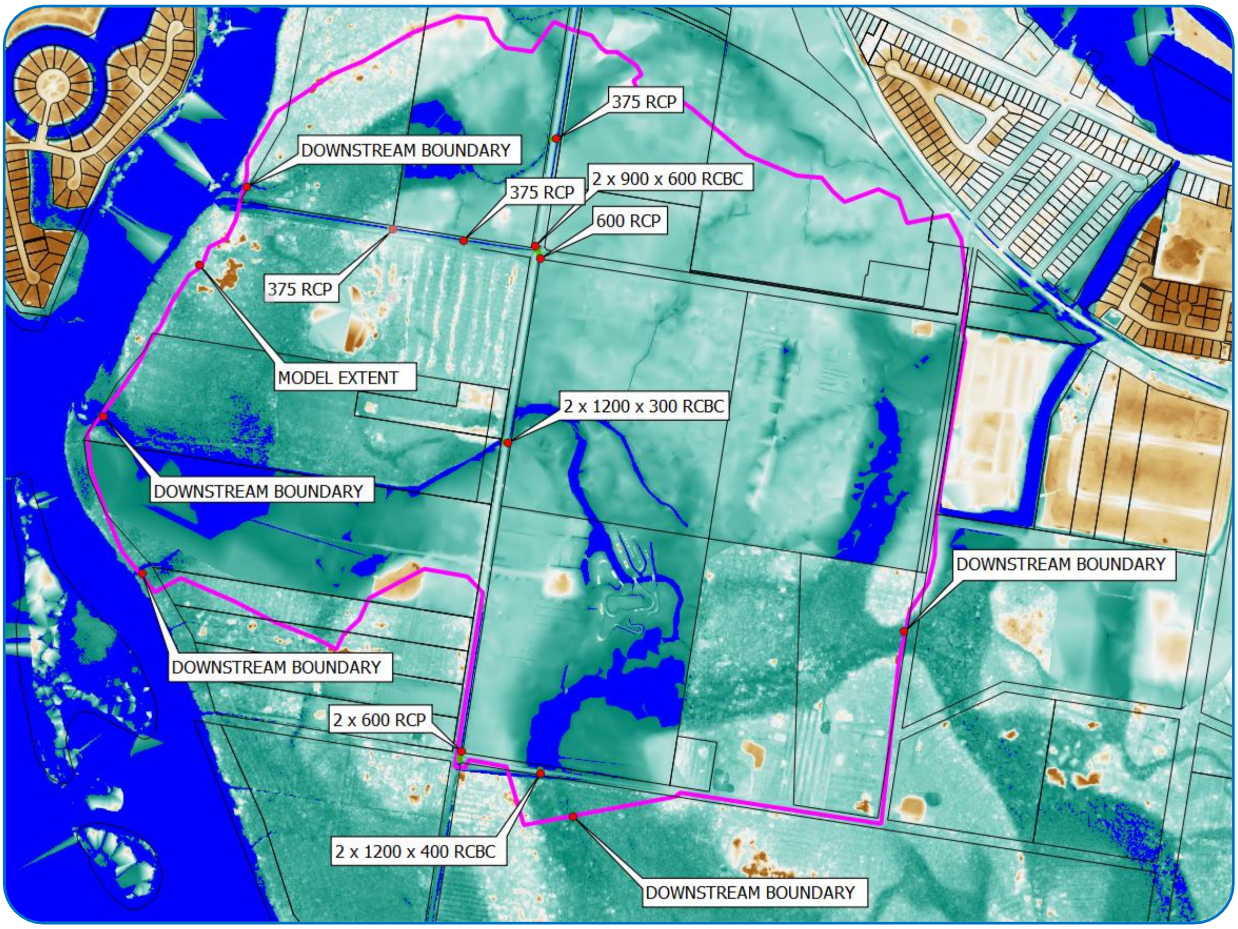


Figure 6.7 *TUFLOW* Pre-Development Model Extent

6.3.4 Manning's Coefficient

Based on recommendations from; *Chow. V. T, (1959) Open Channel Hydraulics*, *Main Roads Drainage Design Manual (1999),* and aerial photography the following Manning Coefficients were applied:

• Concrete/Road:	0.015
• Grassed areas:	0.045
• Light Vegetation:	0.060
• Dense Vegetation:	0.080
• Central Swale:	0.045
• Waterbodies:	0.020
• Houses:	0.300

6.3.5 Downstream Boundary Condition

In accordance with Section 5.5 of the Northern Rivers Local Government Handbook of Stormwater Drainage Design a tailwater equal to the River Half-Tide Level is to be used for receiving tidal waters. Based on Appendix D of the Handbook (Figure 6.8) this level for Gauge 1a would be 0.89 m (Chart Data) - 0.91 m = -0.02 m AHD.

As the site outlet is above this level (0.8 m AHD), consideration was given to coincident flooding (local vs regional events). Based on a catchment ratio of 10,000 to 1 and with reference to QUDM table BN 8.3.4.1 – Suggested ARIs for coincidental occurrence (Figure 6.9), an following event combinations have been considered:

- local 1% AEP on a regional 39.3% AEP; and
- regional 1% on a 39.3% local.

BMT have undertaken regional modelling over the West Yamba study area. The 1% AEP flood level recorded at the site is RL 2.0 m AHD. Whilst no information is provided within the report for a 39.3% event. The results of the regional flood modelling show the subject site as flood free during a regional 18.13% AEP (Figure 6.10). As such the 39.3% regional tailwater case initial water level has been set equal to the proposed outlet of RL 0.8 m AHD.

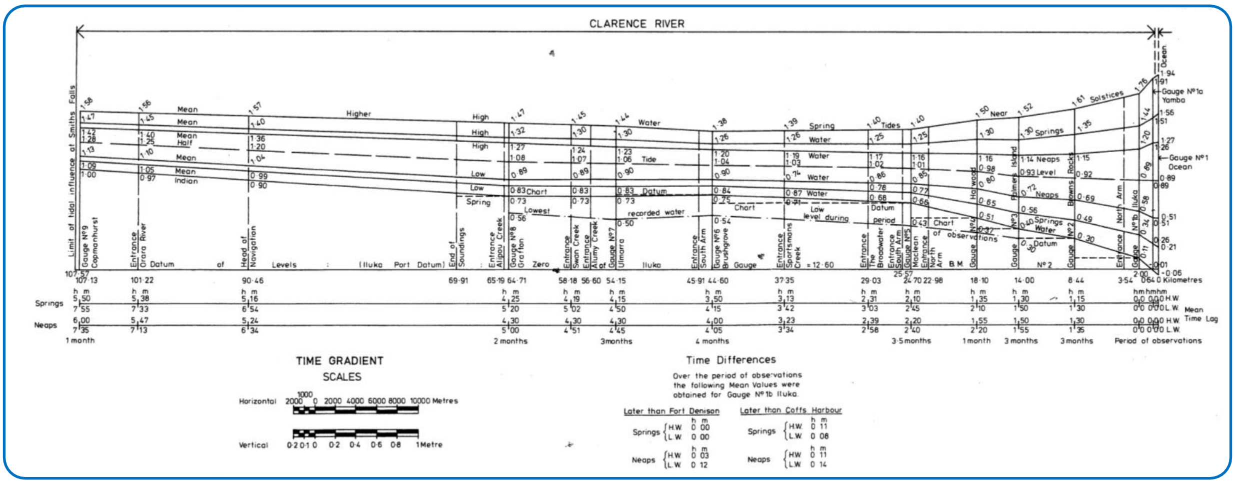


Figure 6.8 Appendix A – Northern Rivers Local Government Handbook

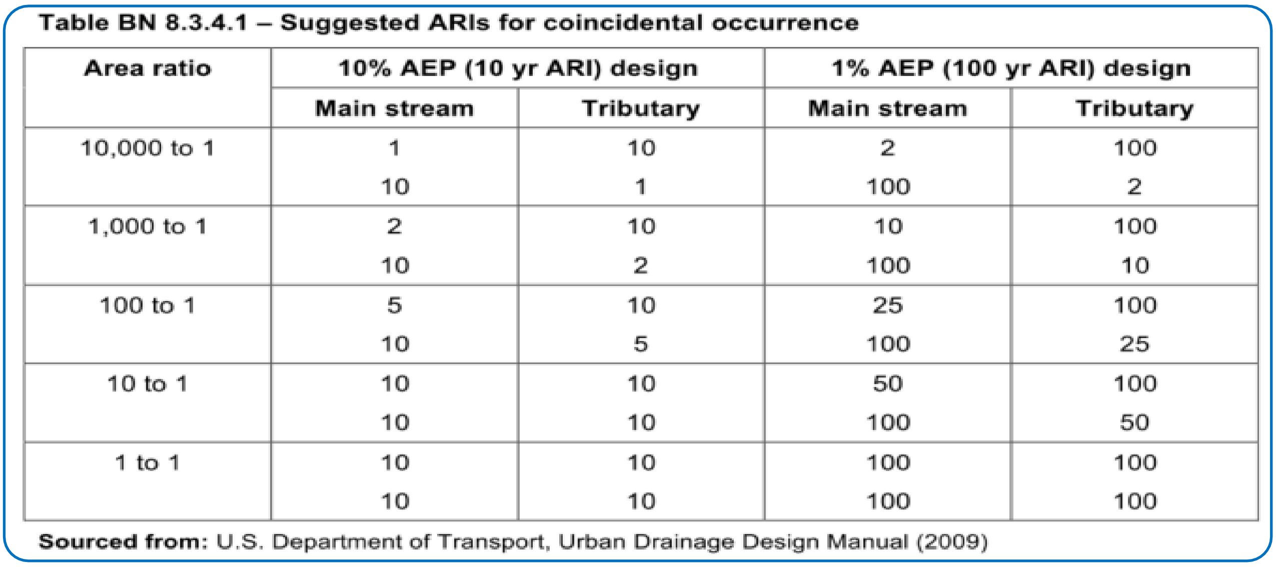


Table BN 8.3.4.1 – Suggested ARIs for coincidental occurrence

Area ratio	10% AEP (10 yr ARI) design		1% AEP (100 yr ARI) design	
	Main stream	Tributary	Main stream	Tributary
10,000 to 1	1	10	2	100
	10	1	100	2
1,000 to 1	2	10	10	100
	10	2	100	10
100 to 1	5	10	25	100
	10	5	100	25
10 to 1	10	10	50	100
	10	10	100	50
1 to 1	10	10	100	100
	10	10	100	100

Sourced from: U.S. Department of Transport, Urban Drainage Design Manual (2009)

Figure 6.9 Suggested ARIs for Coincidental Occurrence (QUDM, 2016)

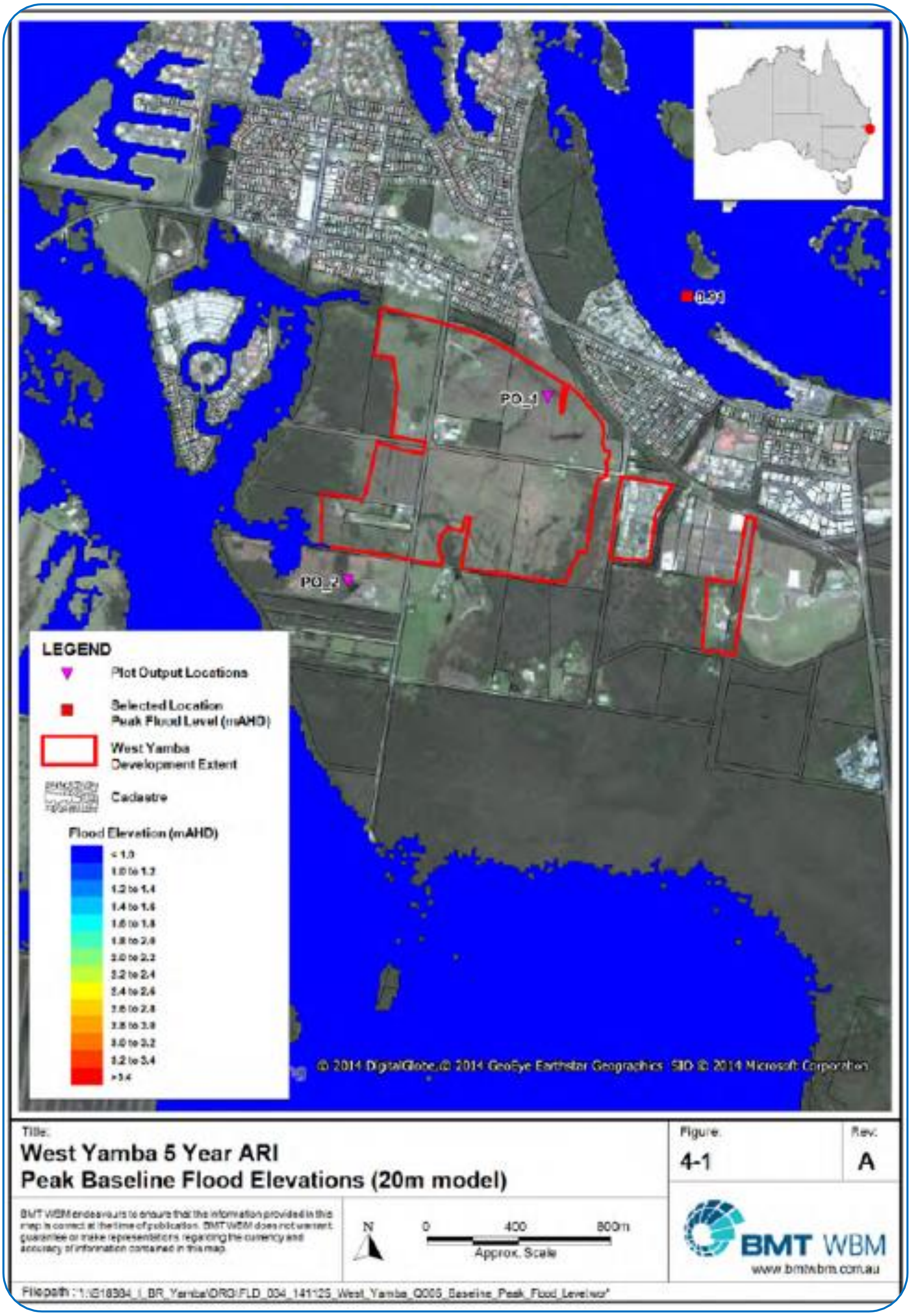


Figure 6.10 BMT Regional 18.13% Flood Extent

6.3.6 Hydrology

The TUFLOW model incorporates a rain-on-grid methodology for the catchment with rainfall and infiltration parameters as described in the above sections.

6.3.7 Critical Storm Duration

An analysis of flows through the catchment was undertaken for all durations, for an ensemble of 10 temporal patterns. Statistical analysis of the peak flow results at the points of interest within the catchment were used to identify the critical design storm for each AEP at the downstream point of interest (culvert at Carrs Drive). The 45-minute storm event was found to be the critical duration for the 1% AEP peak flow to this location.

6.3.8 Pre-Development *TUFLOW* Modelling Results

The local flooding behaviour of the site is characterised by shallow slow moving flow collecting in the low areas of the site and floodplain. There is a defined watercourse through the south-western corner of the site which conveys flow to the culverts under Carrs Drive. Figure 6.11 below shows the local 1% AEP peak depth through the site and downstream catchment, peak depths are generally less than 1 m.

Figure 6.11 1% AEP Pre-Development Peak Flood Depth

Velocity through the site is generally less than 0.5 m/s due to the very flat nature of the site. Figure 6.12 below shows the 1% AEP peak velocity through the site and downstream catchment.

Figure 6.12 1% AEP Pre-Development Peak Flood Velocity

6.3.9 Post-Development *TUFLOW* Modelling Results

The local flooding behaviour in the post-development scenario is similar in the lower catchment to the west of the site. Runoff from the earthworks pad is collected in an internal pipe network and directed to central detention basins. The western basin discharges to the existing watercourse and under Carrs Drive. The post-development TUFLOW model layout is shown on Figure 6.13.

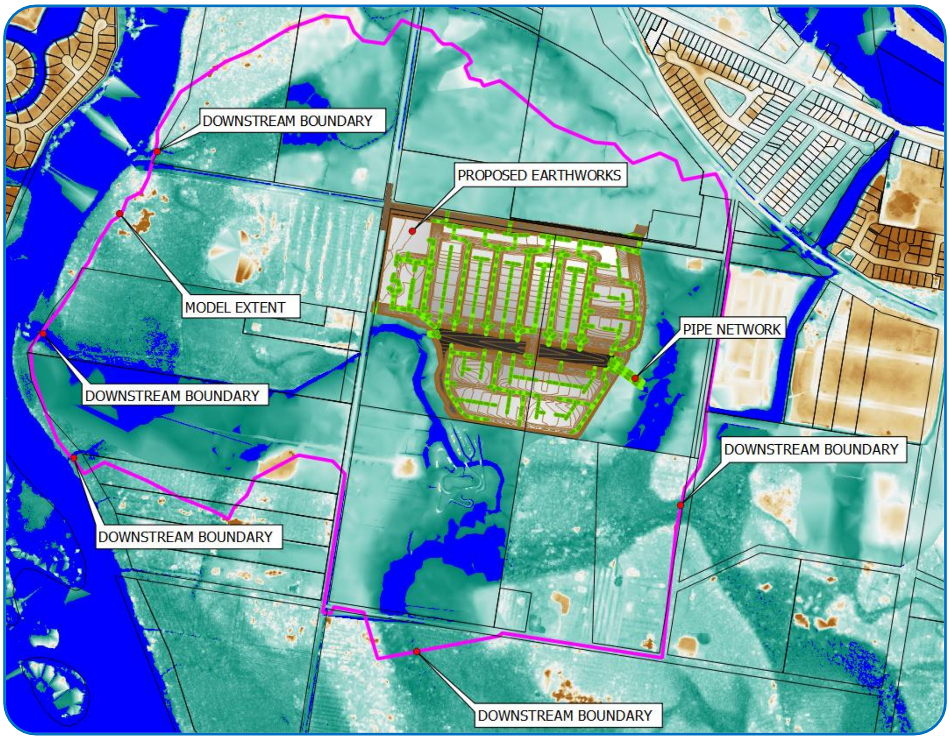


Figure 6.13 *TUFLOW* Post-Development Model Extent

The local peak depth and velocity outside of the earthworks footprint is largely unchanged in the post-development scenario due to the included detention measures. Figure 6.14 shows the peak post-development 1% AEP flood depth and 6.15 shows velocity. The local peak flood depths within the roadways is less than 200 mm. Figure 6.16 present the post-development d.V within the road.

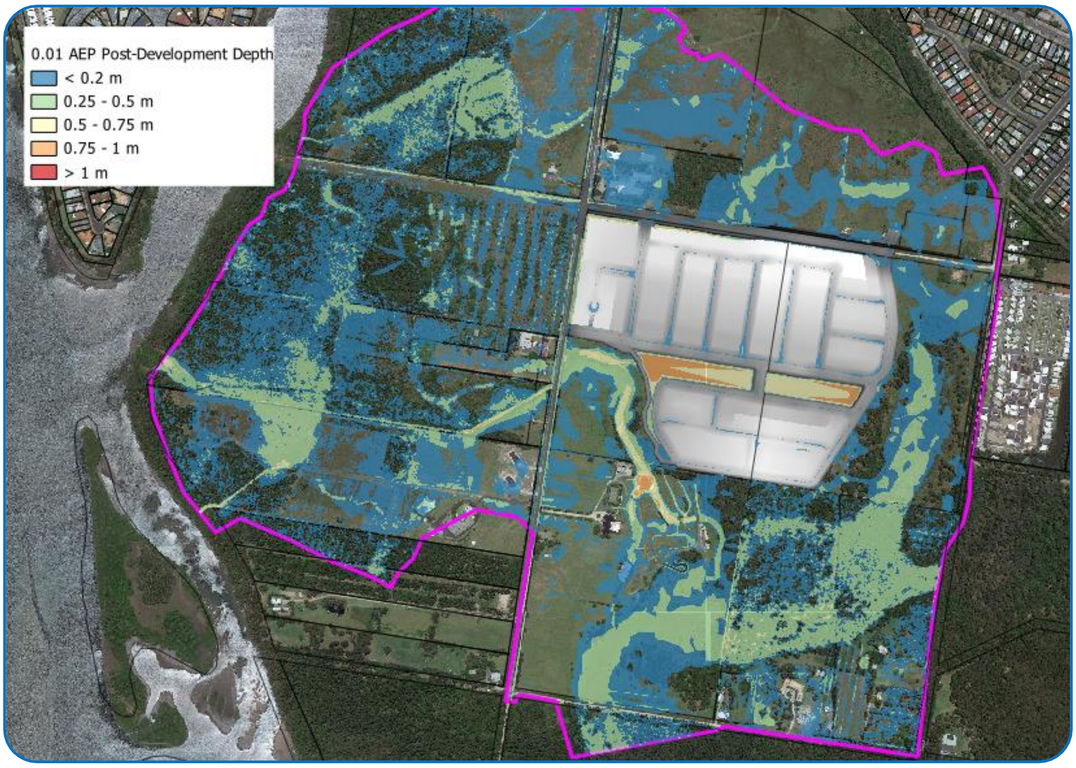


Figure 6.14 1% AEP Post-Development Peak Flood Depth

Figure 6.15 1% AEP Post-Development Peak Flood Velocity

Figure 6.16 1% AEP Post-Development d.V

To analyse the capacity of the pipe network and ponding within road reserve during a coinciding regional 1% and a 39.3% local event, further modelling was undertaken. The results indicate maximum ponding depths in the sag points are less than 200 mm (Figure 6.17).

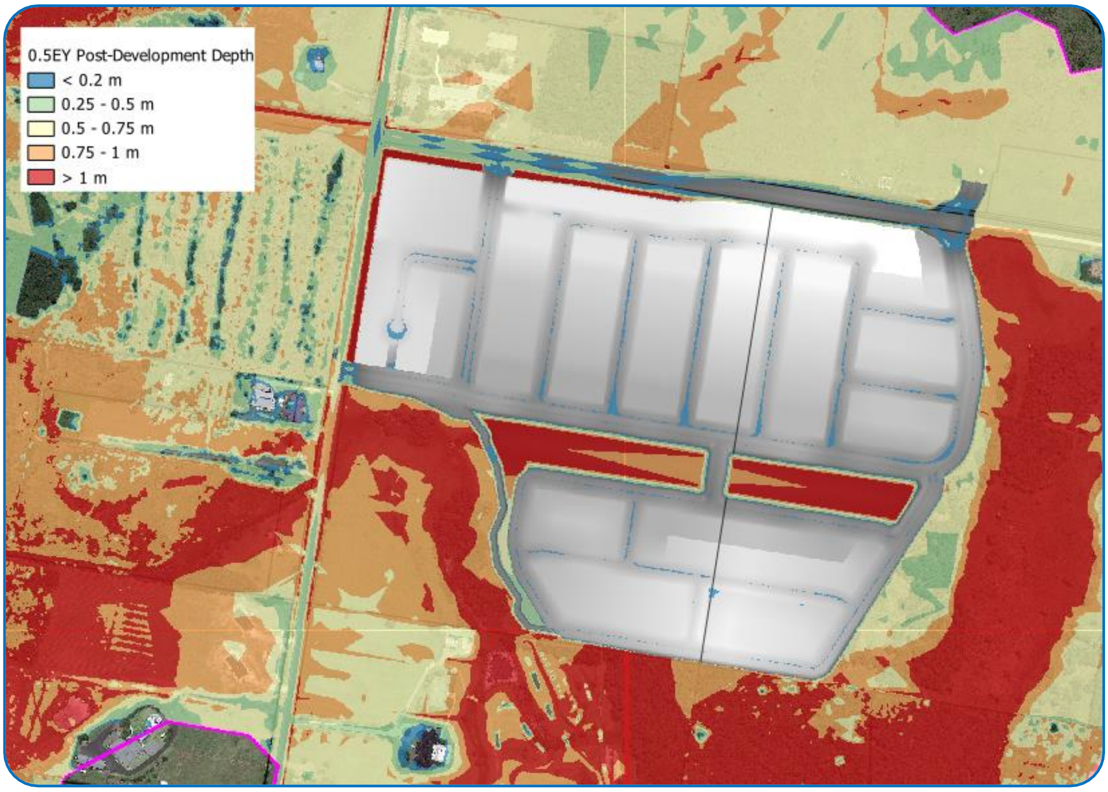


Figure 6.17 39.3% Post-Development Peak Flood Depth

6.3.10 Impact Assessment

In order to illustrate the impacts of the proposed development on flood levels external to the site, a spatial analysis of the pre and post-development results have been prepared for the 1% AEP.

The results of the modelling indicate that the proposed development will not impact on the extent or depth of flood inundation within private property. There are minor isolated velocity impacts surrounding the new headwalls to the north-west of the site due to the upgrading of Miles Street.

Figure 6.18 shows the flood level impact and Figure 6.19 shows the peak velocity impact.

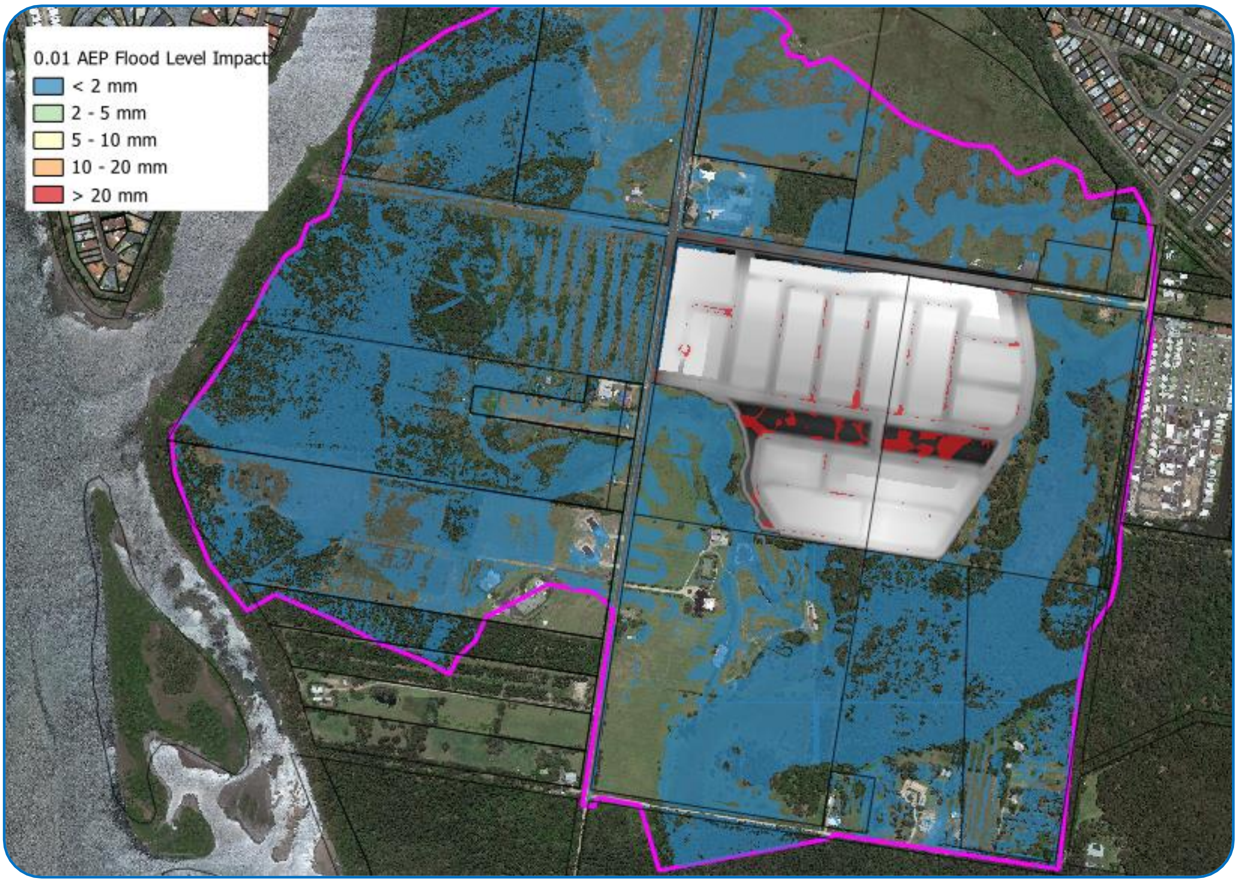


Figure 6.18 1% AEP Flood Level Afflux Plot

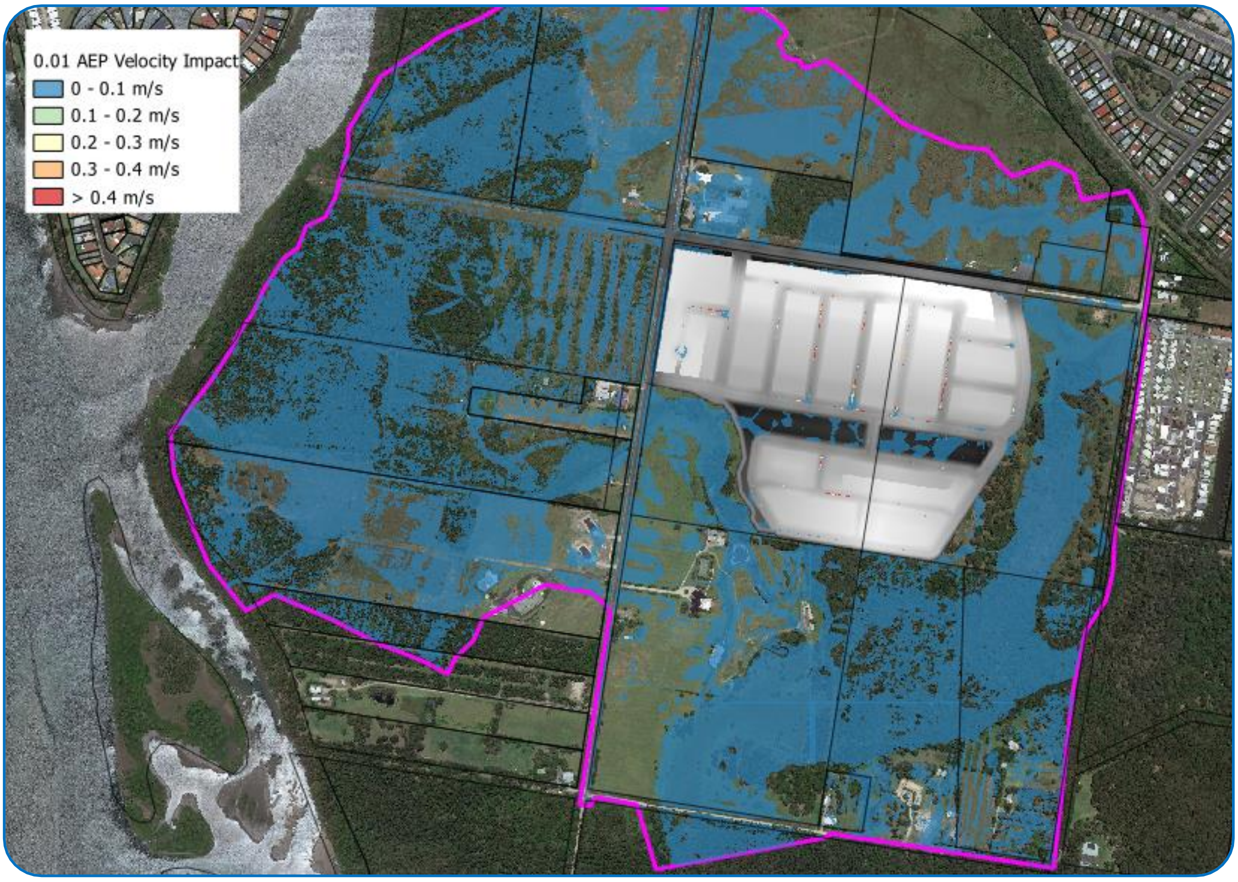


Figure 6.19 1% AEP Velocity Afflux Plot

6.4 Lawful Point of Discharge

The criteria for determining a Lawful Point of Discharge (LPD) as specified within the Queensland Urban Drainage Manual (2016) is as follows:

(i) Will the proposed development alter the site's stormwater discharge characteristics in a manner that may substantially damage a third party property?

- If not, then no further steps are required to obtain tenure for a lawful point of discharge (assuming any previous circumstances and changes were lawful).
- If there is a reasonable risk of such damage then consider (ii) or (iii).

(ii) Is the location of the discharge from the development site under the lawful control of the local government or other statutory authority from whom permission to discharge has been received? This will include a park, watercourse, drainage or road reserve, stormwater registered drainage easement, or land held by local government (including freehold land).

- If so, then no further steps are required to obtain tenure for a lawful point of discharge
- If not, then consider issue (iii). A land owner or regulator may require that the developer obtain an authority to discharge as described in (iii) in order for the stormwater to ultimately flow to a location described in (ii).

(iii) An authority to discharge over affected properties will be necessary. In descending order of certainty, an authority may be in the form of:

- Dedication of a drainage reserve or park;
- A registered easement for stormwater discharge/works; or
- Written approval.

Each point of discharge has been assessed against the above criteria and it is considered that a Lawful Point of Discharge will be achieved at each discharge location. Provided that the design measures set out in this report are implemented it is not anticipated that substantial damage will be caused to a third party property at any discharge point. Figures 6.20 and 6.21 demonstrate the direction of the pre and post development local 1% AEP flows.

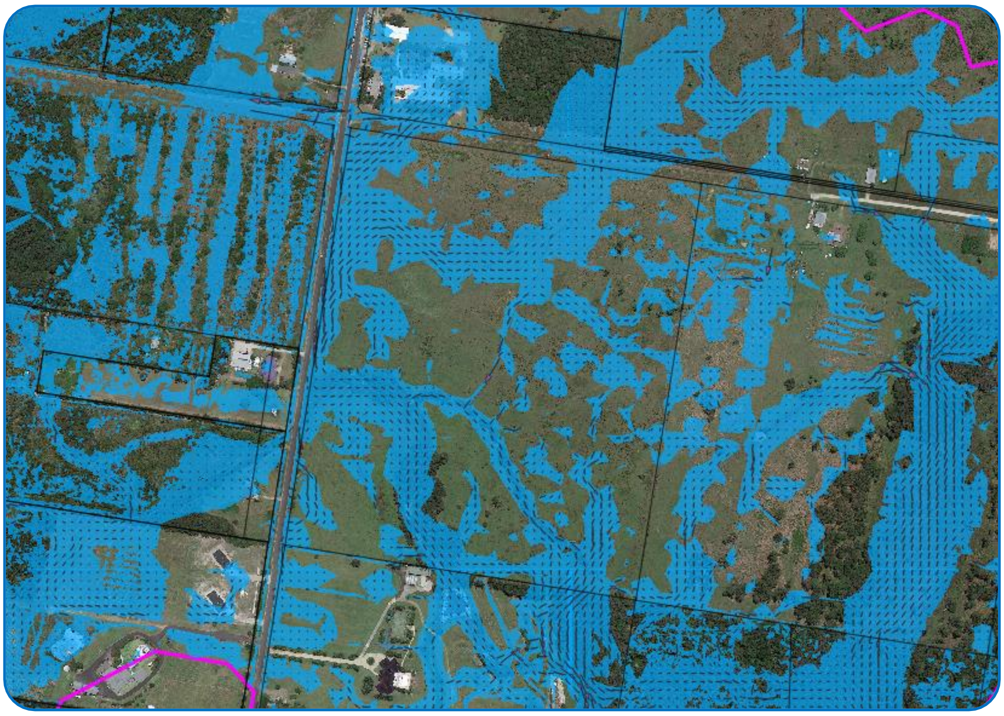


Figure 6.20 1% AEP Flow Direction Plot Pre-Development

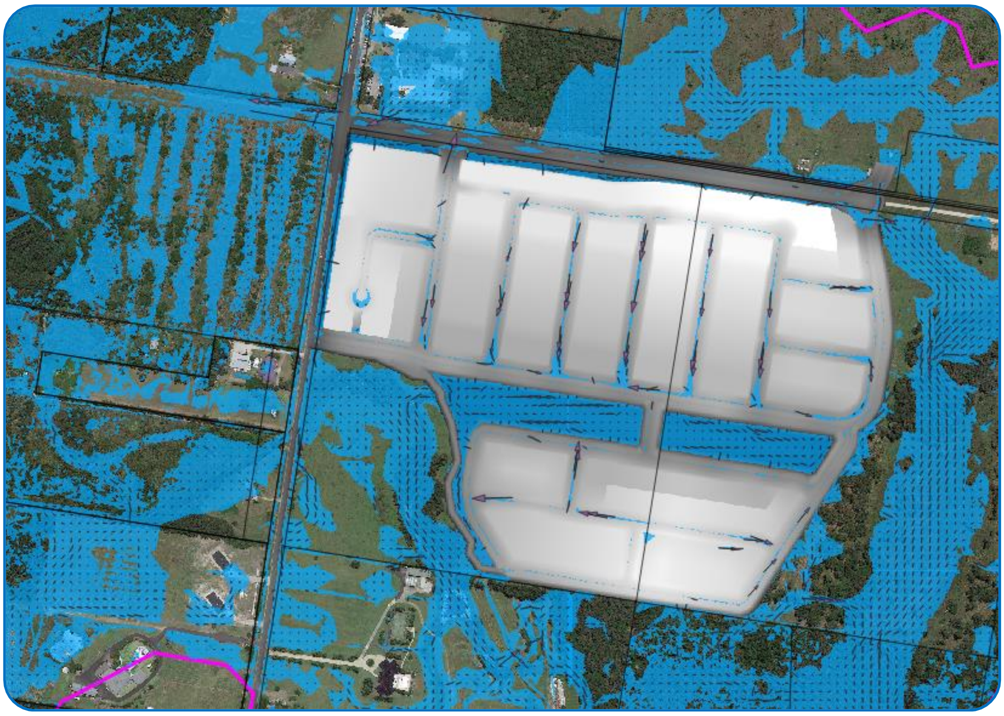


Figure 6.21 1% AEP Flow Direction Plot Post-Development

7 Stormwater Quality Management

In order to ensure that the operational phase objectives outlined within Section 1.1 of this report can be achieved, a network of stormwater quality management measures are proposed for inclusion within the development.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC v6) has been used to estimate the existing and potential pollutant loads generated by the development and to size the proposed treatment measures. The following sections outline the parameters relied upon within the MUSIC v6 modelling.

7.1 Rainfall and Evapotranspiration Data

Rainfall and evapotranspiration data has been obtained from the Bureau of Meteorology (BOM) and is included within Table 7.1 below. The Grafton South station (58076) has been used for modelling purposes, as this is the closest rainfall station with available and accurate pluviograph data to the site.

Table 7.1 Meteorological and Rainfall Runoff Data Reporting

Station	Grafton South (58076)
Period	1/01/1972 to 31/12/1976 (5 years)
Time step	6 minute
Mean annual rainfall (mm)	1,160
Evapotranspiration	1,326

7.2 Catchment Parameters

7.2.1 Pre-Development Case – Catchment Parameters

A pre-development scenario has been included within the MUSIC model to estimate the nutrient and sediment loads generated from the site in it's current condition. Estimated sediment and nutrient loads were then used for comparison purposes to establish whether the development of the site would alter the loadings currently discharging from the site.

The existing site (to the development extent) has been modelled as a rural landuse. The site was then split based on the existing soil types identified on-site (refer to Table 1 of the Preliminary Geotechnical Report by Regional Geotechnical Solutions included as Appendix I of this report). It is noted that several soil types were identified as part of the geotechnical investigation. For preliminary modelling purposes these soil types have been grouped into; Loamy Sands, Sandy Loams, and Sandy Clays which are comparative to the rainfall-runoff parameters within Table 5-5 of the NSW MUSIC Modelling Guidelines (BMT WBM 2015). The soils have then been proportioned across the site based on the ratio of investigation boreholes and soil types present.

Table 7.4 summarises the sub-catchment areas for the pre-development case. The Rainfall Runoff parameters have been based on Table 5.5 of the NSW Music Modelling Guidelines (BMT WBM 2015) and are summarised as Table 7.2 below. The adopted pollutant export parameters for each sub catchment are based on data from the Water by Design MUSIC v6 Modelling Guidelines (2010), as summarised in Table 7.3.

Table 7.2 Rainfall Runoff Parameters – Pre Development Case

Parameter	Pre Developed Case - Loamy Sand node	Pre Developed Case – Sandy Loam node	Pre Developed Case – Sandy Clay node
Landuse	Rural	Rural	Rural
Soil Type	Loamy Sands	Sandy Loams	Sandy Clays
Rainfall threshold (mm)	1	1	1
Soil storage capacity (mm)	139	98	142
Initial storage (% capacity)	25	25	25
Field capacity (mm)	69	70	94
Infiltration capacity coefficient a	360	250	180
Infiltration capacity exponent b	0.5	1.3	3
Initial depth (mm)	10	10	10
Daily recharge rate (%)	100	60	25
Daily baseflow rate (%)	50	45	25
Daily deep seepage rate (%)	0	0	0

Table 7.3 Pollutant Export Parameters (log mg/L) – Pre Development Case

Flow Type	Surface Type	Total Suspended Solids ($\log_{10}$ mg/L)		Total Phosphorous ($\log_{10}$ mg/L)		Total Nitrogen ($\log_{10}$ mg/L)	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Rural							
Base Flow	Lumped	0.53	0.24	-1.54	0.38	-0.52	0.39
Storm Flow	Lumped	2.26	0.51	-0.56	0.28	0.32	0.3

Table 7.4 *MUSIC v6* Sub-Catchment Areas – Pre Development Case

Catchment ID	Land Use	Area (ha)	Total Impervious (%)
Pre-Development – Loamy SAND	Rural	14.957	0
Pre-Development – Sandy LOAM	Rural	4.207	0
Pre-Development – Sandy CLAY	Rural	4.207	0

7.2.2 Developed (Untreated) Case – Catchment Parameters

The developed site has been modelled as having an Urban Residential (Large Site) land use.

The overall site was modelled to determine the total expected pollutant loading from the developed site. The developed site was split into four (4) internal developed catchments within the development extent (excluding the detention basin areas) as per the Developed Catchment Plan DWG-201 included within Appendix A. The developed catchments were then split into roof, road, and ground level areas based on the proposed development layout plan. It is noted that for modelling purposes a typical roof area of 250 m^2 per lot has been assumed (based on Table 3.4 ‘Typical Surface Splits’ of Water By Design MUSIC modelling Guidelines, 2018).

Table 7.5 summarises the modelled catchment areas and Drawing DWG-210 – Appendix A presents a typical stormwater quality catchment for a bioretention measure. The adopted rainfall and runoff parameters for each sub catchment are based on data from the NSW MUSIC

Modelling Guidelines (BMT WBM 2015) as summarised in Tables 7.6. Pollutant export parameters have been based on the Water By Design MUSIC Modelling Guidelines (2010, and 2018) as per advice received from CVC (summarised in 7.7).

Table 7.5 *MUSIC v6* Sub-Catchment Areas –Developed Case

Catchment ID	Land Use	Area (ha)	Total Impervious (%)
A	Urban Residential – Roof (to tank)	0.038	100
	Urban Residential – Roof (to bio)	0.038	100
	Urban Residential – Road	0.16	60
	Urban Residential – Ground	0.065	20
B	Urban Residential – Roof (to tank)	2.488	100
	Urban Residential – Roof (to bio)	2.488	100
	Urban Residential – Road	5.216	60
	Urban Residential – Ground	5.449	20
B (Access Road)	Urban Residential – Road	0.12	60
C1	Urban Residential – Roof (to tank)	0.100	100
	Urban Residential – Roof (to bio)	0.100	100
	Urban Residential – Road	0.197	60
	Urban Residential – Ground	0.113	20
C2	Urban Residential – Roof (to tank)	1.088	100
	Urban Residential – Roof (to bio)	1.088	100
	Urban Residential – Road	2.610	60
	Urban Residential – Ground	2.115	20

Table 7.6 Rainfall Runoff Parameters

Parameter	All Developed Case Nodes
Landuse	Residential
Soil Type	Silty Clay
Rainfall threshold (mm)	1
Soil storage capacity (mm)	54
Initial storage (% capacity)	25
Field capacity (mm)	51
Infiltration capacity coefficient a	180
Infiltration capacity exponent b	3
Initial depth (mm)	10
Daily recharge rate (%)	25
Daily baseflow rate (%)	25
Daily deep seepage rate (%)	0

Table 7.7 Pollutant Export Parameters (log mg/L)

Flow Type	Surface Type	Total Suspended Solids ($\log_{10}$ mg/L)		Total Phosphorous ($\log_{10}$ mg/L)		Total Nitrogen ($\log_{10}$ mg/L)	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Residential							
Base Flow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Road	1.00	0.34	-0.97	0.31	0.20	0.20
	Ground	1.00	0.34	-0.97	0.31	0.20	0.20
Storm Flow	Roof	1.30	0.39	-0.89	0.31	0.26	0.23
	Road	2.43	0.39	-0.30	0.31	0.26	0.23
	Ground	2.18	0.39	-0.47	0.31	0.26	0.23

7.3 Pre-Development vs Developed (Untreated) Nutrient & Sediment Loads

Results of the *MUSIC v6* modelling for the Pre-Developed & Developed (Untreated) scenarios are summarised in Table 7.8 below and indicate urbanisation of the rural catchment will result in increases in both sediment and nutrient loads within the development extent. Stormwater quality treatment measures are therefore required to reduce loadings discharging from the developed catchment.

Table 7.8 Pre-Development vs Developed (Untreated) Nutrient & Sediment Loads

Catchment ID	Pollutant	Pre-Development (kg/yr)	Developed (Untreated) (kg/yr)	Difference (kg/yr)
Overall Site (TOTAL)	TSS	11,041	34,510	+23,469
	TP	13	66	+53
	TN	107	435	+328

7.4 Stormwater Quality Treatment Concepts

It is proposed that stormwater runoff from the developments be collected within the kerb and channel of the internal roads during minor events and treated within street scape quality treatment measures. Flows will enter these measures via openings within the kerb. These measures have been designed to encourage ‘at source treatment’ of flows within the road reserves and to limit earthworks (fill) associated with a traditional piped network.

Post treatment stormwater flows from each streetscape measure will enter the underground piped network. Highflows above the piped network capacity are to be conveyed within the road reserves to the proposed detention basins within Catchments B and C.

Rainwater tanks (3 kL) have been included for the beneficial reuse of stormwater and are to be connected to the roof catchment area within each allotment. Overflows are to be directed to the dedicated inter allotment pipe network contained with a 3 m drainage easement.

In the treatment case two (2) scenarios have been modelled; a typical sub-catchment area model to size the streetscape treatment measures, and an overall site catchment model of the development extent including lumped treatment measures for comparative purposes.

7.4.1 Streetscape Treatment – Typical 2,500 m^2 Catchment Parameters

In order to estimate the size individual streetscape treatment measures – a typical sub-catchment area of 2,500 m^2 was used (equivalent to the approximate catchment of a traditional stormwater pit) to determine the required filter surface area for a typical bioretention. The ratio of filter area to catchment area was then used to size each bioretention to its contribution catchment.

Rainwater tanks are included within the treatment train for the beneficial reuse of water.

The developed catchment has been split into roof, ground, and road source nodes with 50% of roof areas directed to a rainwater tank node (lumped). Catchment splits have been based on advice received from CVC (split of 35%, 25%, and 40% for roof, road, and ground level respectively of the development area).

The catchments relative to the type of bioretention measure (i.e. Type 1, and Type 3 with 500mm and 400mm filters) have been further delineated.

Table 7.9 summarises the modelled sub-catchment areas and Drawing DWG-210 – Appendix A presents a typical stormwater quality catchment for a bioretention measure. The adopted rainfall and runoff parameters for each sub catchment are based on data from the NSW MUSIC Modelling Guidelines (BMT WBM 2015) as summarised in Tables 7.6. Pollutant export parameters have been based on the Water By Design MUSIC Modelling Guidelines (2010, and 2018) as per advice received from CVC (summarised in 7.7).

Table 7.9 *MUSIC v6* Sub-Catchment Areas –Streetscape Treatment

Modelling Scenario	Catchment ID	Land Use	Area (ha)	Total Impervious (%)
Typical 2,500 m^2 Catchment (Rainwater Tanks + Streetscape Treatment)	HAT* Constrained Type 3 Bio	Urban Residential – Roof (to tank)	0.044	100
		Urban Residential – Roof (to bio)	0.044	100
		Urban Residential – Road	0.063	60
		Urban Residential – Ground	0.10	20
	Invert Constrained Type 1 Bio	Urban Residential – Roof (to tank)	0.044	100
		Urban Residential – Roof (to bio)	0.044	100
		Urban Residential – Road	0.063	60
		Urban Residential – Ground	0.10	20
	Streetscape Bio Catchment	Urban Residential – Roof (to tank)	0.044	100
		Urban Residential – Roof (to bio)	0.044	100
		Urban Residential – Road	0.063	60
		Urban Residential – Ground	0.10	20

*HAT – Highest Astronomical Tide

7.5 Quality Control – Pollutant Reduction

In accordance with the CVC's Residential Zone DCP (2011) the proposed streetscape measures will need to achieve the minimum mean annual load based reductions within Table H2 of 85% for Total Suspended Solids (TSS); 60% for Total Phosphorus (TP), 45% for Total Nitrogen (TN), and 90% for Gross Pollutants (GP).

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC v6*) has been used to size the proposed streetscape treatment measures to achieve the required load-based reductions and estimate the potential pollutant loads generated by the development. The following sections outline the parameters relied upon within the *MUSIC v6* modelling of the proposed stormwater treatment train.

7.5.1 Treatment Measures

In order to determine the design requirements for the necessary stormwater treatment measures, key "Treatment Nodes" were added to the *MUSIC v6* model. The following sections outline the modelling parameters relied upon for each "Treatment Node".

Rainwater Tank Parameters

Rainwater tanks have been included for the beneficial reuse of stormwater and are to be connected to the roof catchment area within each allotment. Overflows are to be directed to the dedicated inter allotment pipe network contained with a 3 m drainage easement.

Re-use rates for the tanks have been determined in accordance with the BMT WBM NSW MUSIC Modelling Guidelines (2015) and Water by Design *MUSIC v6* Modelling Guidelines (2010). Conservative irrigation rates and some water saving fixtures have been assumed for all dwellings.

Table 7.10 summarises the input parameters applied to the *MUSIC v6* model for rainwater tanks. Note for water quality modelling purposes, the rainwater tanks were clumped together as one tank.

Table 7.10 Rainwater Tank Parameters (Lumped)

Rainwater Tank Parameter	Rainwater Tanks (Single Streetscape) - Parameter Settings	Overall Site			
		Rainwater Tanks (Catchment A) - Parameter Settings	Rainwater Tanks (Catchment B) - Parameter Settings	Rainwater Tanks (Catchment C1) - Parameter Settings	Rainwater Tanks (Catchment C2) - Parameter Settings
Volume below overflow pipe (kL).	3 x 3 kL = 9	3 x 3 kL = 9	199 x 3 kL = 597	3 x 3 kL = 9	3 x 3 kL = 9
Depth above overflow (m)	0.20	0.20	0.20	0.20	0.20
If tanks are lumped, is depth below overflow the same as a single tank and overflow pipe scaled accordingly?	Yes	Yes	Yes	Yes	Yes
Surface area (m^2).	4.5	4.5	298.5	4.5	4.5
Overflow pipe diameter (mm) $= 90(\sqrt{(no. tanks)}).$	156	156	1,270	156	156
Stored water used for irrigation and other purposes PET PET – Rain	Yes PET – Rain	Yes PET – Rain	Yes PET – Rain	Yes PET – Rain	Yes PET – Rain
Indoor connections e.g. toilet, laundry etc.	Toilet & Washing Machine				
Indoor demand / person (kL/day)	0.058*				
Persons per dwelling	2.8**				
Outdoor demand – single dwelling (kL/yr)	55.0				

Daily demand/ single dwelling (kL/day)	0.162
Monthly distribution of annual demand (kL/day)	0.0
Confirmation that K and C* remain default?	Yes

*Table 6-1, BMT WBM NSW MUSIC Modelling Guidelines

**Table 4.2, Water By Design MUSIC Modelling Guidelines (2018)

Bioretention

It is proposed that streetscape bioretention measures be incorporated into the road reserves of the development layout to provide the necessary load based reductions. Bioretention systems operate by capturing and retaining water in an extended ponding area (no more than 400 mm deep for a maximum of four (4) days to prevent anaerobic conditions, plant death and insect breeding), before filtering through a soil media. The devices remove pollutants via the following physical processes:

- Sedimentation in the extended detention storage;
- Filtration by filter media;
- Nutrient uptake by biofilms;
- Nutrient adsorption and pollutant decomposition by soil bacteria; and
- Adsorption of metals and nutrients by filter particles (Somes & Crosby, 2007).

Bioretention - Site Constraints

As the site is within a low-lying coastal area, there are several constraints which require further consideration when setting design levels of the proposed treatment basins. Based on a desktop review and two (2) preliminary site investigations undertaken by Regional Geotechnical Solutions the following constraints have been identified;

- Potential Acid Sulfate Soils (PASS) are likely present on site as identified within the Acid Sulfate Soil Assessment undertaken by Regional Geotechnical Solutions (November 2018);
- Shallow Groundwater Levels were identified within the Preliminary Geotechnical Assessment undertaken by Regional Geotechnical Solutions (July 2018). At the time of investigation the estimated groundwater level ranged from 0.1-0.6 m AHD. It was also identified that seasonal variations, weather, and tidal influences would likely cause fluctuations in the groundwater levels onsite and hence further investigations would be required;
- Tidal interactions. In accordance with the Northern Rivers Handbook of Drainage Design, D5 (AUS-SPEC, 2018), Appendix D, the Highest Astronomical Tide (HAT) levels level identified for Yamba Gauge No 1a is 1.00 m AHD. This indicates that parts of the site will be affected by the HAT; and
- Invert Constraints. At the piped outlets to Miles Street to the north of the site (relative to Catchments A and C1), outlets are constrained to shallow depths (<1m) due to the swale invert and road access points required for the development.

The following tables identify bioretention design and level recommendations relative to the above identified constraints.

Table 7.11 Site Constraint Bioretention Design Recommendations

Constraint	Recommendations
Presence of PASS	Bioretention to be lined (liner specifications to be provided by Geotechnical Engineer) to prevent interaction with PASS.
Shallow Groundwater	Minimum design levels and freeboard contained within Table 7.7 (and Table 7 of Water By Design 'Bioretention Technical Guidelines – Version 1.1) are to be maintained. If required Bioretention to be lined to prevent interaction with Groundwater (liner specifications to be provided by Geotechnical Engineer)
HAT	Minimum design levels and freeboard contained within Table 7.7(and Table 7 of Water By Design 'Bioretention Technical Guidelines – Version 1.1) are to be maintained.
Invert Constrained	Consider Type 1 drainage profile configuration for Bioretention measures incorporating a saturated zone. (Refer to Section 3.5.1.3 of Water By Design 'Bioretention Technical Guidelines – Version 1.1)

Table 7.12 Recommended Bioretention Design Levels - Groundwater or Tidal Levels

Drainage Profile Type	Level Relative to Wet Season Groundwater Level (WSGL)	Level Relative to Highest Astronomical Tide (HAT)
Type 1 Saturated Zone	Impermeable liner extends ≥ 300 mm above WSGL	Impermeable liner extends ≥ 300 mm above HAT*
Type 2 Sealed	System will be completely sealed. No further Restrictions.	Base of transition layer ≥ 300 mm above HAT*
Type 3 Conventional	Base of underdrainage pipes ≥ 300 mm above WSGL	

*Based on a HAT of 1.0 m AHD this equates to a base media level of 1.3 m AHD

In accordance with Water by Design Guidelines, Table 7.13 summarises the treatment node parameters used in the *MUSIC v6* modelling whilst Figure 7.1 provides typical design parameters for the proposed bioretention devices.

It is noted that several bioretention systems are constrained due to the required freeboard to the HAT and invert constraints. These bioretention systems have been designed with filter depths of 400 mm and with saturated zones respectively and modelled as separate nodes in MUSIC.

It is further noted that in the overall site model, bioretention filters and surface areas have been lumped together for modelling purposes.

Table 7.13 Bioretention Parameters

Bioretention Parameter	2,500 m^2 Catchment			Overall Site				
	Streetscape Bioretention – Typical	Streetscape Bioretention – HAT Constrained	Streetscape Bioretention – Invert Constrained	A	B	B (Access Road)	C1	C2
Drainage Profile (Type 1 = Saturated Zone, Type 2 = Sealed, Type 3 = Conventional, Type 4 = Pipeless)	Type 3	Type 3	Type 1	Type 3	Type 3	Type 3	Type 3	Type 3
Surface area (m^2)	27	25	54	32	1689	13	44	745
Extended detention depth (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Filter area (m^2)	27	25	54	32	1689	13	44	745
Unlined filter media perimeter (m)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Saturated hydraulic conductivity (mm/hr)	200	200	200	200	200	200	200	200
Filter depth (m)	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.5
TN content of filter media (mg/kg)	400*	400*	400*	400*	400*	400*	400*	400*
Proportion of organic material in filter (%)	< 5	<5	<5	< 5	< 5	< 5	< 5	< 5
Orthophosphate content of filter media (mg/kg)	40.0*	40.0*	40.0*	40.0*	40.0*	40.0*	40.0*	40.0*
Is the base lined?	No**	No**	Yes	No**	No**	No**	No**	No**
Effectiveness of plant TN removal	Effective	Effective	Effective	Effective	Effective	Effective	Effective	Effective
Overflow weir width (m)	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10
Exfiltration rate (mm/hr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
If an exfiltration rate has been used, have node water balance losses been used in calculation of treatment train effectiveness?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
If exfiltration rate has been used, is the exfiltration rate justified?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Underdrain present?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Submerged zone with carbon present?	No	No	Yes	No	No	No	No	No

Depth of submerged zone (m)	N/A	N/A	0.4	N/A	N/A	N/A	N/A	N/A
Confirmation that K and C* remain default?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sediment Forebay Required (>2 ha contributing catchment)	No	No	No	No	No***	No	No	No***

*As per NSW MUSIC Modelling Guidelines (BMT WBM 2015)

**Liners are not required for Type 3 (Conventional Basins), however consideration to design recommendations within Table 7.6 should be given based on locations of basins and geotechnical recommendations.

***Note bioretention basins have been lumped for the overall modelling scenario. Individual street scape bioretention basins have catchments <2ha.

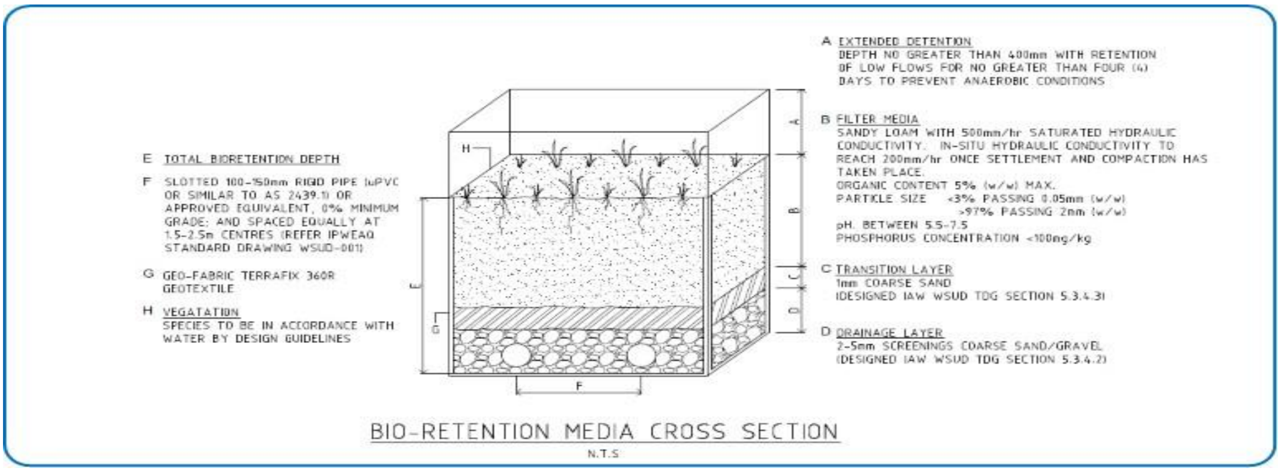


Figure 7.1 Bioretention specifications (Typical)

Coarse Sediment Treatment Requirements

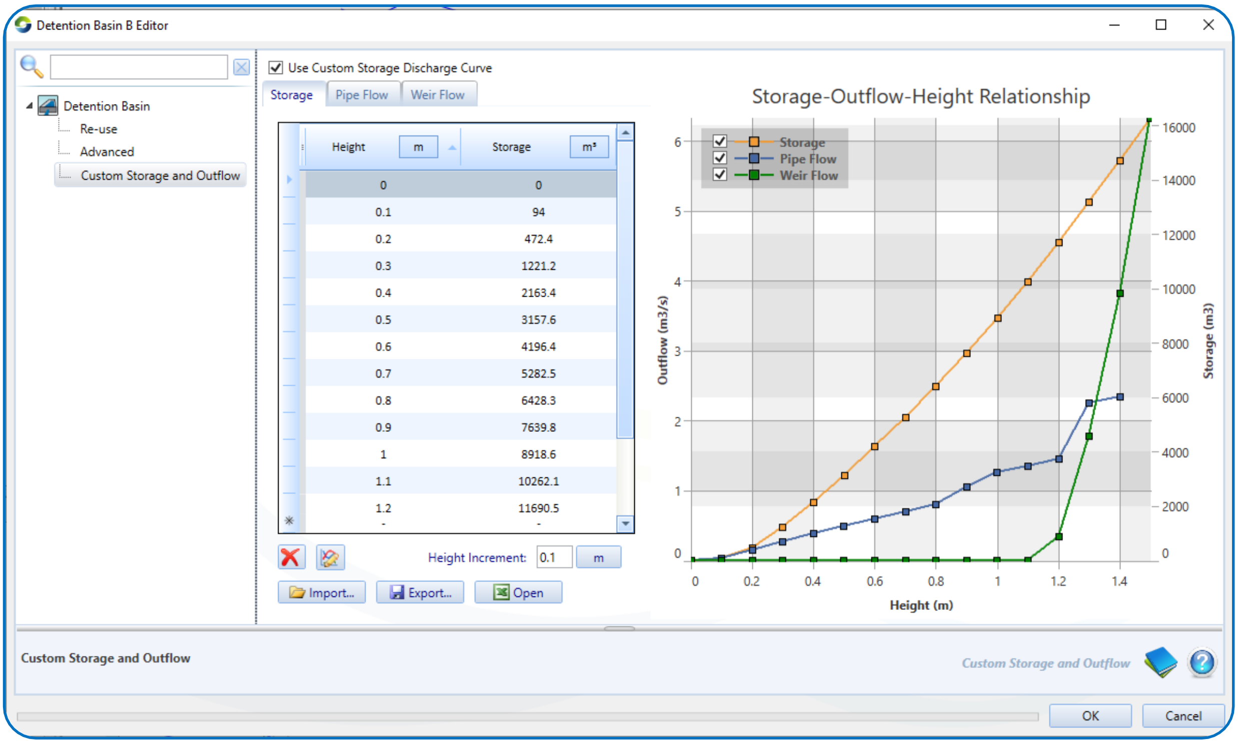
As the contributing catchment to each bioretention measure will be less than 2 ha no coarse sediment forebay (As per Water By Design (2014) Bioretention Technical Design Guidelines Version 1.1) will be required however rock protection will be installed at each discharge point into the streetscape bioretentions to prevent scour of the filter media. Details of scour protection measures will be provided as part of the detailed design phase of the development.

Detention Basins (included in Overall Model only)

As outlined in Section 6.2 of this report, detention basins are required for mitigation of peak flows form the development site. These basins are located within the central portions of Catchments B and C2. All flows from these catchments including treated flows form the bioretention measures and overflows from the rainwater tanks will be directed to the detention basins prior to discharge.

The detention basins have been included within the overall model for the site to gain an understanding of the total nutrient and sediment outflows from the development site. In order to model the proposed basins in MUSIC, a custom stage-storage-discharge relationship has been applied to the ‘Detention Basin’ node of MUSIC based on the basin designs outlined in Section 6.2 of this report. Figures 7.2 and 7.3 below present the applied discharge relationship for Basins B and C respectively.

It is noted that MUSIC has not been relied upon to size the proposed detention basins.

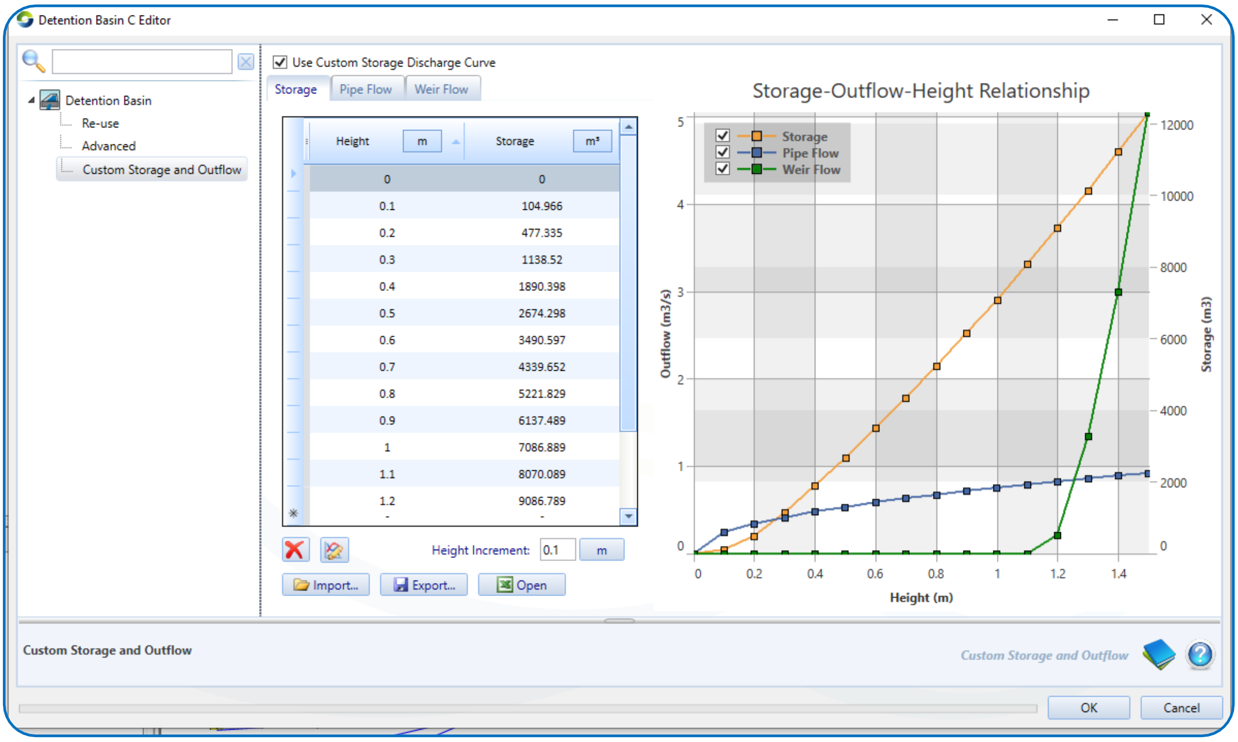


☑ Use Custom Storage Discharge Curve

Height m	Storage m³
0	0
0.1	94
0.2	472.4
0.3	1221.2
0.4	2163.4
0.5	3157.6
0.6	4196.4
0.7	5282.5
0.8	6428.3
0.9	7639.8
1	8918.6
1.1	10262.1
1.2	11690.5

Height Increment: 0.1 m

Figure 7.2 Custom Stage-Storage-Discharge relationship (Detention Basin B)



☑ Use Custom Storage Discharge Curve

Height m	Storage m³
0	0
0.1	104.966
0.2	477.335
0.3	1138.52
0.4	1890.398
0.5	2674.298
0.6	3490.597
0.7	4339.652
0.8	5221.829
0.9	6137.489
1	7086.889
1.1	8070.089
1.2	9086.789

Height Increment: 0.1 m

Figure 7.3 Custom Stage-Storage-Discharge relationship (Detention Basin C)

7.5.2 Bioretention Basin Staged Construction and Establishment

In accordance with the Water by Design Construction and Establishment Guidelines: Swales Bioretention Systems and Wetlands (C & E Guidelines), inflow of sediment-laden runoff during the building stage is a major risk to the successful and long-term functioning of bioretention systems.

During the building phase of developments, sediment can seal the surface of the filter media, move into and clog the filter media and accumulate in the under-drainage. Within the C & E Guidelines, there are four (4) options recommended to overcome the challenges associated with delivering bioretention systems. These generally include the following options:

- Option 1: Surface Protection
- Option 2: Bypass flows and early establishment of vegetation;
- Option 3: Sediment basin and bioretention function; and
- Option 4: Leave as sediment basin.

In accordance with 3.6 of the C & E guidelines, Options 1 and 2 are the preferred construction method for Streetscape Bioretention systems. Either of these options would provide adequate protection of the bioretention during the building phase and are suitable for implementation.

The Option 1 method is progressed in three (3) stages as follows:

Stage 1 Civil Works – civil construction and installation of the functional elements of the bioretention system including under-drainage and media;

Stage 2 Building Phase Protection

- installation of sediment fences around the perimeter of the filter media; and
- installation of a protective layer on the surface of the filter media, allowing it to operate as a shallow sediment basin during the building phase. It is recommended that filter cloth (geofab), topsoil and turf be installed for surface protection.

Stage 3 Landscape Establishment – when 80-90% of building in the catchment is complete, removal of the protective layers and planting and establishment of vegetation in the bioretention system.

The Option 2 method for staged construction generally includes the following:

- Construction of the civil infrastructure, including under-drainage and media, for the bioretention system;
- Bypass stormwater around the bioretention systems or isolate from stormwater using a temporary bund; and
- When 80-90% of building in the catchment is complete, remove the temporary bypass system and the bioretention system is allowed to function as per design.

For details of the procedure and order of construction for Option 1 or 2 method please refer to Section 3.9 (Steps 1-40) of the C & E Guidelines. If an alternative option is found to be more suitable for the site, construction methods and steps should be referenced from the C & E Guidelines.

It is noted that information contained within the SQMP are recommendations for planning purposes and relate to protection of the system within the building phase of the development (i.e. when the subdivision construction works are complete or near complete). It is assumed that in addition to the protection methods proposed, active building sites will also be required to maintain erosion and sediment control management measures to prevent/reduce sediment entrainment within stormwater runoff. Further details of bioretention construction staging will be provided in conjunction with the detailed design phase of the development.

7.5.3 Modelling Results

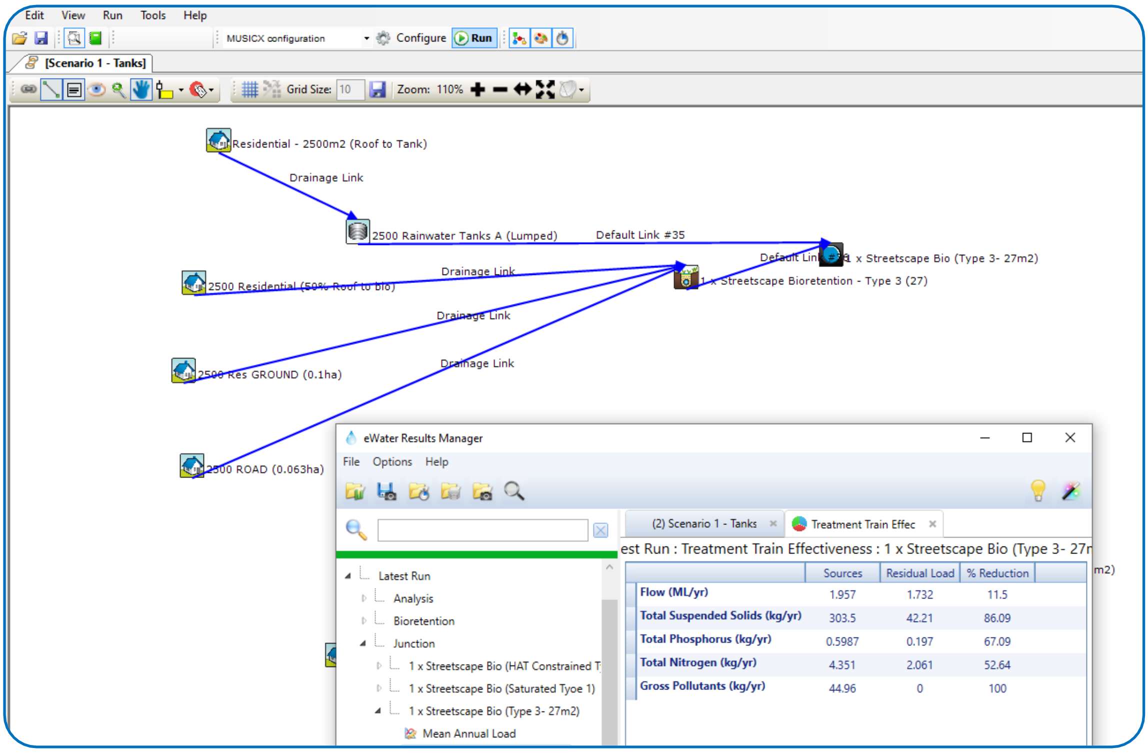
Results of the *MUSIC v6* modelling for the treatment train effectiveness are summarised in Table 7.14. The results indicate 85%, 60%, 45% and 90% reduction target for TSS, TP, TN and GP respectively are achieved for the rainfall data set simulated for all flows captured and conveyed to the proposed bioretention streetscape systems. The modelling results demonstrate that the Default Water Quality Targets include in Table H2 of the Clarence Valley Council DCP can be achieved.

A screen capture of the *MUSIC v6* modelling results is included as Figures 7.4-7.6 (individual streetscape measure catchment) and Figure 7.7 (overall site).

Table 7.14 Treatment Train Effectiveness

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction (%)	Water Quality Objective (%)
2,500 m^2 (1 x Streetscape bio)	TSS	303.47	42.21	261.3	**86.1**	85.0
	TP	0.60	0.20	0.4	**67.1**	60.0
	TN	4.35	2.06	2.3	**52.6**	45.0
2,500 m^2 (1 x HAT Constrained)	TSS	291.8	40.6	251.3	**86.1**	85.0
	TP	0.6	0.2	0.4	**66.5**	60.0
	TN	4.4	2.1	2.3	**51.7**	45.0
2,500 m^2 (1 x Invert Constrained)	TSS	294.42	20.94	273.5	**92.9**	85.0
	TP	0.60	0.21	0.4	**65.4**	60.0
	TN	4.40	1.74	2.7	**60.5**	45.0
Overall Site (TOTAL)	TSS	34,510	3,619	30,891	**89.5**	85.0
	TP	65.9	21.6	44.3	**67.2**	60.0
	TN	435	236	199	**45.7**	45.0

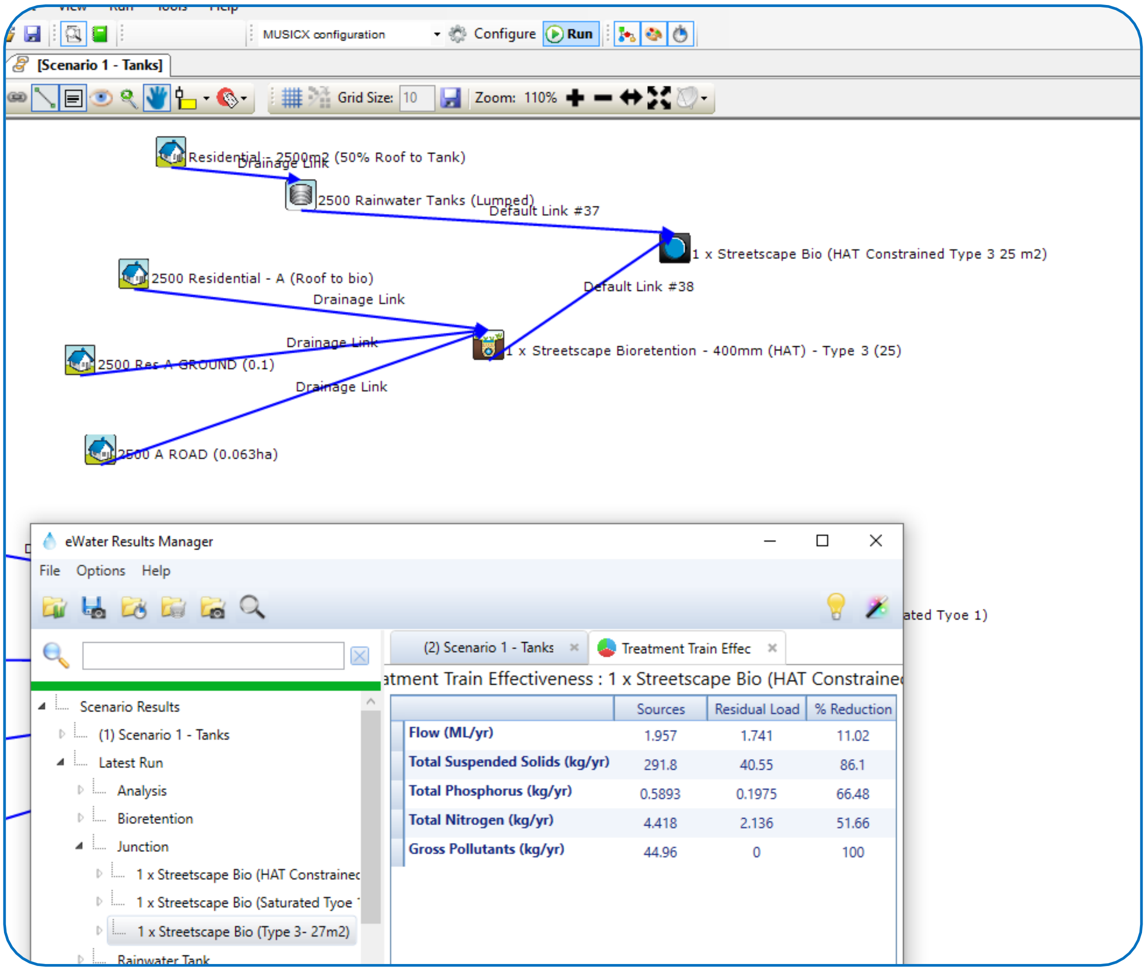
NOTE: All simulations have been run with pollutant export estimation set to “stochastic generation”.



est Run : Treatment Train Effectiveness : 1 x Streetscape Bio (Type 3- 27m2)

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.957	1.732	11.5
Total Suspended Solids (kg/yr)	303.5	42.21	86.09
Total Phosphorus (kg/yr)	0.5987	0.197	67.09
Total Nitrogen (kg/yr)	4.351	2.061	52.64
Gross Pollutants (kg/yr)	44.96	0	100

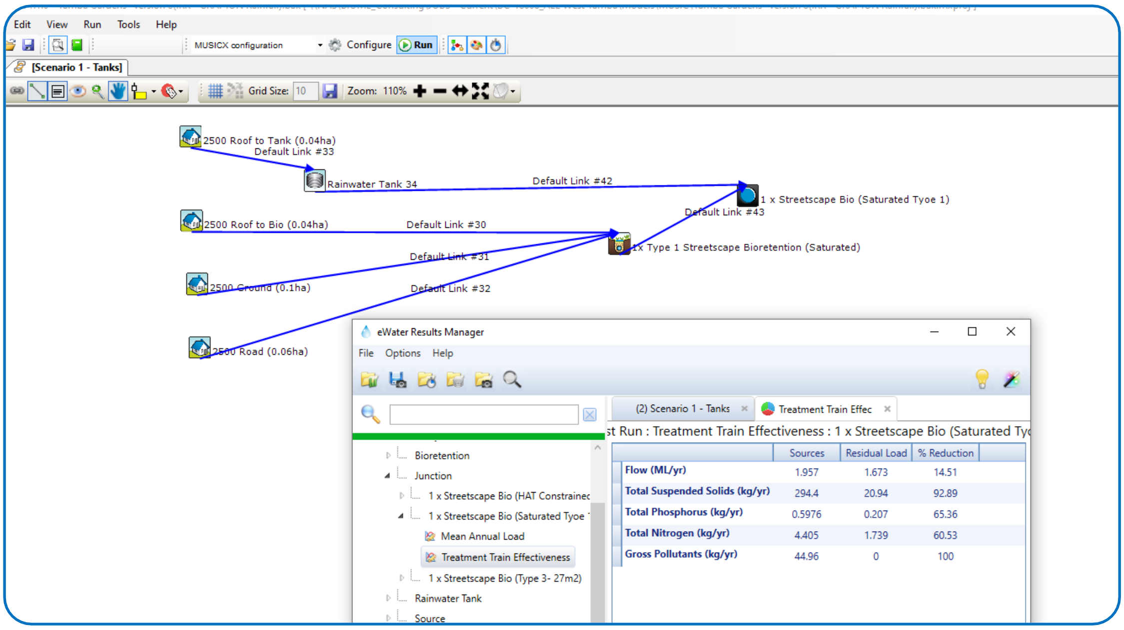
Figure 7.4 Screen Capture (1xStreetscape Bio 27 m^2 – 2,500 m^2 Catchment)



atment Train Effectiveness : 1 x Streetscape Bio (HAT Constrainec

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.957	1.741	11.02
Total Suspended Solids (kg/yr)	291.8	40.55	86.1
Total Phosphorus (kg/yr)	0.5893	0.1975	66.48
Total Nitrogen (kg/yr)	4.418	2.136	51.66
Gross Pollutants (kg/yr)	44.96	0	100

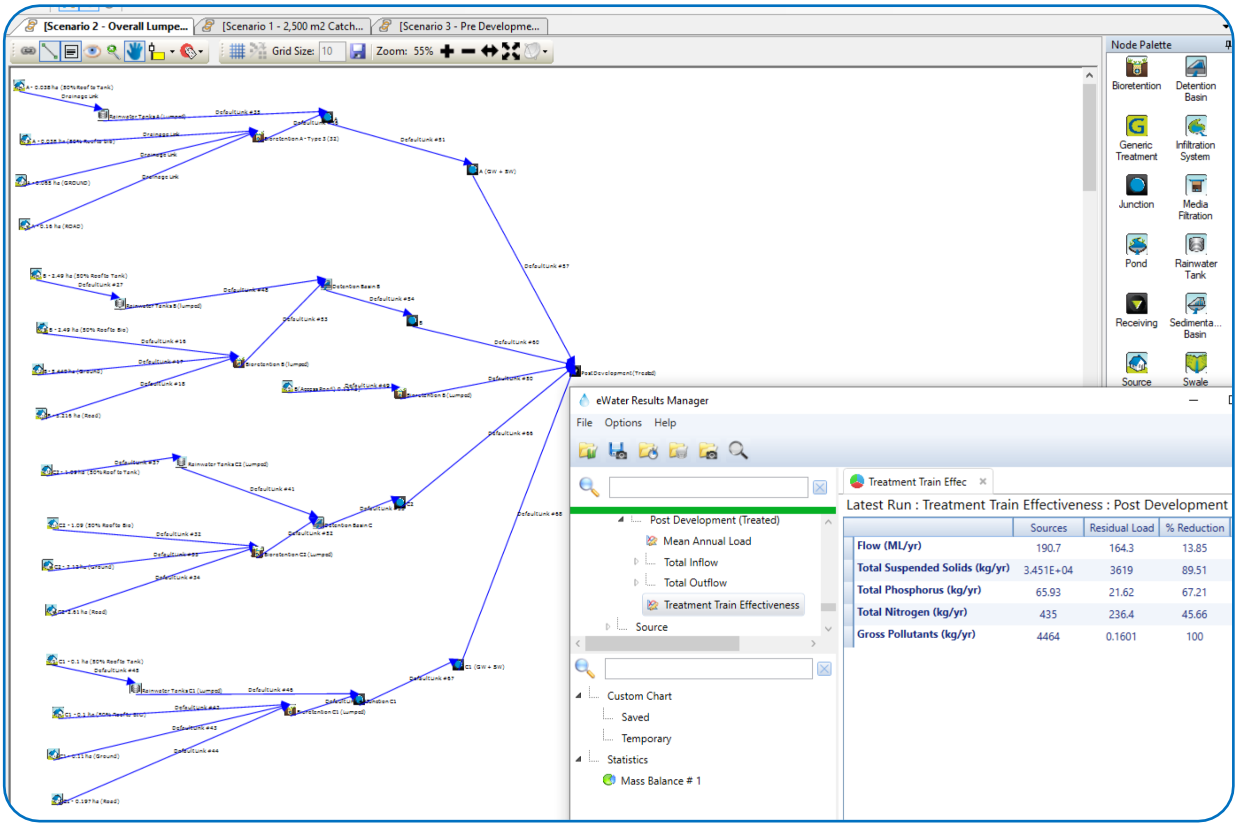
Figure 7.5 Screen Capture (HAT Constrained – 2,500 m^2 Catchment)



st Run : Treatment Train Effectiveness : 1 x Streetscape Bio (Saturated Tyc

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.957	1.673	14.51
Total Suspended Solids (kg/yr)	294.4	20.94	92.89
Total Phosphorus (kg/yr)	0.5976	0.207	65.36
Total Nitrogen (kg/yr)	4.405	1.739	60.53
Gross Pollutants (kg/yr)	44.96	0	100

Figure 7.6 Screen Capture (Invert Constrained – 2,500 m^2 Catchment)



Latest Run : Treatment Train Effectiveness : Post Development

	Sources	Residual Load	% Reduction
Flow (ML/yr)	190.7	164.3	13.85
Total Suspended Solids (kg/yr)	3.451E+04	3619	89.51
Total Phosphorus (kg/yr)	65.93	21.62	67.21
Total Nitrogen (kg/yr)	435	236.4	45.66
Gross Pollutants (kg/yr)	4464	0.1601	100

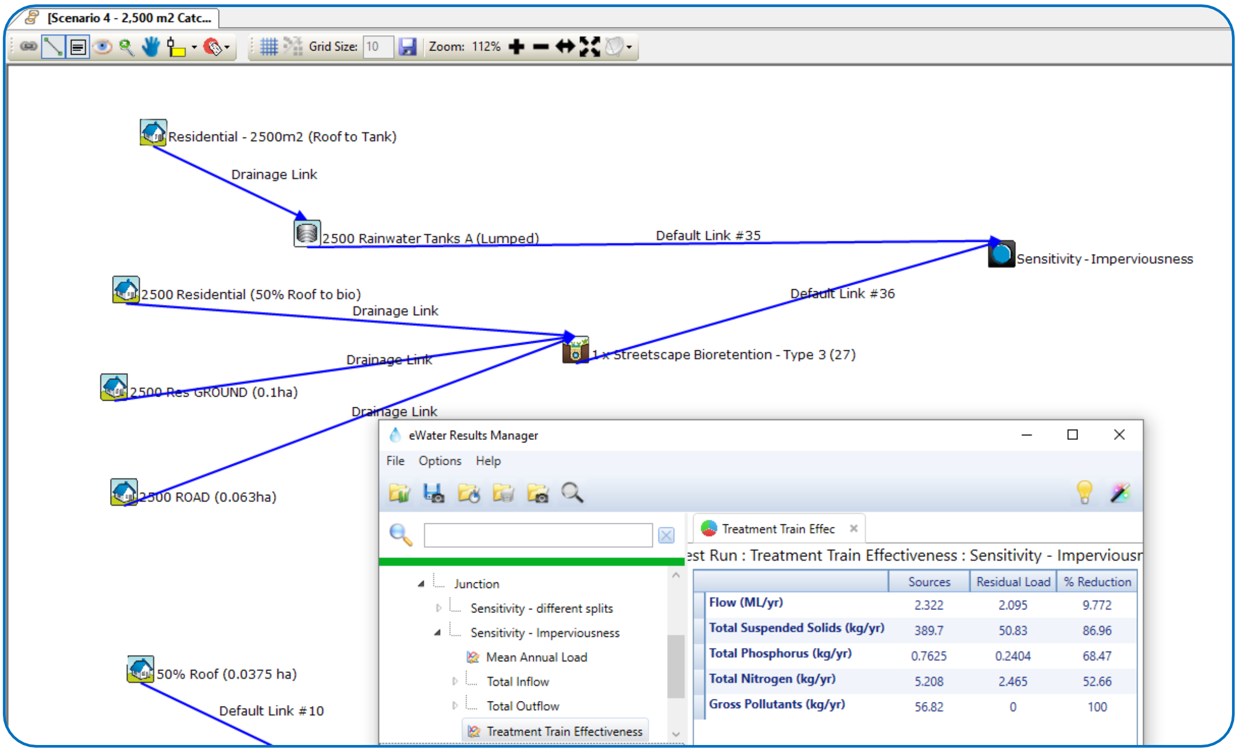
Figure 7.7 Screen Capture (Overall Site)

7.5.4 Modelling Results – Sensitivity Analysis

A sensitivity analysis has been undertaken to determine whether changes in imperviousness and catchment area source node splits would alter the treatment effectiveness of the streetscape bioretention such that the water quality targets in Table H2 of the DCP could not be achieved. In this modelling scenario, the road imperviousness was increased from 60% to 100%, and the ground imperviousness increased from 20% to 50%.

A second sensitivity model was then run with a higher percentage of road catchment. In this scenario the 2,500 m^2 catchment was split based on three lots with a minimum lot size of 450 m^2 and a road area of 1,150 m^2. Roof areas were assumed as 250 m^2 per lot with the remainder of the lot represented as ground area. This equates to a split of 46% road, 30% roof, and 24% ground.

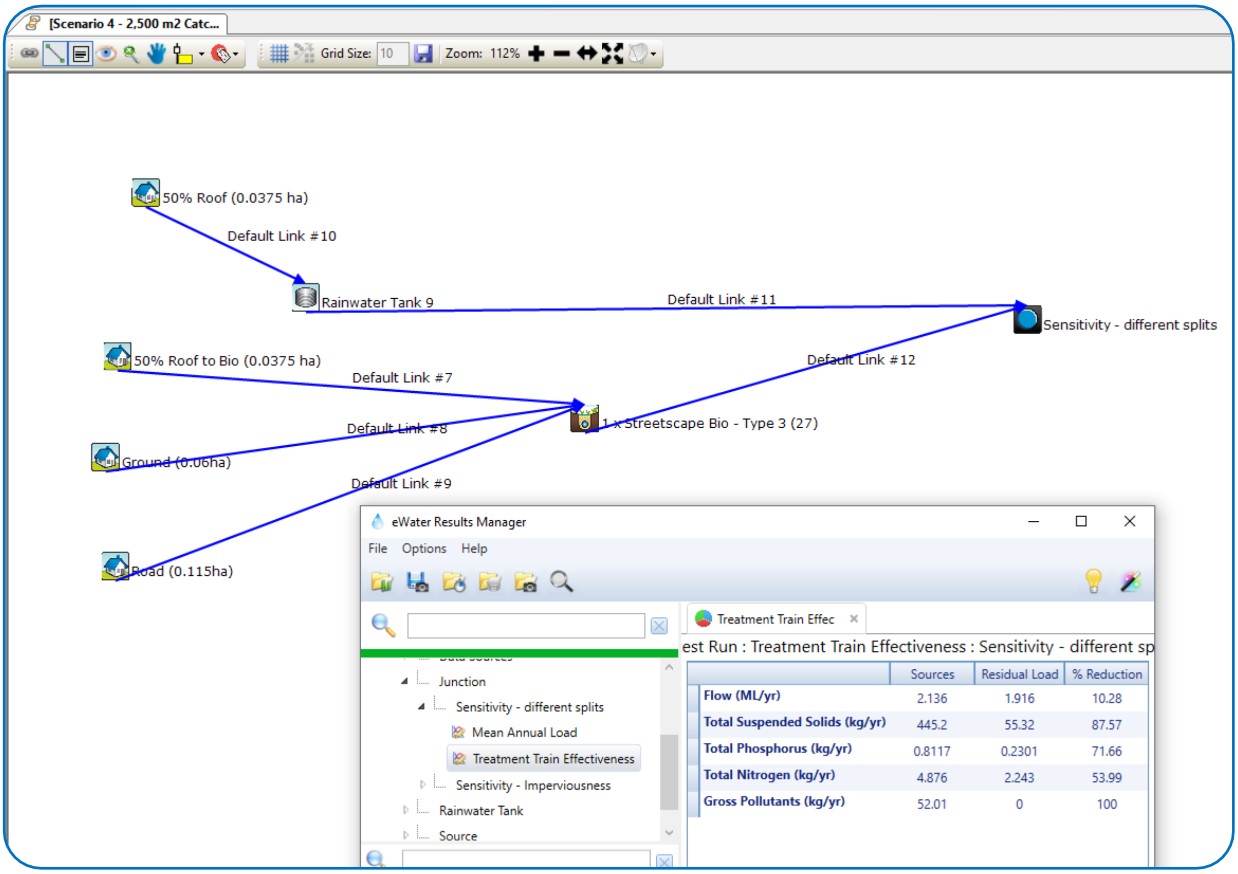
The results of sensitivity modelling indicate that increases in the imperviousness of the road and ground areas will not worsen the treatment train effectiveness of the bioretention systems. Furthermore as demonstrated in the sensitivity model, increasing the road catchment split will improve the treatment effectiveness of the bioretention system. Given MUSIC is based on a percentage load-based reduction, increasing the pollutant load would make each m^2 of bioretention surface more effective. Refer to Figures 7.8 and 7.9 below for screen captures of the sensitivity analysis.



est Run : Treatment Train Effectiveness : Sensitivity - Imperviousn

	Sources	Residual Load	% Reduction
Flow (ML/yr)	2.322	2.095	9.772
Total Suspended Solids (kg/yr)	389.7	50.83	86.96
Total Phosphorus (kg/yr)	0.7625	0.2404	68.47
Total Nitrogen (kg/yr)	5.208	2.465	52.66
Gross Pollutants (kg/yr)	56.82	0	100

Figure 7.8 Screen Capture – Sensitivity (Imperviousness)



est Run : Treatment Train Effectiveness : Sensitivity - different sp

	Sources	Residual Load	% Reduction
Flow (ML/yr)	2.136	1.916	10.28
Total Suspended Solids (kg/yr)	445.2	55.32	87.57
Total Phosphorus (kg/yr)	0.8117	0.2301	71.66
Total Nitrogen (kg/yr)	4.876	2.243	53.99
Gross Pollutants (kg/yr)	52.01	0	100

Figure 7.9 Screen Capture – Sensitivity (Road/Roof/Ground Splits)

7.5.5 Modelling Results – Life Cycle Costing (Streetscape Treatment Measures)

In order to estimate the life cycle costing of the proposed streetscape stormwater treatment measures, Life Cycle Costing modelling was undertaken in MUSICv6. Table 7.15 below summarises the life cycle costing inputs whilst Table 7.16 summarises results of the life cycle costing. It is noted that costings are provided as a generic estimate and have been based on a single streetscape bioretention system. This model does not account for cost savings that may occur as a result from maintaining multiple systems located within close proximity of each other (as discussed in "Guide to the Cost of Maintaining Bioretention Systems" (WaterByDesign, 2015)). For the full Life Cycle Costing Outputs – refer to Appendix F.

Table 7.15 Life Cycle Costing Inputs – 1 x Streetscape Bioretention Basin

Global Properties	
Real Discount Rate (%)	5.5
Annual Inflation Rate (%)	2.0
Base year for costing	2018
Costing Element	**1 x Streetscape Bioretention (27 m^2)**
Acquisition Cost ($)	$8,000
Annual Maintenance Cost ($)	$500
Annual Establishment Cost ($)	$750
Establishment Period (yrs)	1
Renewal/adaptation cost ($)	$5,150
Renewal/adaption period (yrs)	25
Decommissioning cost ($)	$4,120

Table 7.16 Life Cycle Costing Results – 1 x Streetscape Bioretention Basin

Costing Element	Costing Result
Life Cycle Cost of Streetscape Bioretention ($)	$19,119
Equivalent Annual Payment Cost of the Asset ($/yr)	$382.5

8 Water Quality Monitoring and Maintenance

In order to ensure that the stormwater management measures detailed within this management plan function correctly in the long term and to ensure that impacts to downstream receiving environments are mitigated, appropriate operational phase water maintenance and monitoring is to be undertaken. The following sections detail the minimum requirements for each specific control device.

8.1 Operational Phase Water Quality Monitoring

Monitoring during the operational phase will be undertaken to determine the impact of activities on the receiving waters. Surface water quality monitoring is to be undertaken at discharge points from the site. Samples should be collected for TSS, pH, dissolved oxygen (DO), TP, TN and hydrocarbons. Sampling is to be performed in accordance with procedures set out in the Environmental Protection Authority's Water Quality Sampling Manual. A NATA registered laboratory is to be used to analyse the collected samples.

Table 8.1 specifies the sampling parameters and frequencies required. Results of the monitoring program are to be compiled monthly into an ongoing Water Quality Monitoring Report. A copy of the report and monitoring data is to be maintained at all times.

Table 8.1 Operational Phase Water Quality Parameters and Sampling Frequencies

Sampling Parameter	Sampling Frequency
TSS	Water quality monitoring will be completed following a rainfall event of 25 mm or greater in any 24 hour period monthly for a minimum period of 12 months, or as specified by the Local Authority conditions of approval for the development.
pH	
Dissolved Oxygen (DO)	
TN	
TP	
Hydrocarbons	

Table 8.2 sets the water quality criteria for water discharged from the development site.

Table 8.2 Operational Phase Water Quality Discharge Criteria

Water Quality Parameter	Discharge Criteria
TSS	No net deterioration of the downstream receiving environment as a result of discharge from the development.
Turbidity (NTU)	
pH	
DO	
TN	
TP	
Hydrocarbons	

8.2 Operational Phase Device Maintenance

In order for each of the proposed stormwater treatment devices to achieve the necessary pollutant removal efficiencies regular maintenance is necessary. Poorly maintained devices will result in under performance and in some instances may cause leaching of pollutants to downstream receiving environments. Based on the proposed treatment train Table 8.3 details appropriate maintenance regimes for each treatment device. A typical Maintenance Checklist has been included as Appendix G.

Table 8.3 Operational Phase Device Maintenance Requirements

Treatment Device	Maintenance Action
Grassed Swales	Routine inspection to identify obvious increased sediment deposition. Remove sediment when flow within the swale is impeded or smothering of vegetation occurs. If necessary reprofile swale and revegetate.
	Regular watering of vegetation until plants are established.
	Mowing of grass or slashing of vegetation to preserve the optimal design height.
	Removal and management of invasive weeds.
	Removal and replacement of dead and dying vegetation.
	Regular inspection and removal of litter and gross pollutants.
Bioretention	Routine inspection to identify obvious increased sediment deposition. Remove sediment when flow within the bioretention is impeded or smothering of vegetation occurs.
	Routine inspection of inlet and outlet pit to identify any areas of scour, litter build up or blockages.
	Tilling of the bioretention surface if there is evidence of clogging.
	Regular watering of vegetation until plants are established.
	Removal and management of invasive weeds.
	Removal and replacement of dead and dying vegetation.
	Regular inspection and removal of litter and gross pollutants.
	Resetting (i.e. complete reconstruction) of the bioretention will be required if the flow within the bioretention system is reduced by 25% due to an accumulation of sediment.
Detention Basins	Routine inspection to identify obvious increased sediment deposition. Remove sediment if there is any sign of smothering of vegetation. If necessary reprofile base and revegetate.
	Routine inspection of inlet and outlet structures to identify any areas of scour, litter build up or blockages.
	Regular watering of vegetation until plants are established.
	Removal and management of invasive weeds.
	Removal and replacement of dead and dying vegetation.
	Regular inspection and removal of litter and gross pollutants.

All material removed during maintenance, whether solid or liquid, is to be disposed of in a manner that does not cause ongoing soil erosion or environmental harm.

9 Conclusions

The report has been prepared on behalf of Kahuna No.1 Pty Ltd and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase of the development. Additionally, this report also includes a hydraulic impact assessment (velocities and peak depths) to ensure the development does not impose any hydraulic impacts upon the western downstream drainage network (relevant to Lot 46) as requested by Clarence Valley Council.

In order to address the management of stormwater quantity during the operational phase of the development, two (2) formal stormwater detention basins have been proposed. These basins include purpose-built outlet structures and detention volumes to control discharge from the site. In addition to the basins, detention storage will also be provided within the drainage swale along the northern boundary of the site adjacent to Miles Street. Modelling of the proposed detention measures and their associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A, PD-B and PD-C. It is estimated that a total detention volume of 20,420 m^3 (for the 1% AEP) is required and has been provided to mitigate peak flows from the site.

TUFLOW modelling of the downstream discharge locations of Lot 46 has demonstrated that the proposed development will not adversely affect neighbouring properties or materially change the hydraulic impacts on the downstream drainage structures of Carrs Drive. It is noted the impacts associated with the eastern floodway (Lot 47) and general filling of the West Yamba development area has previously been investigated as part of the Hydraulic Impact Assessment undertaken by BMT. As such this report will not cover these items.

In order to address the management of stormwater quality for Stages 1-10 of the development, numerous streetscape bioretention systems (pods) have been proposed for incorporation within the road reserve areas of the development. This design concept will promote at source treatment of runoff from the road network.

Rainwater tanks have been included for the beneficial reuse of stormwater and are to be connected to the roof catchment area within each allotment. Overflows are to be directed to the dedicated inter allotment pipe network contained with a 3 m drainage easement.

MUSIC v6 modelling indicates that the inclusion of bioretention pods and rainwater tanks within each allotment will achieve the required pollutant removal efficiencies of 85%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively. These results demonstrate that the Default Water Quality Targets include in Table H2 of the Clarence Valley Council DCP can be achieved.

10 RPEQ Certification

I am aware that Council may rely upon the contents and findings of this assessment for the purposes of development assessment. In my opinion, the Council can rely upon the information contained within the report and there are no reservations or qualifications in respect to the information other than set out in the report.

I confirm that if the design parameters set out in this report are included within the development:

- there should be no worsening in peak discharge, as a result of the proposed development that would result in actionable damage to downstream properties; and
- stormwater pollutant load reductions in accordance with best practice should be achieved.

06-06-23

....

Brad Comley **RPEQ 17706** **DATE**

11 References

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Appendix A

Stormwater Management Drawings

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DATE: 06.06.23
PROJECT No. : BC-18008
DRAWING No. : DWG 100
REVISION No. : D

CONCEPTUAL STORMWATER MANAGEMENT DESIGN DRAWINGS

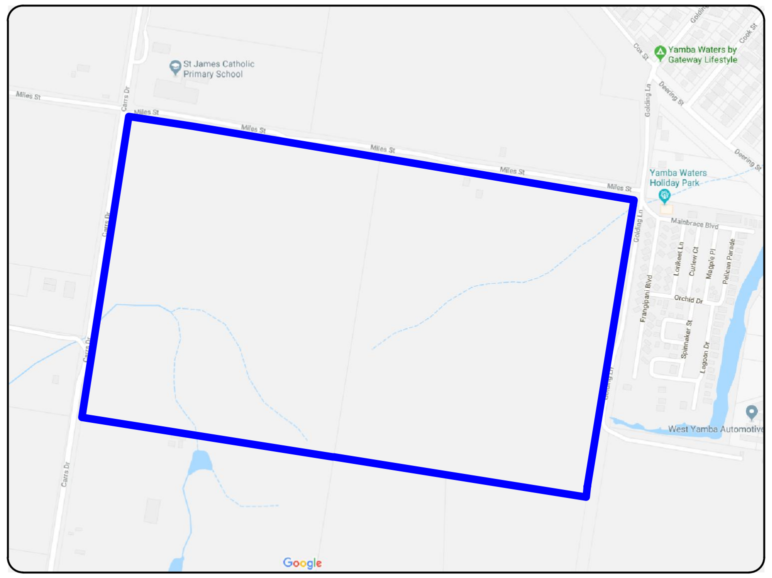
Yamba Gardens - Stage 1-10
Lot 46 & 47 on DP751395
52-54 Miles Street, Yamba

for

Kahuna No.1 Pty Ltd

Project No: BC-18008

June 2023



Site Location

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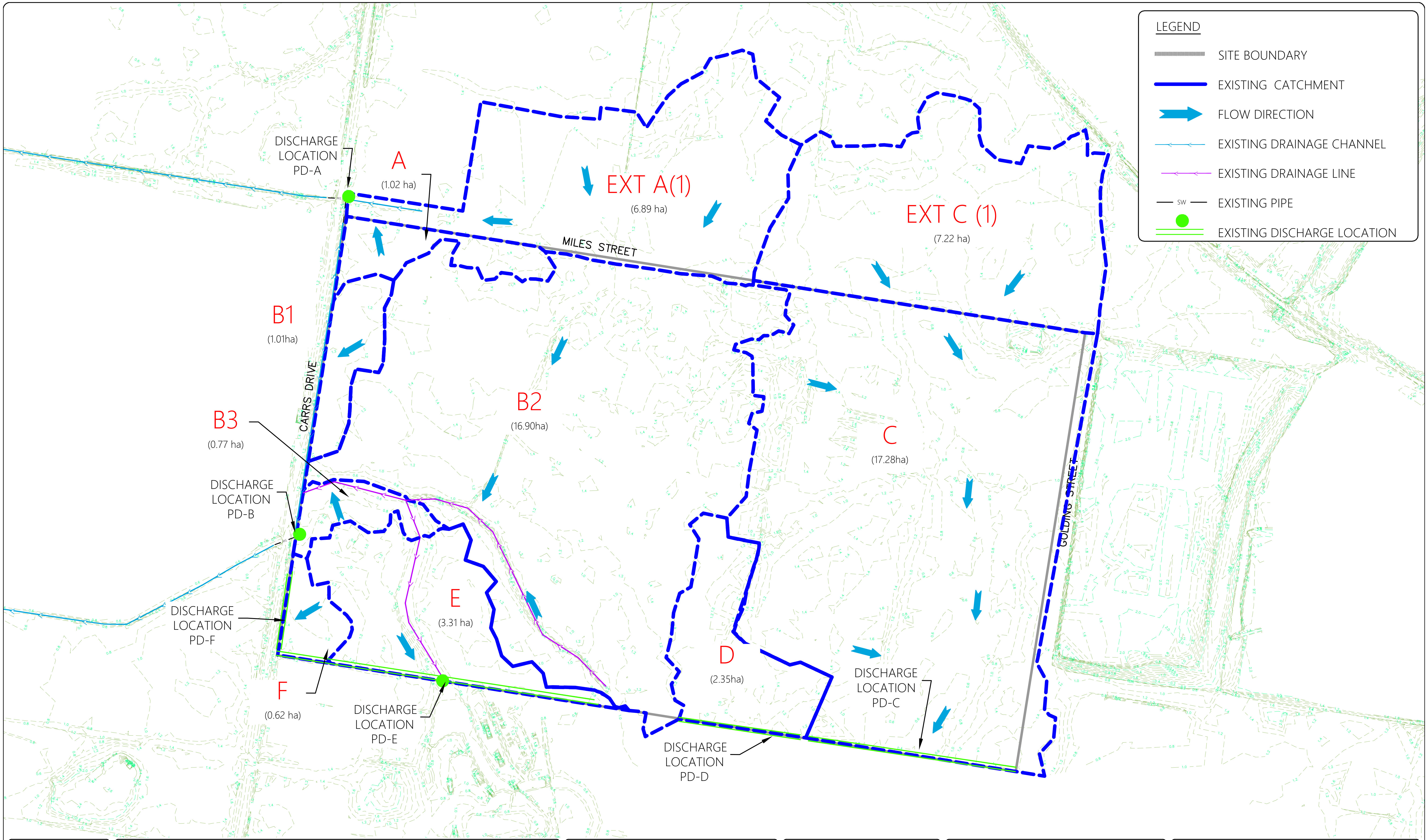
ABN 86 166 087 476

SCHEDULE OF DRAWINGS

Drawing No.	Drawing Title
DWG-100	LOCALITY AND DRAWING INDEX PLAN
DWG-200	EXISTING CATCHMNET PLAN
DWG-201	DEVELOPED CATCHMNET PLAN
DWG-210	MUSIC CATCHMENT PLAN - TYPICAL 2,500 M² CATCHMENT
DWG-300	OPERATIONAL CONTROL PLAN
DWG-310	BIO-POD LAYOUT PLAN - TYPICAL
DWG-311	DETENTION BASIN B LAYOUT PLAN & TYPICAL SECTION
DWG-312	DETENTION BASIN C LAYOUT PLAN & TYPICAL SECTION
DWG-320	BIO-POD SECTION DETAILS
DWG-321	RAINWATER TANKS & BIO-PODS - TYPICAL LAYOUT & SECTIONS
DWG-330	BIO-POD – FILTER MEDIUM & UNDERDRAINAGE DETAILS - SHEET 1
DWG-331	BIO-POD – FILTER MEDIUM & UNDERDRAINAGE DETAILS - SHEET 2
DWG-350	BIORETENTION STANDARD NOTES



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PROJECT No. :
BC-18008

DRAWING No. :
DWG-200

REVISION No. :
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PROJECT
YAMBA GARDENS - STAGES 1-10

DRAWING TITLE
EXISTING CATCHMENT PLAN

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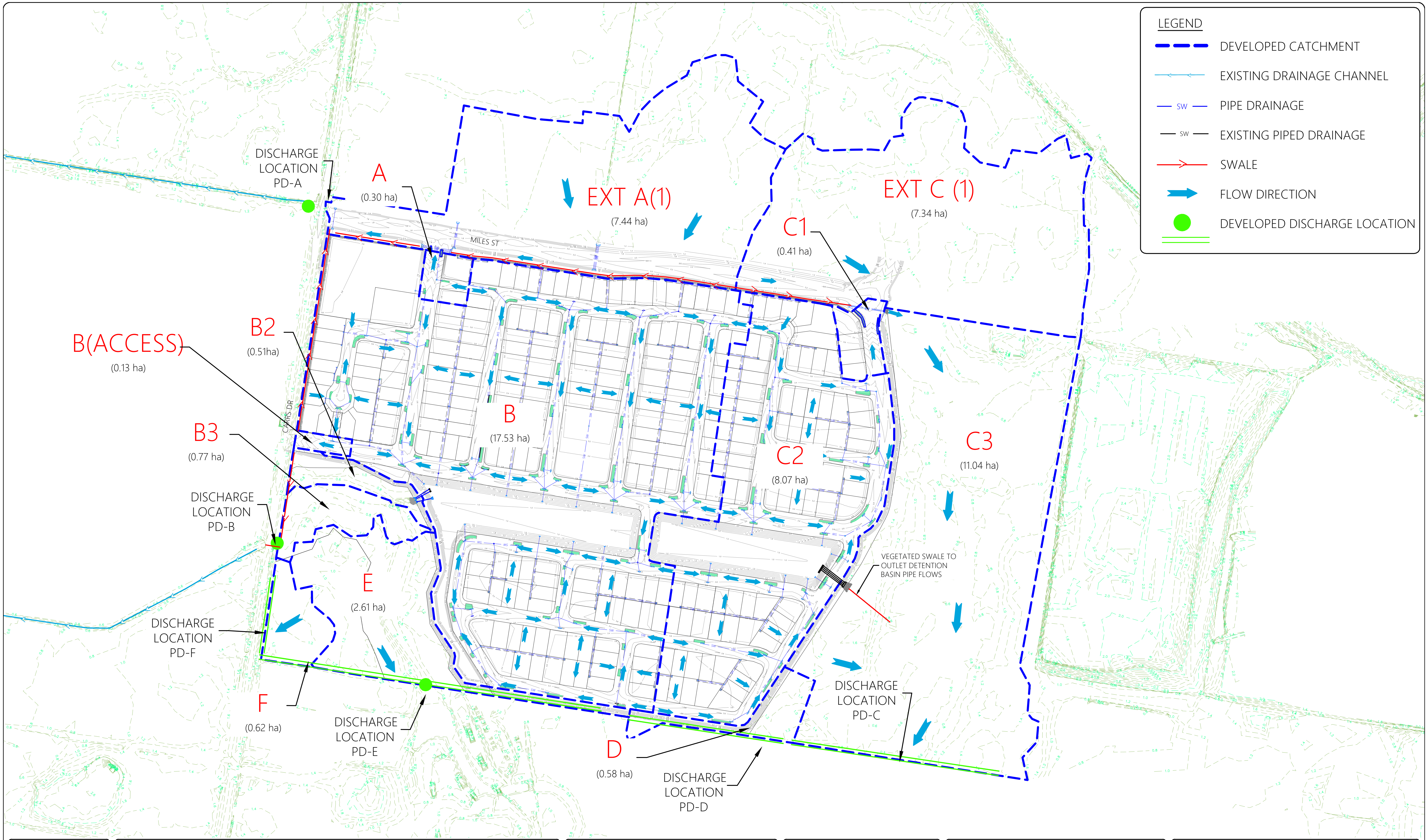

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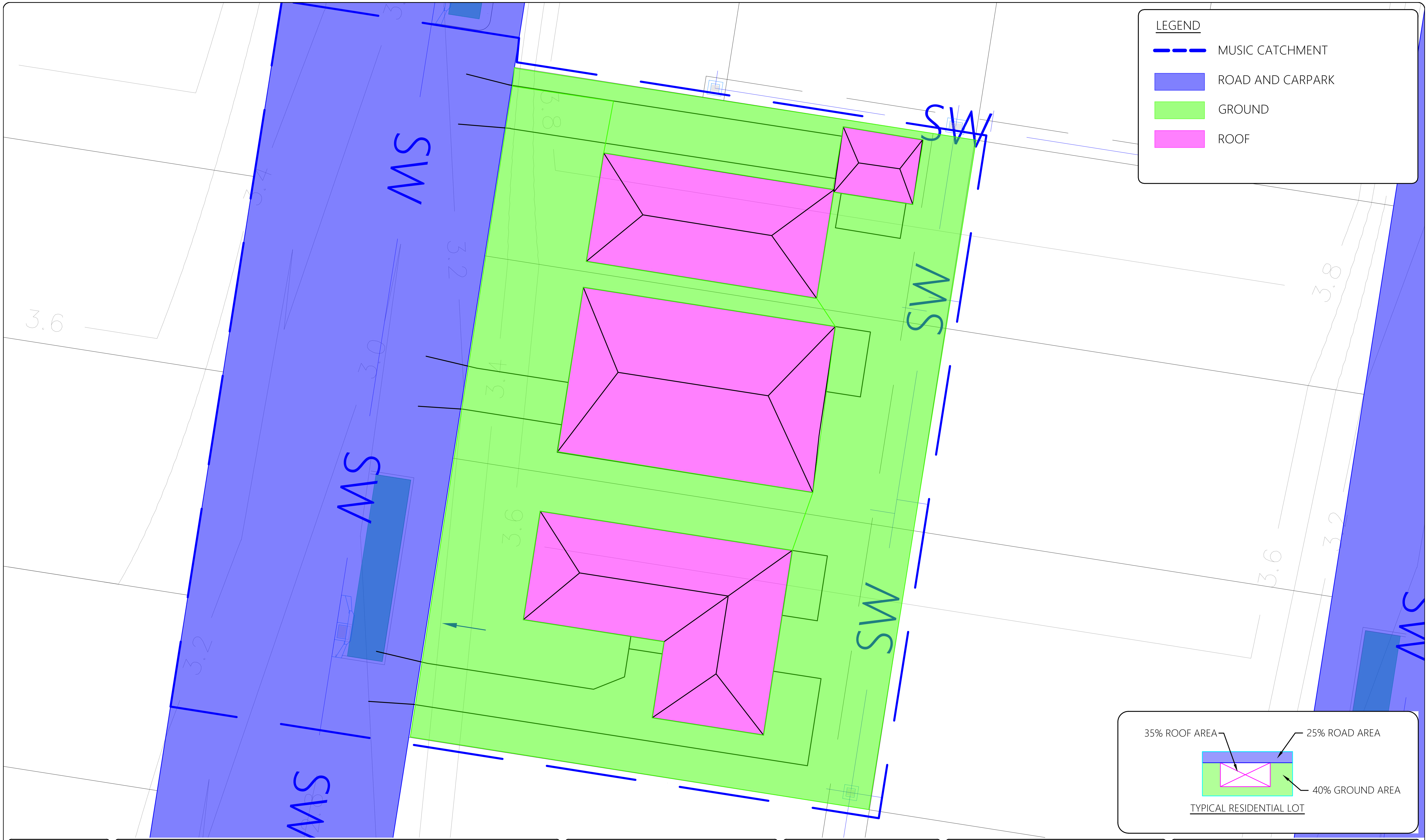

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PROJECT
YAMBA GARDENS - STAGES 1-10

DRAWING TITLE
MUSIC CATCHMENT PLAN (TYPICAL 2,500 M2)

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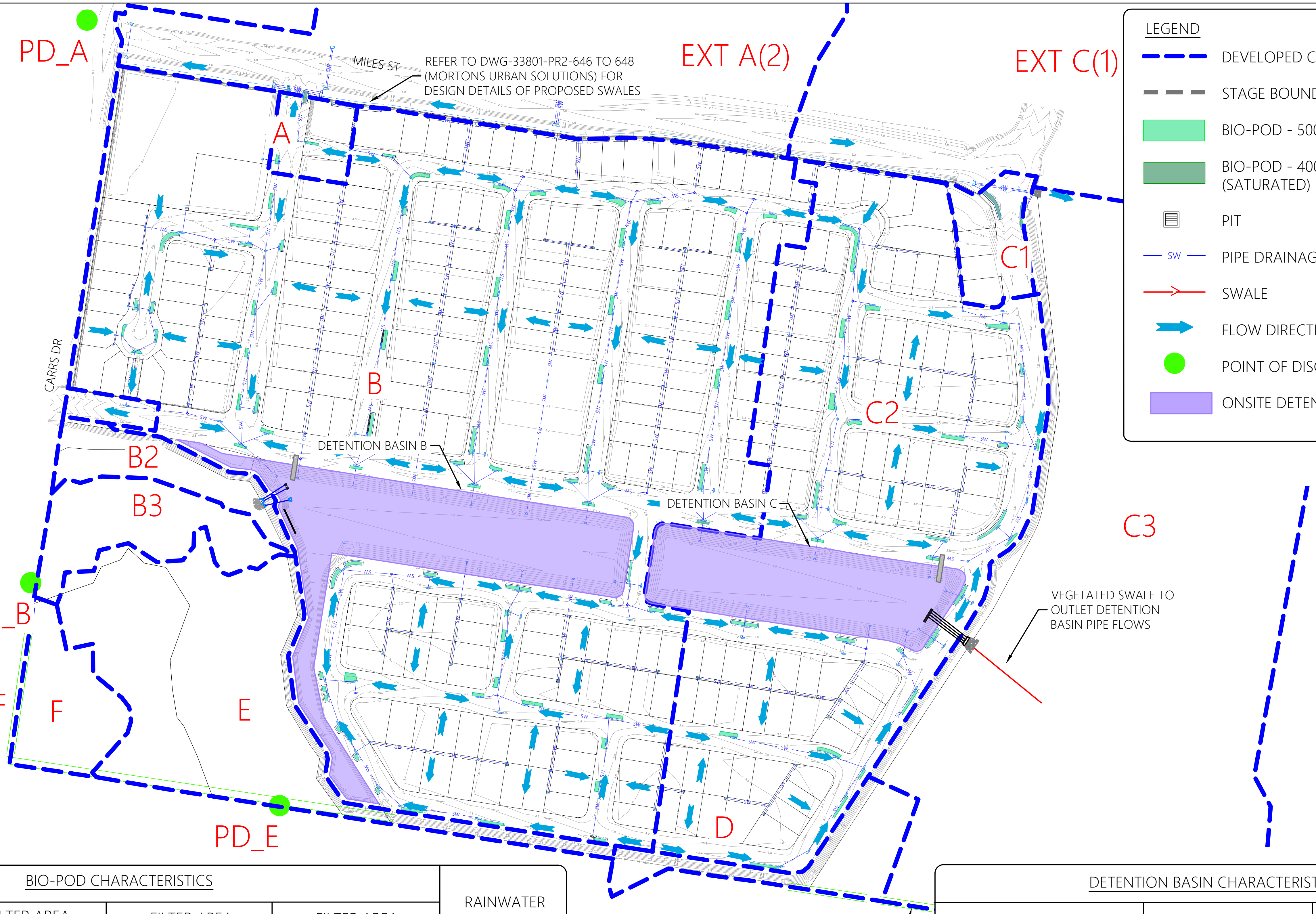

LEGEND

▬ ▬	DEVELOPED CATCHMENT
▬ ▬	STAGE BOUNDARY
🟩	BIO-POD - 500 mm FILTER
🟩	BIO-POD - 400 mm FILTER (SATURATED)
▤	PIT
— SW —	PIPE DRAINAGE
→	SWALE
➡	FLOW DIRECTION
●	POINT OF DISCHARGE
🟪	ONSITE DETENTION BASIN

BIO-POD CHARACTERISTICS

TREATMENT CATCHMENT	FILTER AREA HAT CONSTRAINED (400mm FILTER DEPTH)	FILTER AREA STANDARD (500mm FILTER DEPTH)	FILTER AREA INVERT CONSTRAINED (400mm FILTER DEPTH)	RAINWATER TANKS
2,500 m^2 CATCHMENT (m^2)	25	27	54	3kL/DETACHED DWELLING

DETENTION BASIN CHARACTERISTICS

MEASURE ID	BASIN B	BASIN C
1% AEP DETENTION VOL. (m^3)	11,200	9,186
1% AEP DETENION DEPTH (m)	1.22	1.26

DATE
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PROJECT No. :
BC-18008

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DWG-300

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PROJECT
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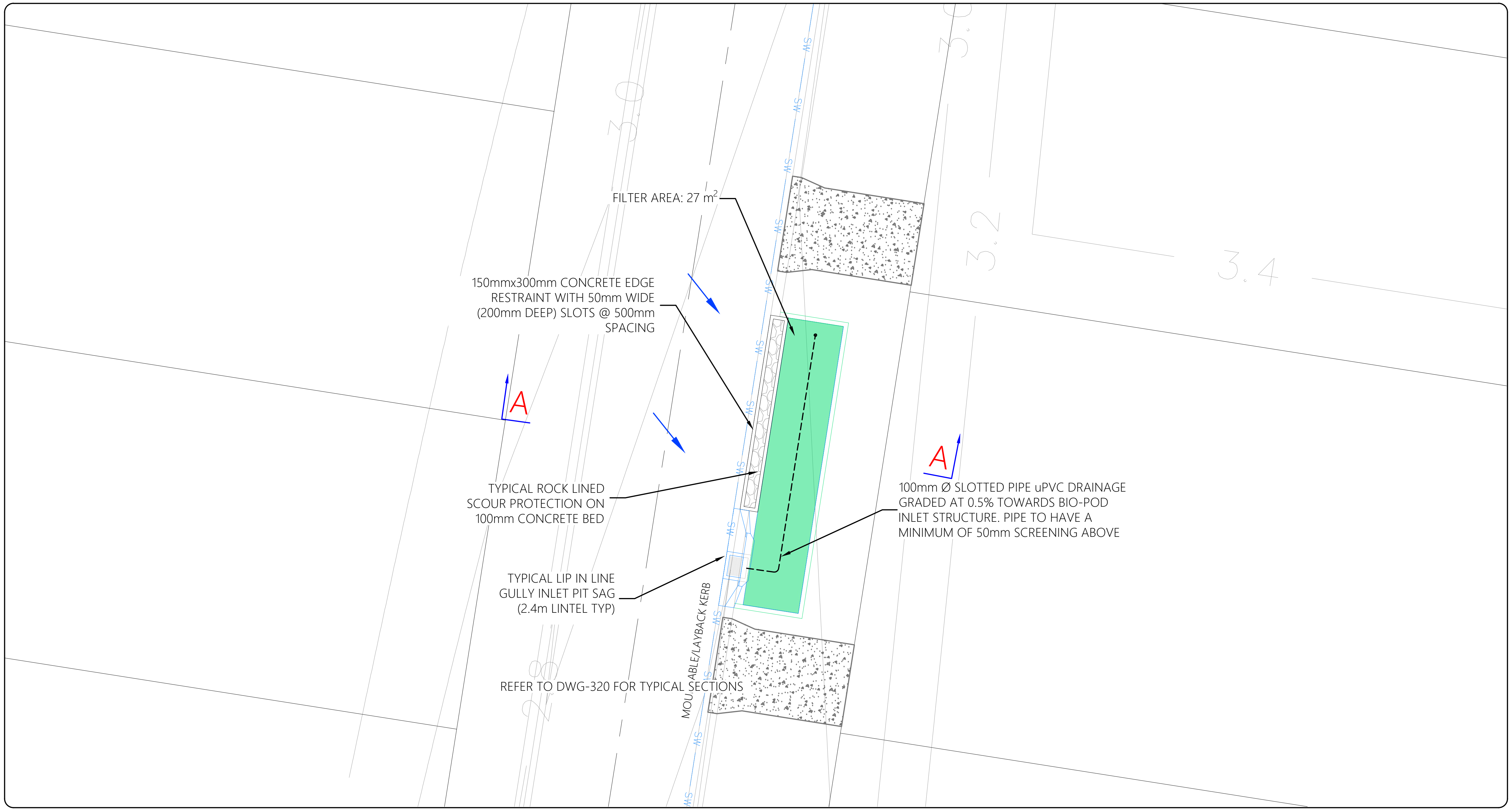

BIO-POD PLAN (TYPICAL)

2 0 2 4 6 8 10

1 : 200 (FULL SIZE) (metres)

NOTE: FOR FURTHER DETAILS REFER TO MORTONS URBAN SOLUTIONS DRAWINGS:
- 33801-PR2-660-A 'STORMWATER TYPICAL BIO-POD PLAN SHEET 01';
- 33801-PR2-661-A 'STORMWATER TYPICAL BIO-POD PLAN SHEET 02';
- 33801-PR2-663-A 'STORMWATER TYPICAL BIO-POD TYPICAL DETAILS'; &
- 33801-PR2-660-A 'CONCEPT BIO-POD END OF LINE TREATMENT'.

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BC-18008

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PROJECT
YAMBA GARDENS - STAGES 1-10

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BIO-POD LAYOUT PLAN (TYPICAL)

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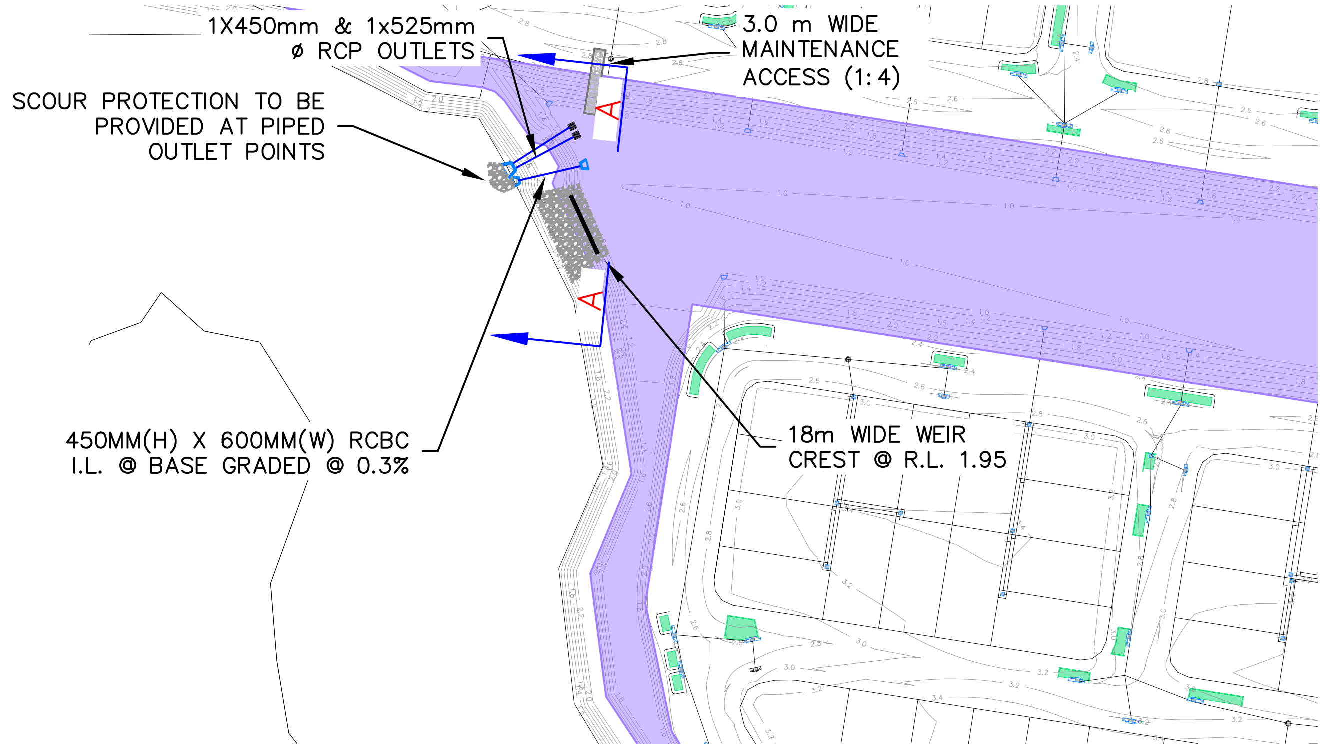
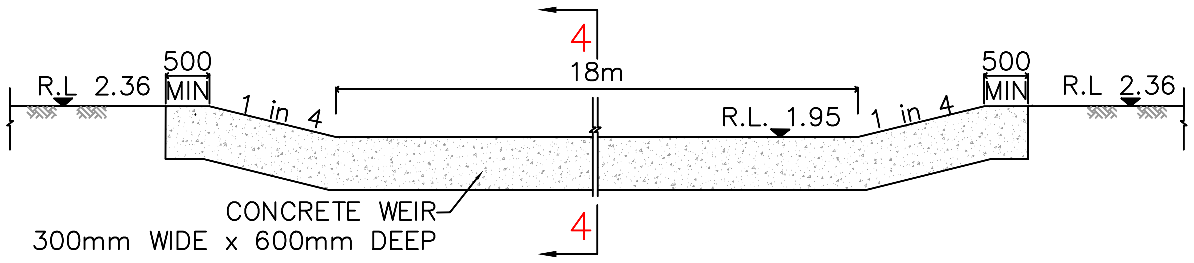
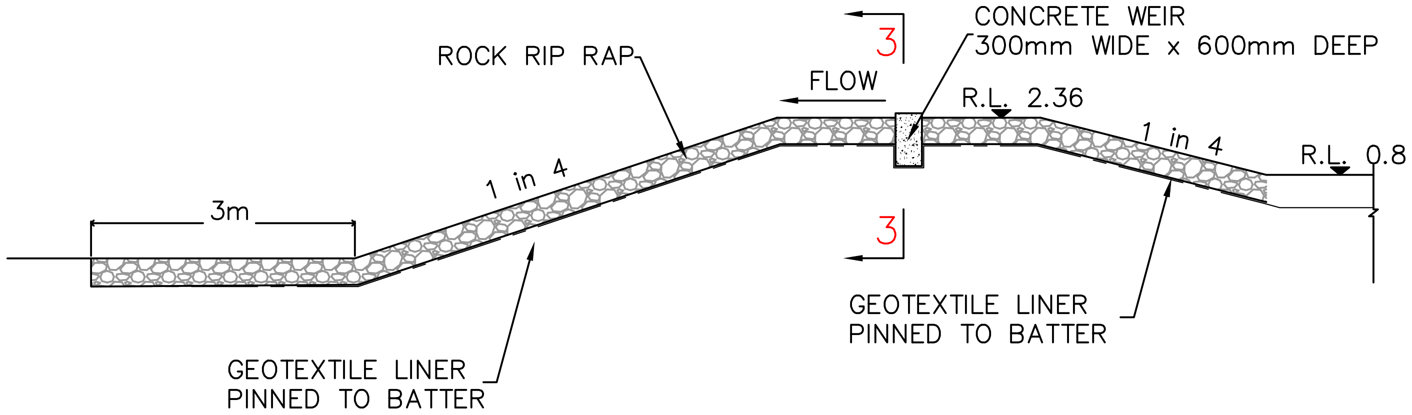


DETENTION BASIN B PLAN VIEW

20 0 20 40 60 80 100
1 : 2000 (FULL SIZE) (metres)

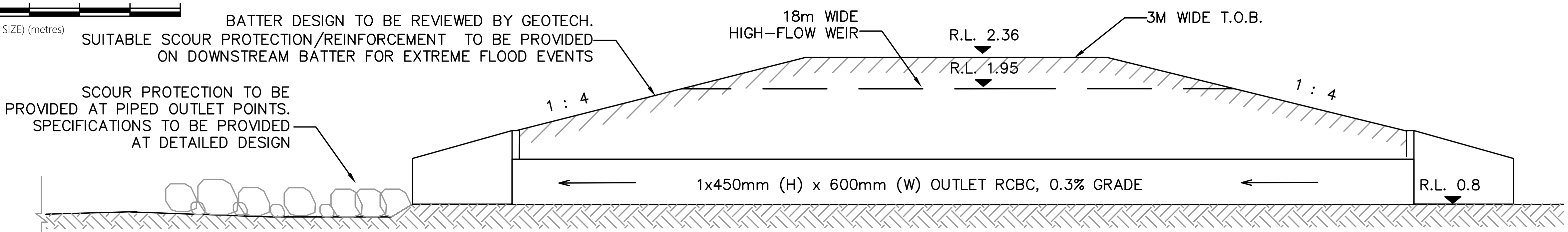


WEIR DETAIL – SECTION 3 – 3



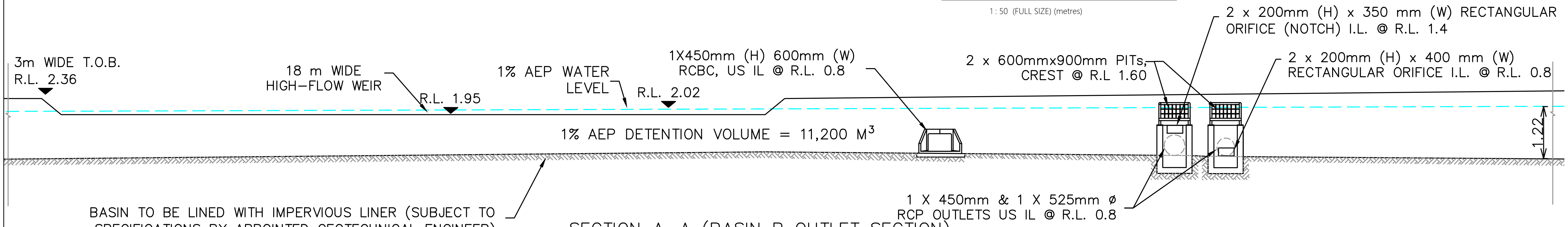
WEIR DETAIL – SECTION 4 – 4

NOTE: REFER TO MORTONS URBAN SOLUTIONS DRAWINGS 33801-PR2-666-A & 33801-PR2-667-A FOR LONG SECTIONS OF THE PROPOSED DETENTION BASIN



TYPICAL DETENTION HEADWALL OUTLET

0.5 0 0.5 1.0 1.5 2.0 2.5
1 : 50 (FULL SIZE) (metres)



SECTION A–A (BASIN B OUTLET SECTION)

1 0 1 2 3 4 5
1 : 100 (FULL SIZE) (metres)

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PROJECT
YAMBA GARDENS - STAGES 1-10
DRAWING TITLE
DETENTION BASIN B TYPICAL DETAILS
CLIENT
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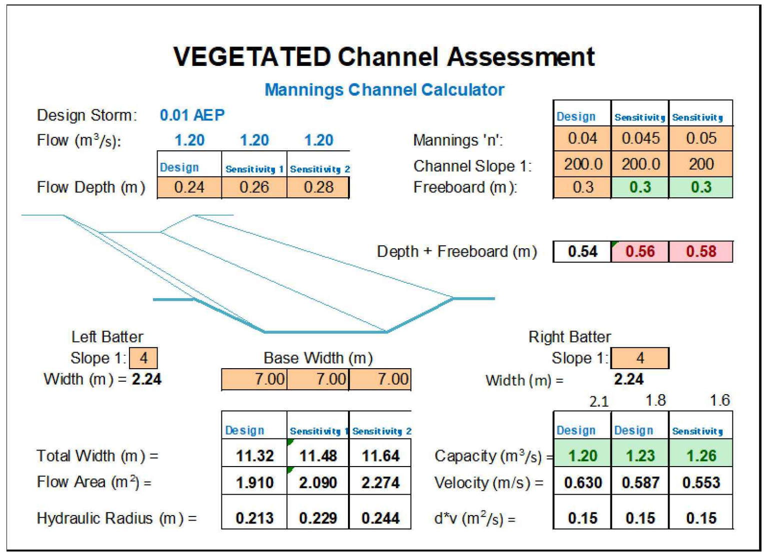
NOTE: REFER TO MORTONS URBAN SOLUTIONS DRAWINGS 33801-PR2-668-A & 33801-PR2-669-A FOR LONG SECTIONS OF THE PROPOSED DETENTION BASIN

DETENTION BASIN C PLAN VIEW

15 0 15 30 45 60 75

1 : 1500 (FULL SIZE) (metres)



VEGETATED Channel Assessment

Mannings Channel Calculator

Design Storm: 0.01 AEP

Flow (m³/s):	1.20	1.20	1.20
	Design	Sensitivity 1	Sensitivity 2
Flow Depth (m)	0.24	0.26	0.28

	Design	Sensitivity	Sensitivity
Mannings 'n':	0.04	0.045	0.05
Channel Slope 1:	200.0	200.0	200
Freeboard (m):	0.3	0.3	0.3
Depth + Freeboard (m)	0.54	0.56	0.58

Left Batter
Slope 1: 4
Width (m) = 2.24

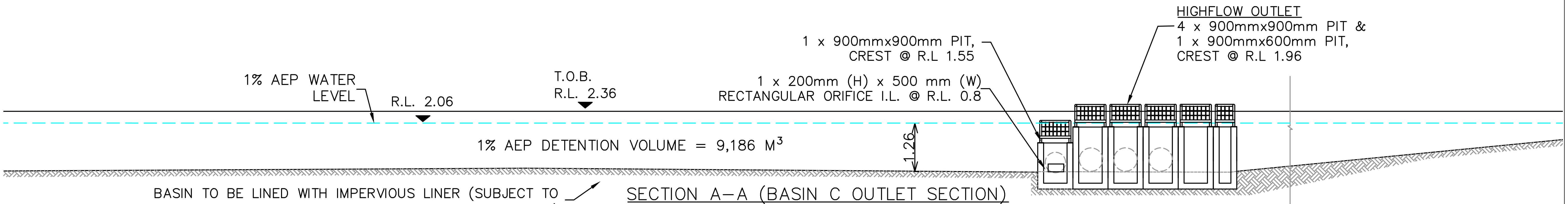
Base Width (m): 7.00 7.00 7.00

Right Batter
Slope 1: 4
Width (m) = 2.24

	Design	Sensitivity 1	Sensitivity 2
Total Width (m) =	11.32	11.48	11.64
Flow Area (m²) =	1.910	2.090	2.274
Hydraulic Radius (m) =	0.213	0.229	0.244

	2.1	1.8	1.6
	Design	Design	Sensitivity
Capacity (m³/s) =	1.20	1.23	1.26
Velocity (m/s) =	0.630	0.587	0.553
d*v (m²/s) =	0.15	0.15	0.15

BASIN C OUTLET SWALE DESIGN



SECTION A–A (BASIN C OUTLET SECTION)

1 0 1 2 3 4 5

1 : 100 (FULL SIZE) (metres)

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PROJECT
YAMBA GARDENS - STAGES 1-10

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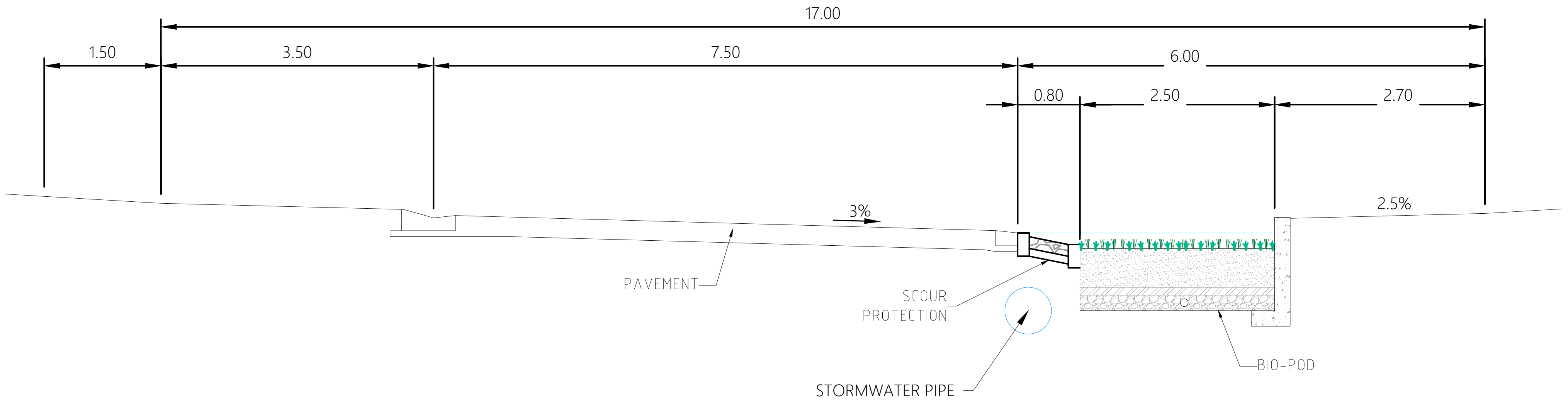

SECTION A - A

1 0.5 0 0.5 1 1.5 2 2.5 3 3.5 4

1 : 75 (FULL SIZE) (metres)

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REVISION No. :
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PROJECT
YAMBA GARDENS - STAGES 1-10
DRAWING TITLE
BIO-POD - SECTION DETAILS - SHEET 1
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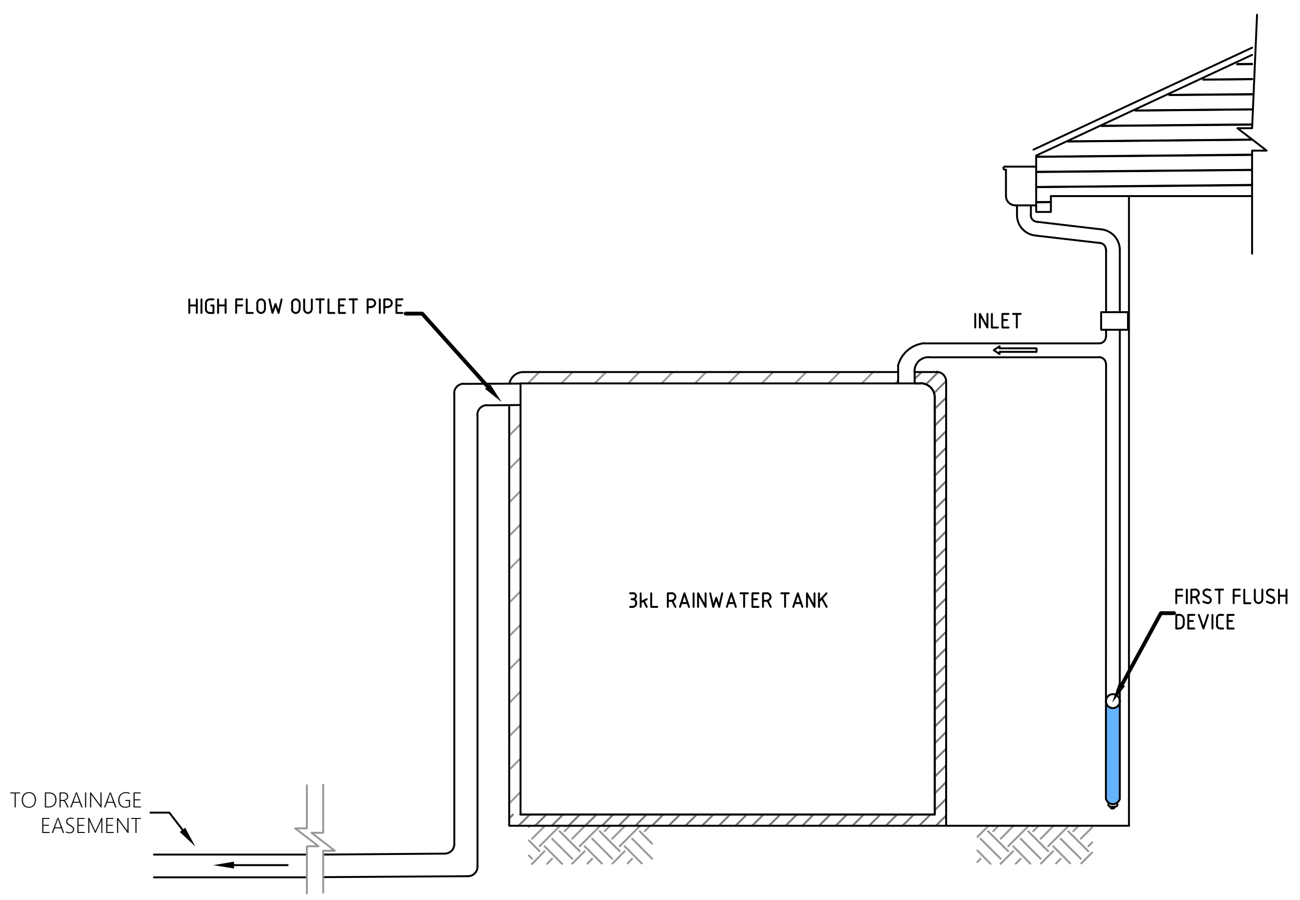
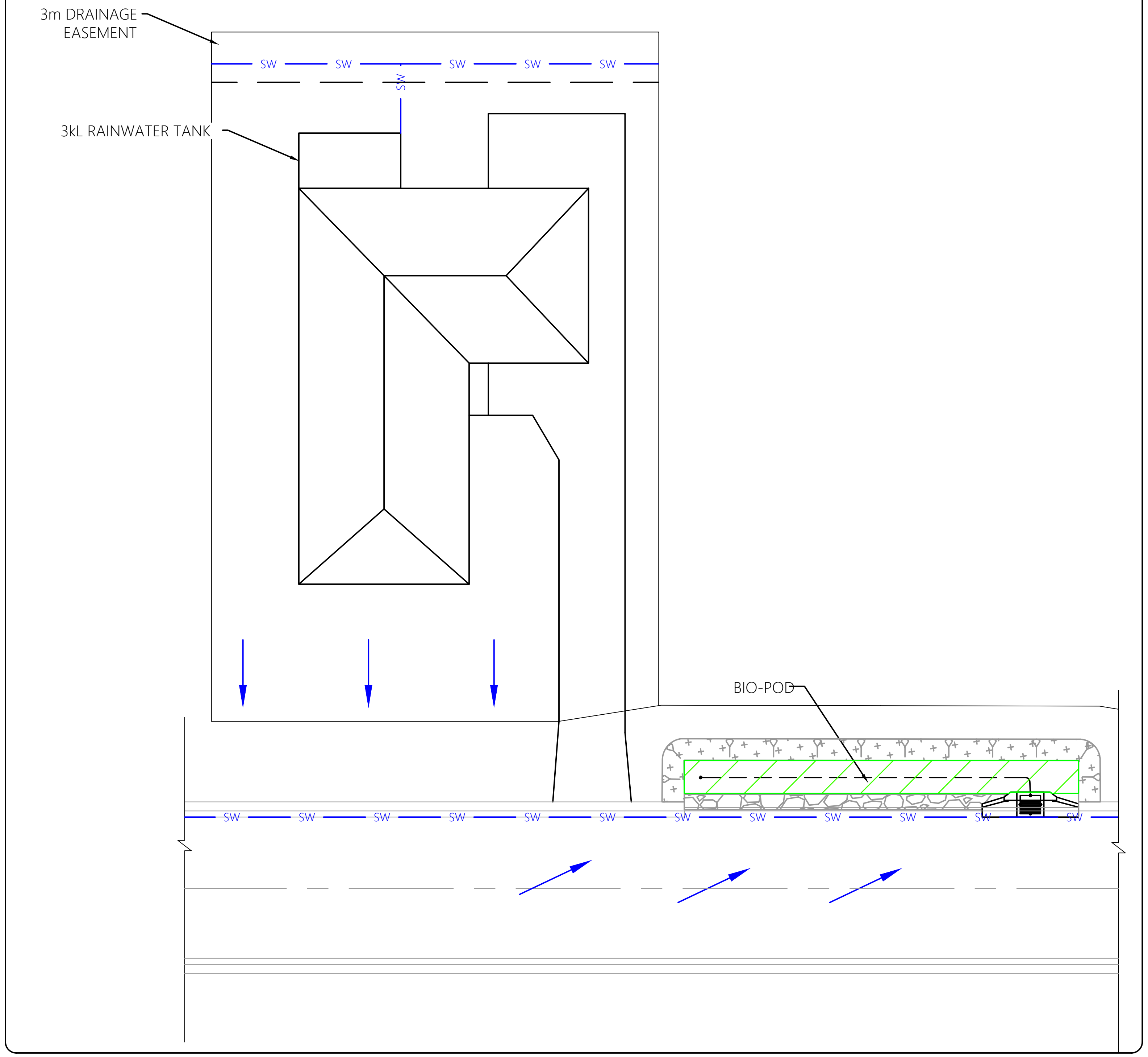


RAINWATER TANK SECTION (TYPICAL)

N.T.S



STORMWATER TREATMENT TRAIN - RAINWATER TANKS WITH BIO-PODS (TYPICAL LAYOUT)

N.T.S

DATE
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PROJECT No. :
BC-18008

DRAWING No. :
DWG-321

REVISION No. :
D

PROJECT
YAMBA GARDENS - STAGES 1-10

DRAWING TITLE
RAINWATER TANKS & BIO-PODS – TYPICAL LAYOUT & SECTIONS

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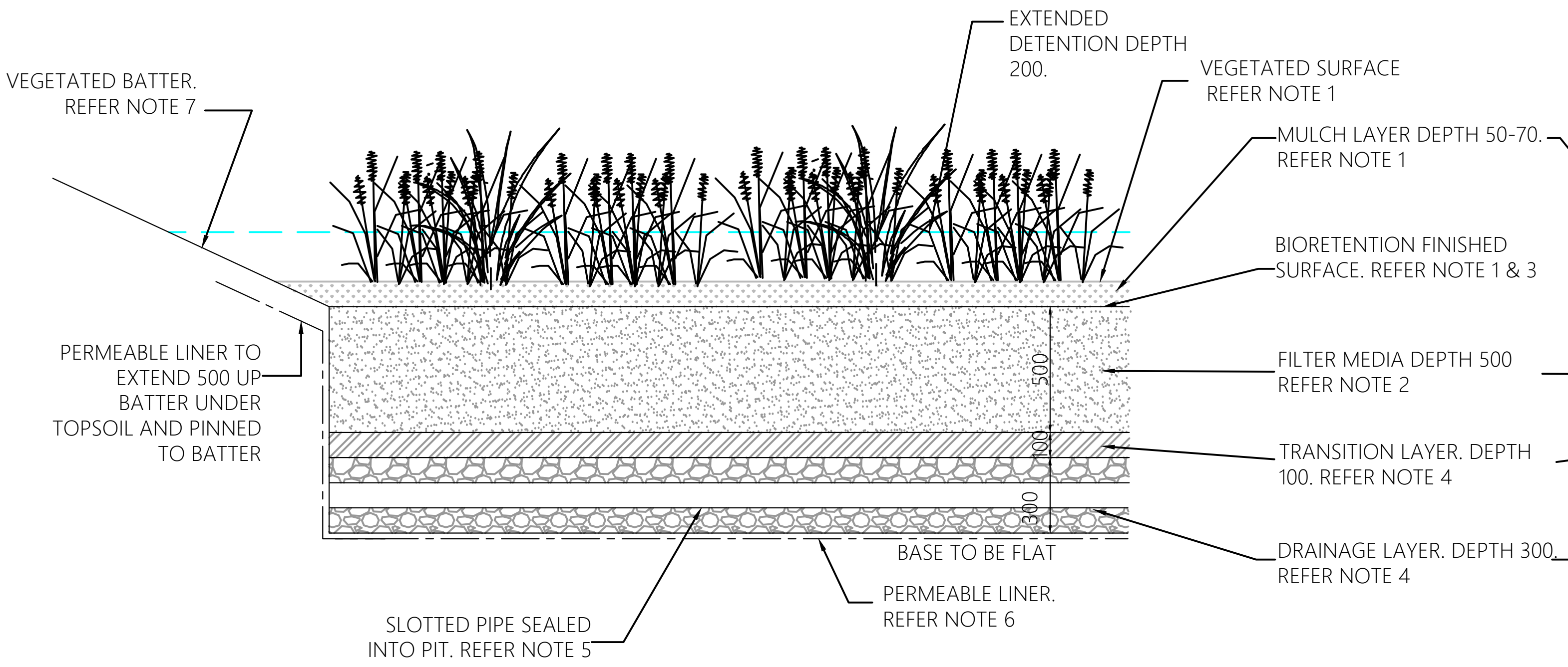
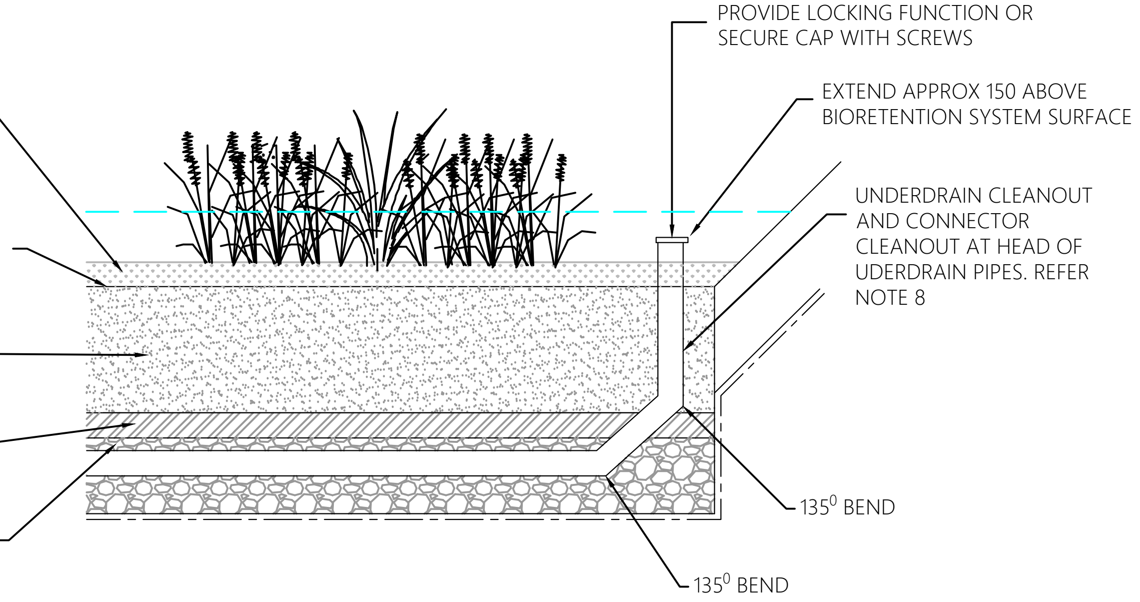


BIORETENTION MEDIA (TYPE 3-CONVENTIONAL) CROSS SECTION

N.T.S



BIORETENTION BASIN SUBSOIL DRAIN CLEANOUT (TYPE 3-CONVENTIONAL)

N.T.S

NOTES (IN ACCORDANCE WITH IPWEAQ STANDARD DRAWINGS DS-070 AND DS-073):

1. BIORETENTION SYSTEM SURFACE. SURFACE LEVEL IS TOP OF FILTER MEDIA. SURFACE TO BE MULCHED AND PLANTED AS PER THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN).
2. FILTER MEDIA SPECIFICATION SHALL BE IN ACCORDANCE WITH THE 'ADOPTION GUIDELINES FOR STORMWATER BIOFILTRATION SYSTEMS (CRC FOR WATER SENSITIVE CITIES) AND THE BIORETENTION TECHNICAL DESIGN GUIDELINES (WATER BY DESIGN). BIORETENTION HYDRAULIC CONDUCTIVITY SHALL BE IN ACCORDANCE WITH PRACTICE NOTE 1: IN SITU MEASUREMENT OF HYDRAULIC CONDUCTIVITY' (FAWB). THE NUMBER OF SAMPLES TO BE TESTED SHALL BE IN ACCORDANCE WITH THE 'CONSTRUCTION AND ESTABLISHMENT GUIDELINES - SWALES, BIORETENTION SYSTEMS AND WETLANDS' (WATER BY DESIGN).
3. CONSTRUCTION TOLERANCES SHALL BE IN ACCORDANCE WITH THE 'CONSTRUCTION AND ESTABLISHMENT GUIDELINES -SWALES, BIORETENTION SYSTEMS AND WETLANDS' (WATER BY DESIGN)
4. TRANSITION LAYER AND DRAINAGE LAYER. DEPTHS AND SPECIFICATION TO BE IN ACCORDANCE WITH THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN)
5. UNDERDRAIN. SLOTTED RIGID PIPE LAID FLAT. PIPE SHOULD NOT BE INSTALLED WITH A FILTER SOCK SURROUNDING PIPE. UNDERDRAIN PIPES SHALL BE SEALED INTO PITS USING GROUT OR OTHER APPROVED WATERTIGHT SEAL.
6. PERMEABLE LINER. NON-WOVEN GEOTEXTILE FILTER CLOTH TO BASE AND SIDES OF BIORETENTION SYSTEM. FILTER CLOTH NOT TO BE PLACED BETWEEN ANY FILTER LAYERS. PERMEABLE LINER AS PER "BIORETENTION TECHNICAL DESIGN GUIDELINES" (WATER BY DESIGN).
7. VEGETATED BATTER. SLOPE AND PLANTING TO BE IN ACCORDANCE WITH 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN).
8. INSPECTION/CLEANOUT POINT. VERTICAL SOLID PIPE SECTION ATTACHED TO THE END OF EACH UNDERDRAIN IN ACCORDANCE WITH THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES'(WATER BY DESIGN)
9. FILTER CLOTH TO BE FIXED TO PERIMETER OF PIT TO AVOID RUNNELLING OF WATER BETWEEN PIT AND SOIL INTERFACE. BEGIN FILTER CLOTH 100 ABOVE SURFACE. EXTEND TO 100 BELOW SURFACE. CONTINUE 300 HORIZONTALLY INTO FILTER MEDIA.
10. FOR GENERAL DESIGN AND CONSTRUCTION NOTES REFER TO DS-078
11. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.

DATE
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PROJECT No. :
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DWG-330
REVISION No. :
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PROJECT
YAMBA GARDENS - STAGES 1-10
DRAWING TITLE
BIO-POD – FILTER MEDIUM & UNDERDRAINAGE DETAILS - SHEET 1
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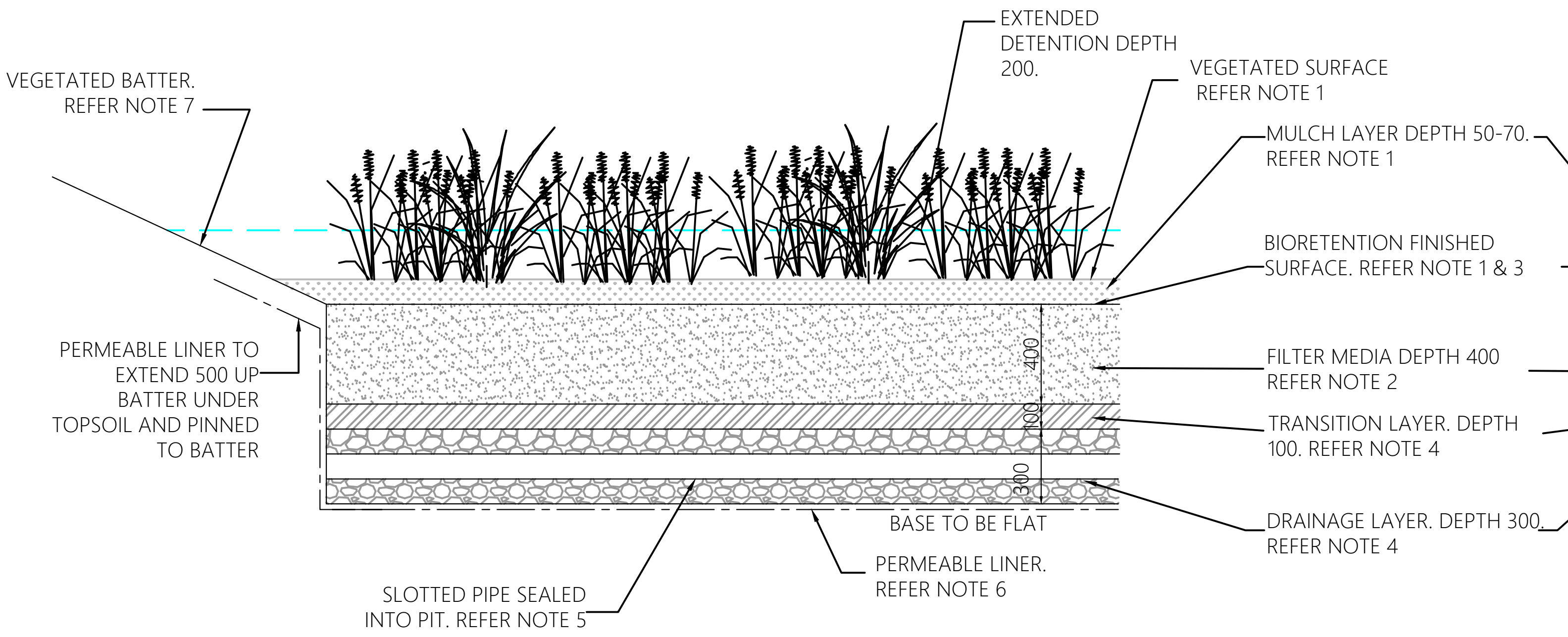
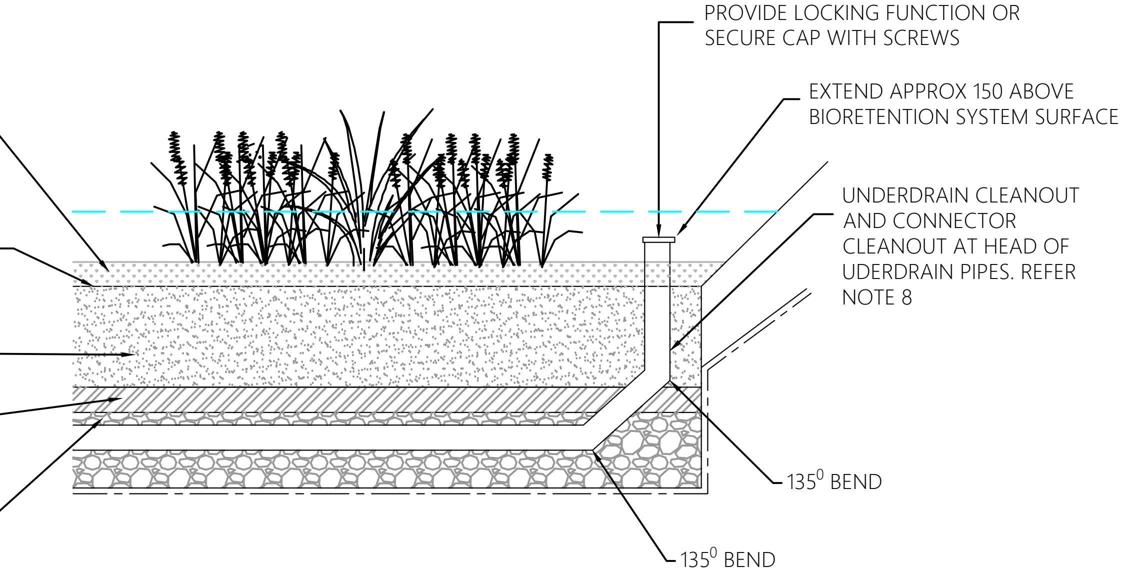
T.B.C as part of detailed design





BIORETENTION MEDIA (TYPE 3-CONVENTIONAL) CROSS SECTION

N.T.S

BIORETENTION BASIN SUBSOIL DRAIN CLEANOUT (TYPE 3-CONVENTIONAL)

N.T.S

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PROJECT
YAMBA GARDENS - STAGES 1-10
DRAWING TITLE
BIO-POD – FILTER MEDIUM & UNDERDRAINAGE DETAILS - SHEET 2
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BIORETENTION SYSTEM SPECIFICATION

1. Referenced documents.

The following documents are incorporated into this specification by reference:

1.1. Standards

1.1.1. AS 1289- Methods of Testing Soils for Engineering Purposes

1.1.2. AS 1289.5.4.1-2007- Soil Compaction and Density Tests-Compaction Control Test-Dry Density Ratio, Moisture Variation and Moisture Ratio

1.1.3. AS 1289.5.7.1-2006 - Soil Compaction and Density Tests - Compaction control Test-Hilf Density Ratio and Hilf Moisture Variation (rapid method)

1.1.4. AS 2758 - Aggregates and Rock for Engineering Purposes

1.1.5. AS 4419 - Soils for Landscaping and Garden Use

1.1.6. AS 4454 - Composts, Soil Conditioners and Mulches

1.2. Other publications

1.2.1. Guidelines for Soil Filter Media in Bioretention Systems (FAWB) - the current version of the guideline can be found at http://www.Monash.edu.au/FAWB/

1.2.2. Construction and Establishment Guidelines - Swales, Bioretention systems and Wetlands (Water by Design) http://waterbydesign.com.au/ceguide/

1.2.3. Transferring Ownership of Vegetated Stormwater Assets (Water by Design) http://waterbydesign.com.au/transfergulde/

1.2.4. Transferring Ownership of Vegetated Stormwater Assets (Water by Design) http://waterbydesign.com.au/transferguide/

1.2.5. Bioretention Technical Design Guidelines (Water by Design) http://waterbydesign.com.au/techguide/

1.2.6. Water Sensitive Urban Design Field Guide (Water by Design)

2. Abbreviations and definitions

2.1. The bioretention system specification consists of the following abbreviations and definitions:

2.2. Filter soil layer which acts as a pollutant filter and supports plant growth.

2.3. Impermeable liners: the liner that prevents water movement between the filter and the surrounding soils and defines the edge of the system.

2.4. Transition layer: layer to separate filter layer from the drainage layer to avoid migration of soils from the filter to the drainage layer

2.5. Drainage layer relatively free d raining layer to convey infiltrated water to the underdrainage.

2.6. Under-drains: slotted drains collect treated stormwater from the drainage layer at the base of the bioretention system.

3. Test methods and standards

3.1. The following test methods and standards are to be used as specified in the above guidelines when conducting tests associated with this specification:

3.2. The hydraulic conductivity of potential filter media shall be measured using the ASTM F1815-11 method

3.3. Particle size distribution: AS1289.3.6.1 - 1995

3.4. Soils for landscaping and garden use: AS4419 - 2003.

4. Materials

4.1. Materials shall meet the required specifications detailed in Section 8 Filter media, Section 9 Transition layer, Section 10 Drainage layer, Section 11 Under drainage. Section 12 Permeable liner. Section 13 Impermeable liner end section 14 landscaping of this document.

4.2. All materials must be certified by the supplier with certification and delivery supply dockets shall be provided on request to certify the material delivered is the material tested.

5 Timing and erosion and sediment control

5.1. The timing of civil and landscape works for bioretention systems must be carefully planned to ensure that both the bioretention system and the downstream waterways, are not impacted by stormwater and sediment (e.g. through best practice erosion and sediment control). In particular, the drainage layer, transition layer and filter media must not be placed until the risk of high sediment loading from upstream construction activities has been mitigated. The construction sequence must be approved by the superintendent

5.2. Erosion and sediment control during construction must be delivered in accordance with all legislative requirements including, where required, the preparation of site-specific ESC plan/s in accordance with current Best Practice Erosion and Sediment Control (e.g. IECA 2008, or later version).

6. Earthworks and hydraulic structures

6.1. The construction of hydraulic structures must ensure the design levels are achieved. Bunds/ embankments surrounding the system shall be at correct levels. The below table summarises the construction tolerances for each element of a typical bioretention system.

6.2. Bioretention systems tolerances

Bioretention element	Tolerance (unless specified otherwise)
Hydraulic structures	+/-25 mm (+/-15 mm for streetscape systems)
Earthworks	+ / - 50 mm
Underdrainage	+/ 25 mm
Drainage and transition layers	+ 25 mm
Surface level	+/- 25mm +/- 40mm for filter media >300m^2 provided the average extended detention requirement is within 25mm of the design requirement.
Embankments and bunds	- 25 mm, + 50 mm

7. Maintenance access.

Maintenance access is provided in accordance with the design drawings.

8. Filter media

8.1. Materials

A fundamental part of bioretention systems is the filter media. The main role of the filter media is to support vegetation and remove pollutants. Filter media should be loamy sand that has high permeability when compacted. It should not contain any rubbish or deleterious material. The loamy sand should contain some organic matter to improve water-holding capacity and plant health, but it should be low in nutrient content. The filter media must be compliant with AS 4419 - Soils for Landscaping and Garden Use, and meet the following requirements:

Parameter	Test method in accordance with	Requirement
Saturated hydraulic conductivity	ASTM f1815 -11	50 - 500 mm/hr (200 preferred)
pH	AS 4419	5.5 - 7.5
Electrical conductivity	AS 4419	<1,2 dS/m
Nitrogen content	AS 4419	<800 mg/kg
Phosphorus content	AS 4419	<40 mg/kg
Organic content	AS 4419	3%-10%. Where organic content Is below this threshold, the filter media may be ameliorated by adding 50mm of compost and tining it into the top 150mm of filter media.
Particle size distribution	AS 1289.3.6.1 - 1995	Clay & silt 3-6% (<0.05mm) Very fine sand 5-30% (0.05-0.15mm) Fine sand 10-30% (0.15-0,25mm) Medium to coarse sand 40-60% (0.25 -1.0mm) Coarse sand 7-10% (1.0-2.0mm) Fine gravel <3% (2.0-3.4%)

Source: Guidelines for Soil Filter Media in Bioretention Systems (FAWB) and Bioretention Technical DEsign Guidelines (Water by Design)

Filter media must be free of weeds and propagates. Other characteristics of the filter media required for plant growth should be confirmed with a soil analysis or confirmed with a horticulturist/landscape architect.

8.2. Testing frequency

Suitable filter media can be delivered to site or imported sand can be ameliorated to meet the above specification. In either case, the media shall be tested against the above parameters at one sample per 500m^3 of filter media. For soil supplied to site, testing must be undertaken on the actual material to be delivered to the bioretention system. The supplier and contractor will be responsible for ensuring the filter media meets the specification and the correct material is delivered to site prior to installation.

8.3. Installation and compaction

When installing, the following specifications shall be applied:

8.3.1. Filter media shall be installed and compacted in two lifts for depths of over 500mm. Compaction shall be light and even across the surface.

8.3.2. The top surface of the drainage layer, transition layer and the filter media layer shall be level and free from localised depressions to ensure even distribution of stormwater flows across the surface and prevent localised ponding.

8.3.3. Filter fabric must not be used between drainage layer, transition layer and the filter media layers or wrapped around the under-drainage

9. Transition layer

9.1. Transition layers prevent filter media migrating into the drainage layer.

9.1.1. Materials

9.1.1.1. Transition layer shall be minimum thickness of 100 mm coarse sand unless otherwise specified (typically 1mm particle size diameter) with <2% fines.

9.1.1.2. A particle size distribution for the sand shall be obtained to ensure that it meets the following criteria (VicRoads).

9.1.1.3. D15 (transition layer) =< 5x D85 (filter media)

9.2 Testing

A sample of the proposed transition layer is to be provided to the superintendent for approval prior to installation. The superintendent may require the transition layer to be tested to ensure its particle size.

10. Drainage layer

Drainage layers convey infiltrated water into the slotted under-drainage pipes.

10.1. Materials

10.1.1. Drainage layer shall be comprised of fine gravel (nominal 2-5mm) with <2% fines and a minimum saturated hydraulic conductivity of 400mm/hr. The depth of the drainage layer shall ensure at least 50mm of aggregate cover over all perforated under-drainage pipes.

10.1.2. A particle size distribution for the gravel shall be obtained to ensure that it meets the following bridging criteria (VicRoads): D15 (drainage layer) =< 5xD85 (transition layer)

10.2. Testing

A sample of the proposed drainage layer is to be provided to the superintendent for approval prior to installation. The superintendent may require the drainage layer to be tested to ensure its particle size.

11. Under-drainage

11.1. Materials

Either slotted rigid pipe (HDPE or similar) or ag-pipe can be used for under-drainage as specified in the construction drawings. When installing, the following specifications shall be considered:

11.1.1. Typically 100mm-slotted hdpe pipe is the preferred type of rigid pipe.

11.1.2. The slots in the pipe shall not allow the drainage layer aggregate to freely enter the pipe (under-drainage with slot width of 2mm or smaller is preferred).

11.1.3. Under-drainage pipes must not be surrounded by any geofabric or sock.

11.2. Installation

11.2.1. The maximum spacing of under-drains for blo-retentlon systems <100m^2 is 1.5m from centre to centre. For bioretention systems >100 m^2 the maximum spacing can be increased to 2.0-2.5m if specified in the construction drawings.

11.2.2. The under-drains shall be sloped towards the outlet pit (min. 0.5% longitudinal grade) and the base of filtration trench shall be free from localised depressions. For bioretention systems with a saturated zone a 0% pipe grade is acceptable.

11.2.3. All junctions and connections shall be appropriately sealed.

11.2.4. Under-drainage pipes shall be sealed into the overflow pit

11.2.5. All under drainage pipes to have raised dean out points constructed from non-slotted pipes which extend to 150mm above filter media surface

12. Permeable liner (where specified)

12.1. A permeable geotextile liner fabric must be used to line the outside of the bioretention system.

12.2. The liner must extend at least 500mm beyond the top of the sides and must be keyed into batter and covered by at least 200mm of topsoil.

12.3. The liner must be resistant to all soil acids and alkalis, resistant to microorganisms and comply with the requirements of AS 3706.12 and AS 3706.13.

13. Impermeable liner (where specified)

13.1. Materials

Liner options include day, geosynthetic bentonite day liners or high-density poly ethylene (HDPE) liners. Refer to the project drawings for liner details.

13.2. Installation

Installation must be in accordance with manufacturers specifications and design drawings and achieve the following:

13.2.1. The liners shall be keyed into the batters and to the embankments.

13.2.2. Liners must be sealed around protrusions such as outlet pipes.

13.2.3. Must achieve a maximum permeability of 1 x10^{-9}m/s

14. Landscaping

14.0. Refer to landscape design drawings.

14.1. Batter slopes must have min 200mm topsoil which must be tested by a NATA-accredited laboratory in accordance with AS 4419.

14.2. Subsoils to be cultivated to 150mm prior to placing topsoil on batter slopes.

14.3. Planting densities and species must be consistent with the landscape design drawings. No substitutions should be made unless approved by the superintendent.

14.4. Plants supplied to site must:

14.4.1. Be grown in clean, weed-and pest-free conditions;

14.4.2. Be well developed, sun-hardened and contain a fully established root ball that does not crumble when removed from its container.

14.4.3. Be at least 200mm high.

14.4.4. Show no sign of pest and disease

14.4.5. Show no signs of nutrient deficiency

14.4.6. Be free from weeds

14.4.7. Be clearly labelled

14.4.8. Be supplied in a container that is at least 90mm high x 50mm wide

14.5. Preparing filter media: unless specified otherwise, each plant must receive at least 10 g of slow-release native fertilizer in granular or tablet form. Pre-hydrated water crystals may be applied at 1-2% by weight

14.6. Mulch must be applied in accordance with the design drawings, be applied prior to planting, provide coverage of the soil and not exceed 75mm thickness, and be kept 50 mm dear of plant stems. Unless otherwise specified, mulch should be fine sugar cane mulch secured in place by a loose weave jute net pinned at 500mm centres.

14.7. Filter media surface and plant stock are to be watered immediately prior to planting. Unless otherwise specified, plants should be planted in clumps of the same species, and large monocultures avoided.

14.8. Plant method must minimise soil compaction and ensure that all roots are covered by at least 10-20mm of soil, avoid covering plant crowns.

14.9. Unless specified otherwise, the following irrigation schedule applies during plant establishment (at 2.5 - 5L per plant per week)

- Week 1 -5 five waterings per week
- Week 6-10 three waterings per week
- Week 11-15 two waterings per week
- Thereafter as required to sustain plants until successful establishment

14.10. Replanting must occur during the establishment period if less than 90% of plants survive.

14.11. Successful plant establishment in bioretention systems is considered when the plants are robust and self-sustaining, and meet the following criteria.

- Vegetation must cover at least 90% of the bioretention surface with mulch covering the remainder (< 10% mulch visible from above)
- Average groundcover plant height must be greater than 500mm.
- Plants must be healthy and free from disease.
- No weeds or litter to be present.

15. Certification and chain of custody

15.1. The following certification and the chain of custody applies to bioretention media:

15.1.1. The supplier and contractor are responsible for ensuring the bioretention media meets the specifications outlined in these guidelines and that the correct material is delivered to site. The supplier must arrange for testing of the filter media by a soil laboratory certified for the methods in accordance with the requirements listed above. On the basis of the testing, the soil laboratory and supplier must certify the material meets these specifications. The supplier must provide the certification and laboratory test results to the contractor with the supply docket.

15.1.2. The contractor provides a copy of the supplier's certification, test results and supply docket to the site superintendent or bioretention designer for review.

15.1.3. Following review of the certification, test results and the supply docket, the site superintendent or bioretention designer approves installation of the bioretention media.

15.1.4. The relevant sections of the bioretention media sign-off form as per the construction and establishment guidelines (Water by Design) should be completed and signed. This sign-off form is provided as part of the construction certification by the site superintendent or bioretention designer.

16. Hold points

16.1. The following hold points must be observed in accordance with the most recent Water by Design construction checklists and superintendent approval is required for works to proceed:

16.1.1. Prestart meeting

16.1.2. Completion of hydraulic structures and under-drainage

16,1.3. Prior to placing filter media

16.1.4. After placement of filter media (prior to applying mulch and planing).

17. Compliance testing (for on-maintenance or off-maintenance)

17.1. Compliance testing must be in accordance with chapter 5 of Transferring Ownership of Vegetated Stormwater Assets (Water by Design). Checklists must be completed and signed by the superintendent.

Disclaimer:It is the responsibility of the certifying registered professional engineer to ensure these standard notes are adapted to the specific needs of the project. It is expected that additional drawing notes would be required to cover other important project issues (e.g. Workplace Health and Safety, Environmental Protection, Erosion and Sediment Control, etc). Healthy waterways, IPWEA and all contributors to this document accept no liability for the use, misuse or any omission or inaccuracy in this document.

DATE
06.06.23
PROJECT No. :
BC-18008
DRAWING No. :
DWG-350
REVISION No. :
D

PROJECT
YAMBA GARDENS - STAGES 1-10
DRAWING TITLE
BIORETENTION STANDARD NOTES
CLIENT
KAHUNA NO.1 PTY LTD
ADDRESS:
52 - 54 MILES STREET, YAMBA

DRAFTED BY :	DESIGNED BY :	CHECKED BY:	PAPER SIZE :	SCALE :
TP / LD	AK	BC	A3	AS SHOWN

APPROVED FOR AND ON BEHALF OF BIOME CONSULTING PTY LTD
ACN 166 087 476
RPEQ No. :

VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		30.05.21
B	RFI RESPONSE		18.08.22
C	REVISED LAYOUT - PARK ADDED		19.12.22
D	FURTHER RFI		06.06.23

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ORIGINAL SCALE BEFORE REDUCTION

CERTIFIED BY

Appendix B

Preliminary Civil Design Drawings - Mortons Urban Solutions

STORMWATER

1. ALL FIELD GULLIES SHALL CONTAIN A 150mm DIA STUB 600mm BELOW GRADE LEVEL FOR FUTURE ROOFWATER DRAINAGE.
2. MANHOLES TO BE IN ACCORDANCE WITH IPWEAQ STANDARD DRAWING No DS-010, DS-015, DS-018, DS-019, DS-020, DS-021 OR STRUCTURAL DRAWINGS (STRUCTURAL DRAWINGS TAKE PRECEDENCE).
3. OUTLET HEADWALLS TO BE IN ACCORDANCE WITH LOCAL COUNCIL STANDARD DRAWINGS.
4. ALL HEADWALLS WITH A FALL GREATER THAN 900mm HIGH REQUIRE INSTALLATION OF PEDESTRIAN SAFETY FENCES.
5. PIPE JOINT TYPES TO BE IN ACCORDANCE WITH LOCAL AUTHORITY REQUIREMENTS.
6. ALL ALLOTMENTS TO BE GRADED SUCH THAT FUTURE ROOFWATER DRAINAGE DISCHARGES TO KERB OR TO PIPED DRAINAGE SYSTEM.
7. ALL PIPE 300mm DIA & GREATER SHALL BE CONSTRUCTED USING SRC OR FRC PIPES. CONTRACTOR MAY ELECT TO USE PVC PIPES WITHIN ALLOTMENTS FOR PIPES SMALLER THAN 300mm DIA.
8. FOR SETOUT DETAILS REFER TO 640 SERIES DRAWINGS (PROFILES & PIT DETAILS).
9. GULLY PITS TO BE IN ACCORDANCE WITH IPWEAQ STANDARD DRAWING No DS-060, DS-061, DS-062, DS-063. WHERE PITS ARE CONSTRUCTED AS DRAINWAY PITS, TO BE IN ACCORDANCE WITH IPWEAQ STANDARD DRAWINGS No 05-068.
10. LOTS WHICH CAN DRAIN OVERLAND FLOW TO THE STREET SWALE / DRAINAGE WITHOUT FLOWING THROUGH ADJOINING PROPERTIES NEED TO PROVIDE FOR Q100 OVERLAND FLOW TO THE ROAD
11. LOT EARTHWORKS DURING BUILDING CONSTRUCTION MUST NOT CHANGE FLOW PATH DIRECTION UNLESS IT IS REPLACED WITH ANOTHER FLOW PATH DRAINING TO THE ROAD SWALE / DRAINAGE.
12. THE CONTRACTOR IS TO INCLUDE ROCK EXCAVATION AS PART OF THEIR STORMWATER RATE.
13. PIPE CLASS - PIPE CLASSES/TRENCH BEDDING SHOWN ON THE DRAWINGS ARE SUBJECT TO THE CONTRACTORS PREFERRED INSTALLATION METHOD. THE CONTRACTOR IS RESPONSIBLE FOR INSTALLING THE APPROPRIATE PIPE CLASSES & BEDDING, & CONSIDERING CONSTRUCTION LOADING.
14. KERB ADAPTORS ARE TO BE INSTALLED TO AUTHORITIES REQUIREMENTS.
15. ALL RCBC SLABS ARE TO BE CAST INSITU.

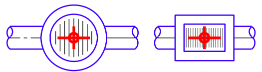
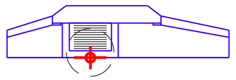
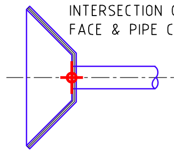
LEGEND

———	EXISTING KERB (INVERT)
———	EXISTING KERB (LIP & BACK)
———	EXISTING PROPERTY LINE
– – – – –	EXISTING RETAINING WALL
——SW——	EXISTING STORMWATER
——RW——	EXISTING ROOFWATER
—SS— — —SS— — —	EXISTING SUBSOIL
— — —1.0— — —	EXISTING CONTOURS
— — — — — —	FUTURE KERB
— — — — — —	FUTURE PROPERTY LINE
– – – – –	FUTURE RETAINING WALL
——SW——	FUTURE STORMWATER
——RW——	FUTURE ROOFWATER
——SS——	FUTURE SUBSOIL
▬ ▬ ▬	SITE BOUNDARY
▬ ▬ ▬	STAGE BOUNDARY
——— — ———	CONTROL LINE / CENTER OF ROAD
———	PROPOSED KERB (INVERT)
———	PROPOSED KERB (LIP & BACK)
———	PROPOSED PROPERTY LINE
– – – – –	PROPOSED RETAINING WALL
—o—o—o—o—o—o—	PROPOSED BOULDER RETAINING WALL
——1.0——	DESIGN CONTOURS
——SW——	PROPOSED STORMWATER
——RW——	PROPOSED ROOFWATER
→ → → → —	PROPOSED SWALE
——SS——	PROPOSED SUBSOIL

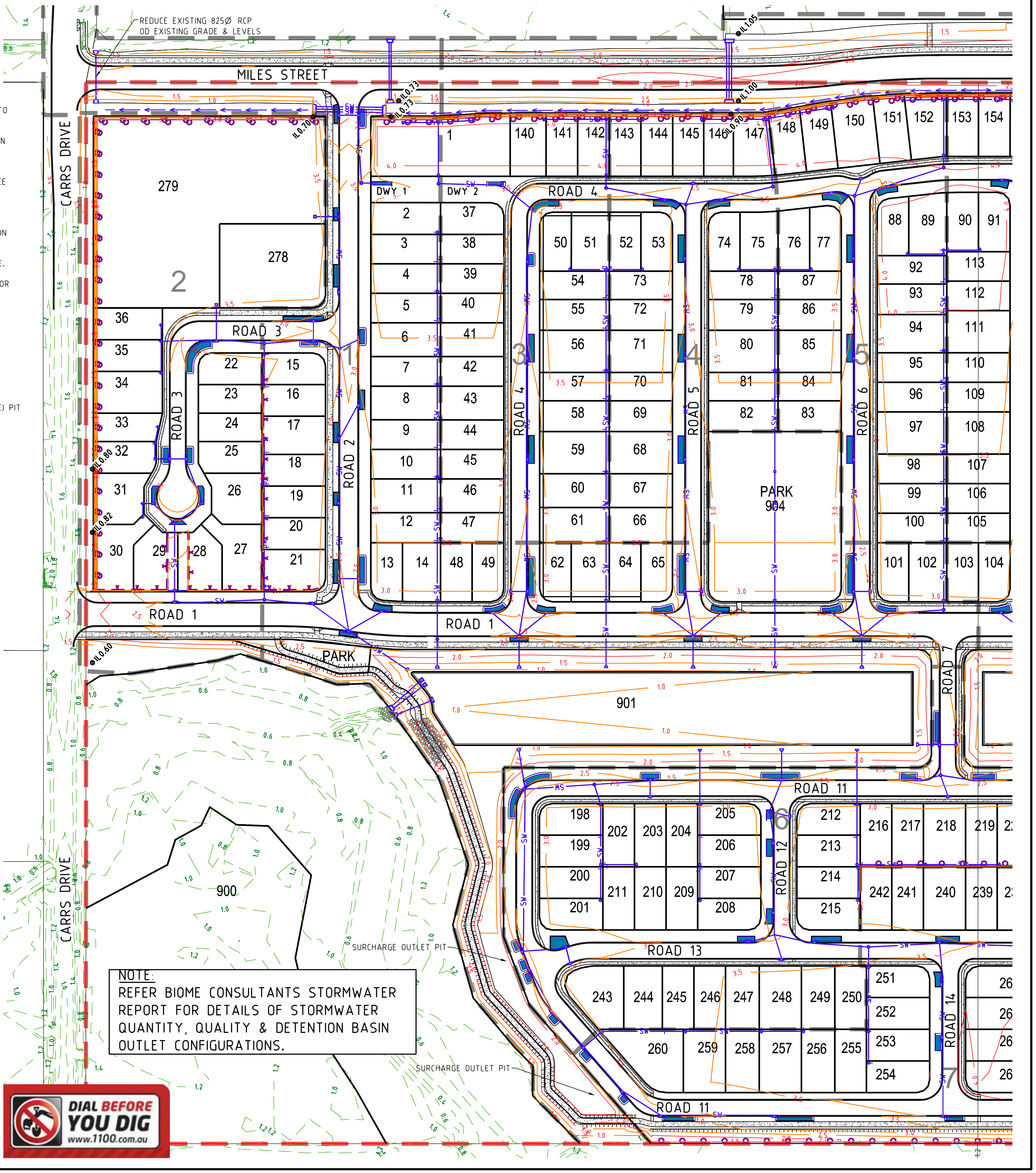
●	MANHOLE
▣	FIELD INLET
▭	KERB INLET (ON GRADE) PIT
▭	KERB INLET (SAG) PIT
▽	HEADWALL
▨	SCOUR PROTECTION
🟦	BIO PODS

NOTE:
1. PRELIMINARY SERVICE LAYOUTS ARE SUBJECT TO CHANGE DURING DETAILED DESIGN AT CONSTRUCTION CERTIFICATE STAGE.
2. EXTENSION TO SERVICE ADJACENT DEVELOPMENT SITES BY OTHERS.

REFERENCE POINT LOCATION FOR DRAINAGE STRUCTURES

STRUCTURE TYPE	HORIZONTAL CONTROL (Reference Point Location)	VERTICAL CONTROL (Reference Level)
MANHOLE / GRATED PIT	 CENTRE OF MANHOLE / PIT	FINISHED SURFACE LEVEL
GULLY PIT	 LIP AT CENTRE OF PIT	FINISHED SURFACE LEVEL (LIP OF CHANNEL)
HEADWALL	 INTERSECTION OF HEADWALL FACE & PIPE CENTRELINE	INVERT LEVEL

REFER TO DWG SERIES 640 FOR ALL DRAINAGE STRUCTURE SETOUT AND/OR CUSTOM DETAILS.



NOTE:
REFER BIOME CONSULTANTS STORMWATER REPORT FOR DETAILS OF STORMWATER QUANTITY, QUALITY & DETENTION BASIN OUTLET CONFIGURATIONS.

PROJECT NAME
YAMBA GARDENS
PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT
KAHUNA NO. 1 PTY LTD

NORTH
0 10 20 30 40 50m
Scale 1:1000 - A1 (1:2000 - A3)

ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

PRE	DATE	AMENDMENT
C	07-12-22	PARK AND LOTS AMENDED
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL

ASSOCIATED CONSULTANTS
BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE
STORMWATER
DRAINAGE
PLAN
SHEET 01

PRELIMINARY ISSUE

MORTONS urbansolutions
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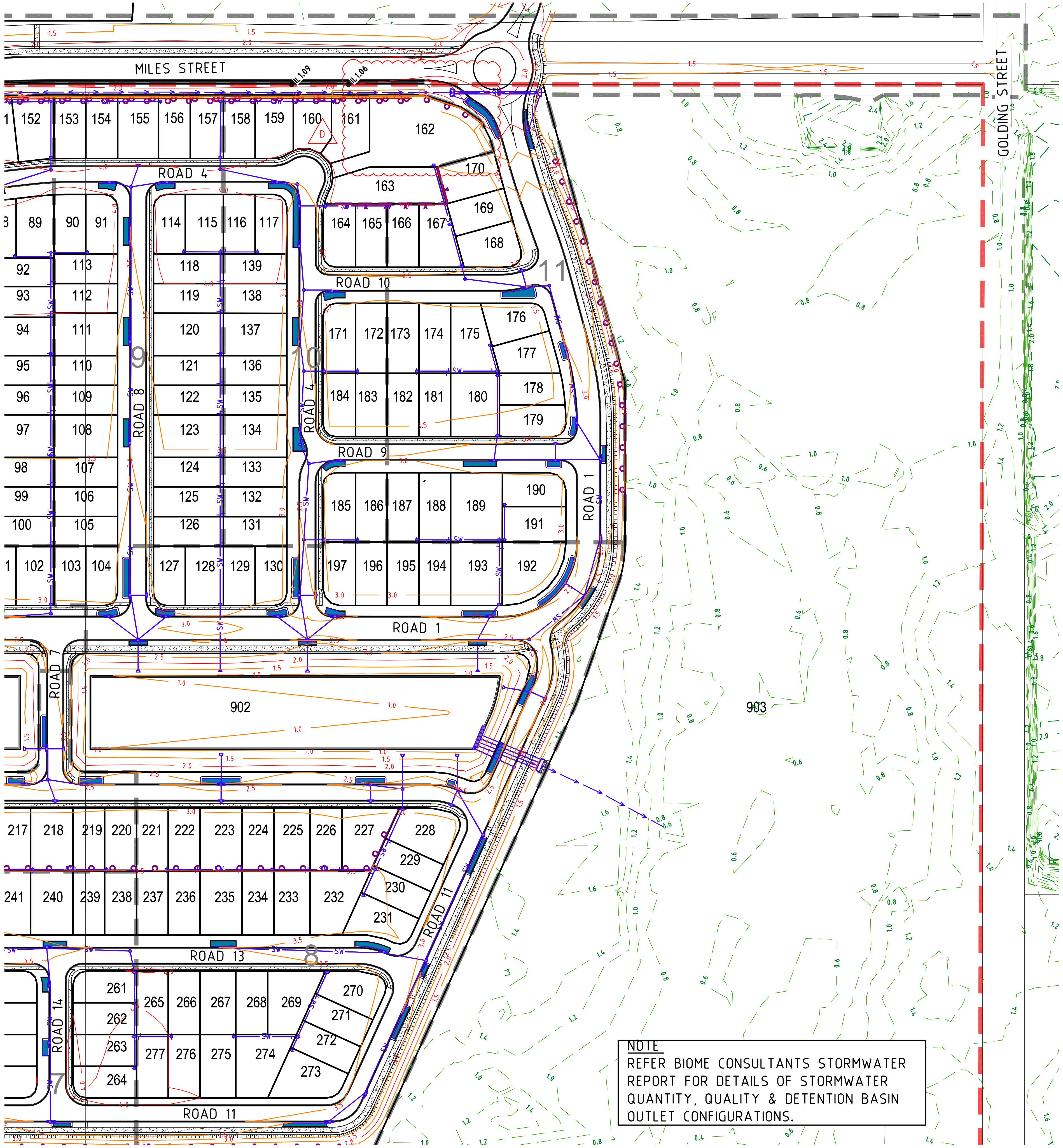
DESIGNED PP	DRAWN SF
APPROVED	NER 906726 DATE 22-08-22

DRAWING NUMBER 33801-PR2-600
AMEND. C



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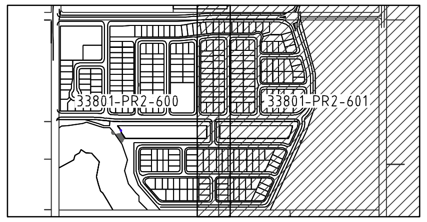

SHEET LAYOUT

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PROJECT NAME

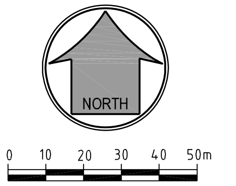
YAMBA GARDENS

PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT

KAHUNA NO. 1 PTY LTD



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ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

D	12-12-22	R.WALL & STAGE BDY AMENDED
C	07-12-22	PARK AND LOTS AMENDED
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL
PRE	DATE	AMENDMENT

ASSOCIATED CONSULTANTS

BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE

STORMWATER
DRAINAGE
PLAN
SHEET 02

PRELIMINARY ISSUE

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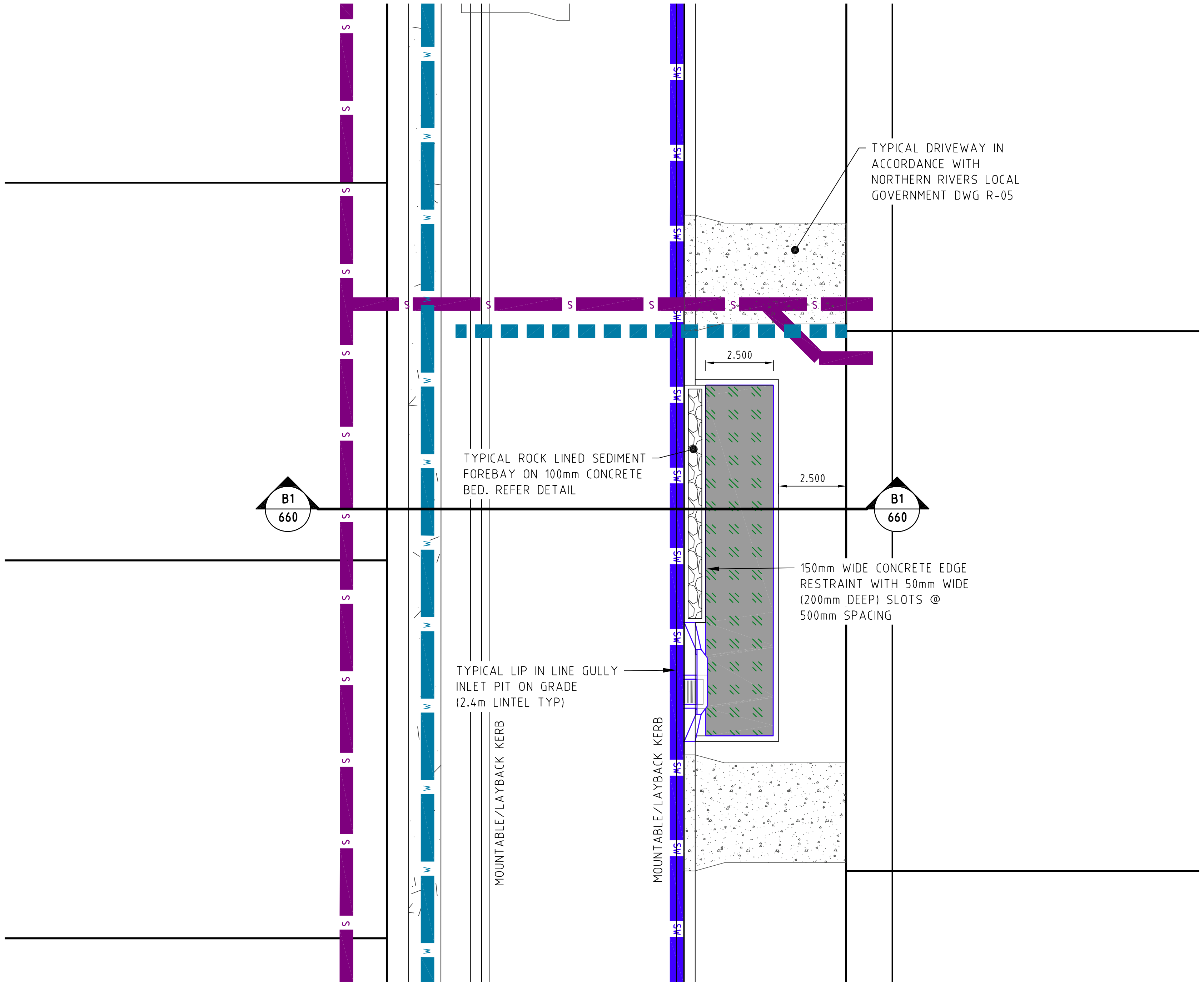
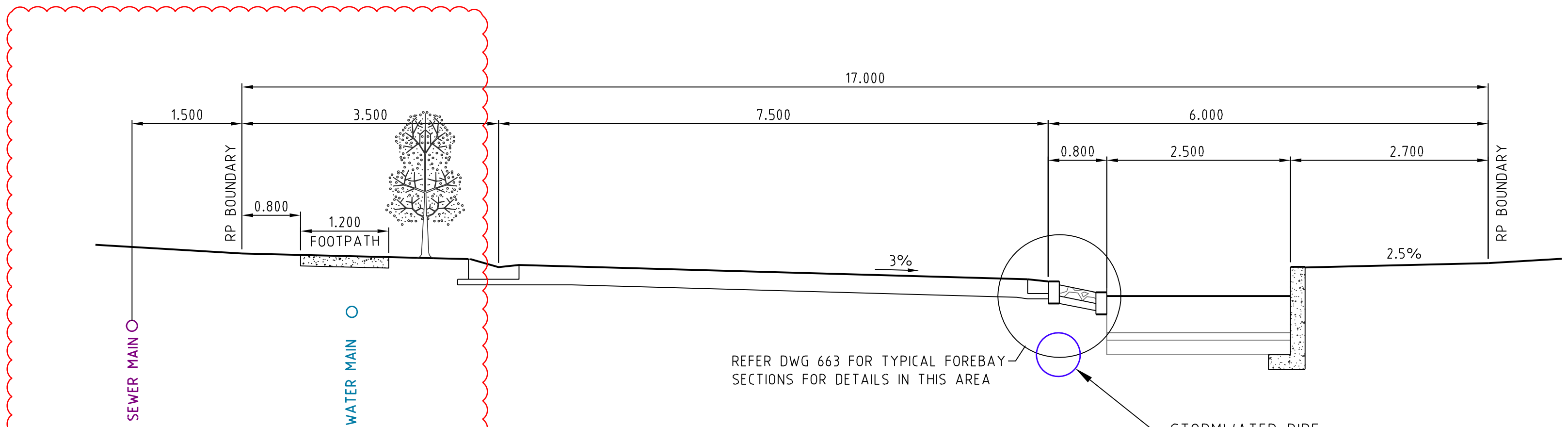
DESIGNED PP		DRAWN SF	
APPROVED Vsh		NER 906726	DATE 22-08-22

DRAWING NUMBER	AMEND.
33801-PR2-601	D





SECTION B1
SCALE 150

LEGEND

- PROPOSED PROPERTY LINE
- —S— PROPOSED RISING MAIN
- —SW— PROPOSED STORMWATER
- —W— PROPOSED WATER
- - - - SERVICE CONDUIT
- ▨ PROPSOED ROCK SCOUR PROTECTION
- ▨ PROPOSED FILTER MATERIAL
- ▨ PROPOSED LANDSCAPED BATTER
- ▨ PROPOSED CONCRETE
- ← PROPOSED FLOW DIRECTION

BIO FILTRATION NOTES

- BIO FILTRATION BASIN TO BE EXCAVTED TO LEVEL BELOW FILTRATION MEDIA
- UNSUITABLE MATERIAL TO BE REMOVED OFF SITE AND BASIN TRIMMED TO FINAL PROFILE PRIOR TO PLACEMENT OF FILTER MEDIA AT 80% COMPLETION OF HOUSING

PROJECT NAME

YAMBA GARDENS

PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT

KAHUNA NO. 1 PTY LTD

NORTH

0 0.5 1.0 1.5 2.0 2.5m
Scale 1:50 - A1 (1:100 - A3)

0 1 2 3 4 5m
Scale 1:100 - A1 (1:200 - A3)

ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

PRE	DATE	AMENDMENT
C	12-12-22	TREE & FOOTPATH ADDED
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL

ASSOCIATED CONSULTANTS

BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE

STORMWATER
TYPICAL BIO-POD
PLAN
SHEET 01

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APPROVED
NER 906726
DATE 22-08-22

DRAWING NUMBER 33801-PR2-660
AMEND. C

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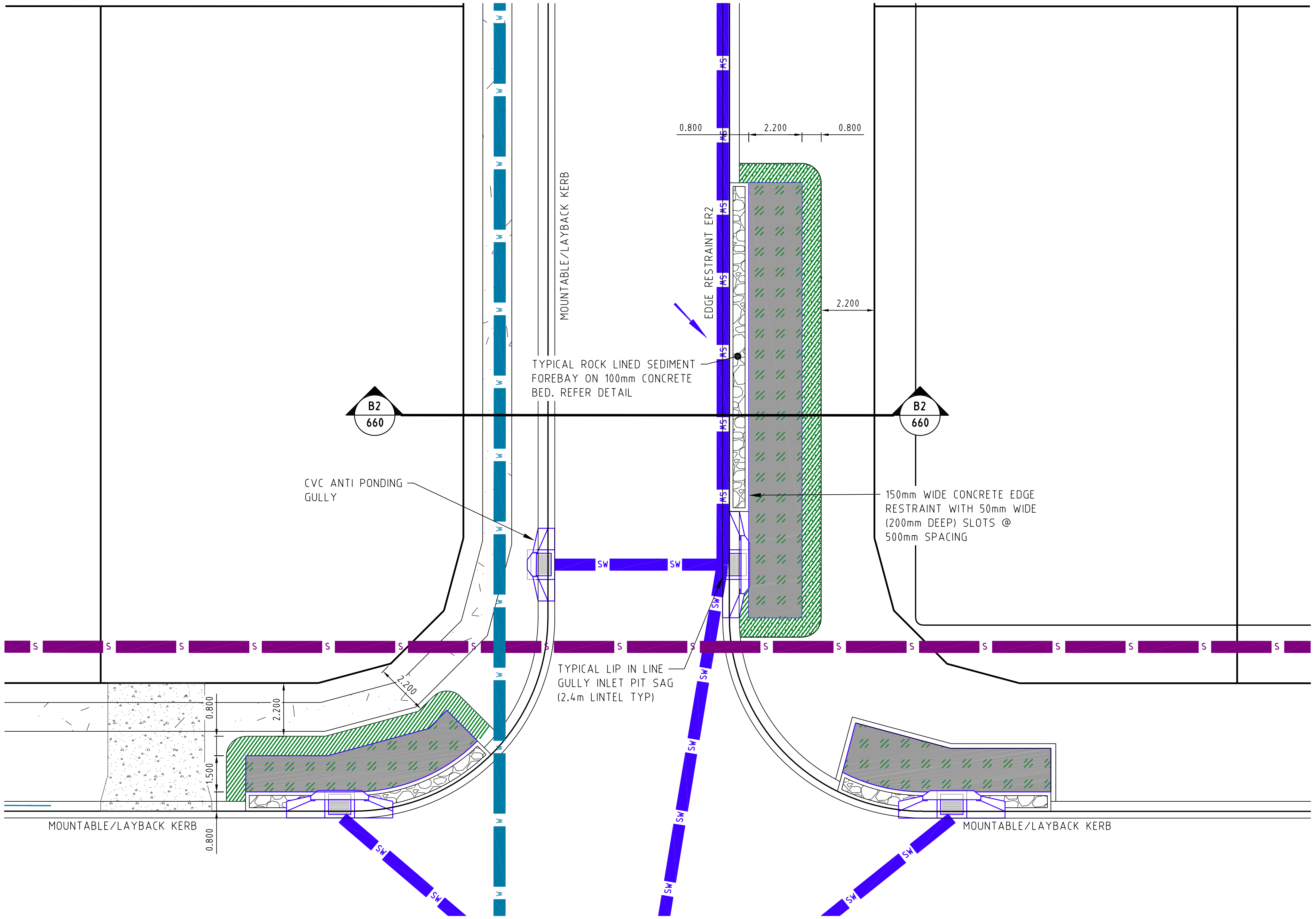

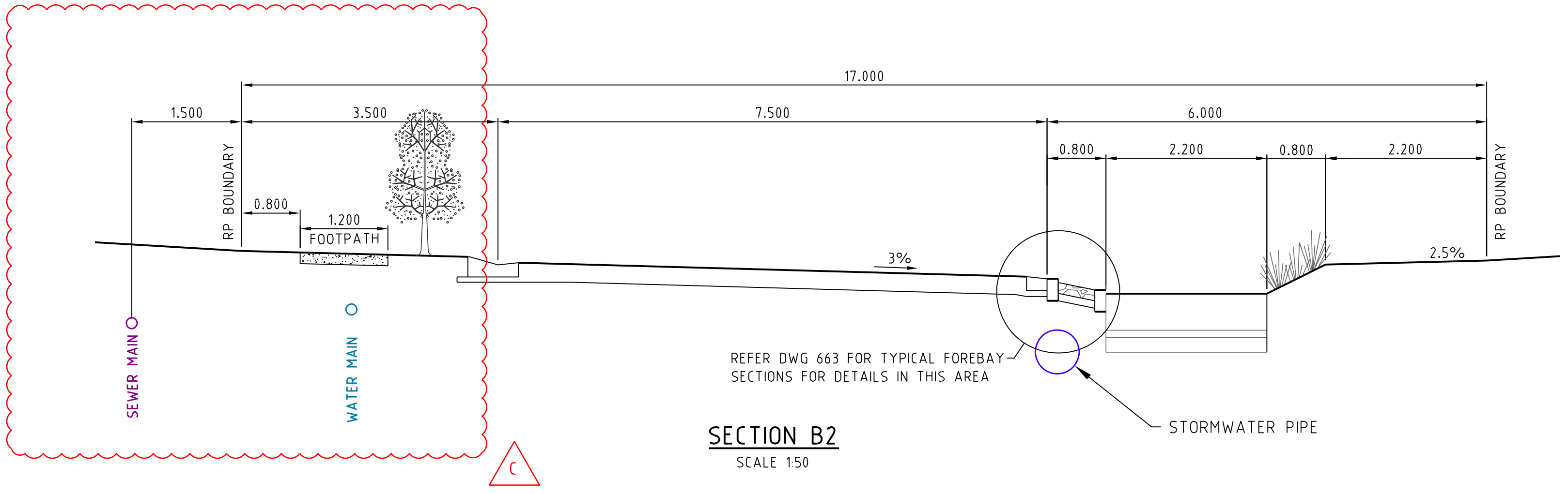

SECTION B2

SCALE 1:50

PROJECT NAME

YAMBA GARDENS

PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT

KAHUNA NO. 1 PTY LTD

NORTH

0 0.5 1.0 1.5 2.0 2.5m
Scale 1:50 - A1 (1:100 - A3)

0 1 2 3 4 5m
Scale 1:100 - A1 (1:200 - A3)

ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

C	12-12-22	FOOTPATH & TREE ADDED
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL
PRE	DATE	AMENDMENT

DO NOT SCALE FROM THIS DRAWING.

ASSOCIATED CONSULTANTS

BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE

STORMWATER
TYPICAL BIO-POD
PLAN
SHEET 02

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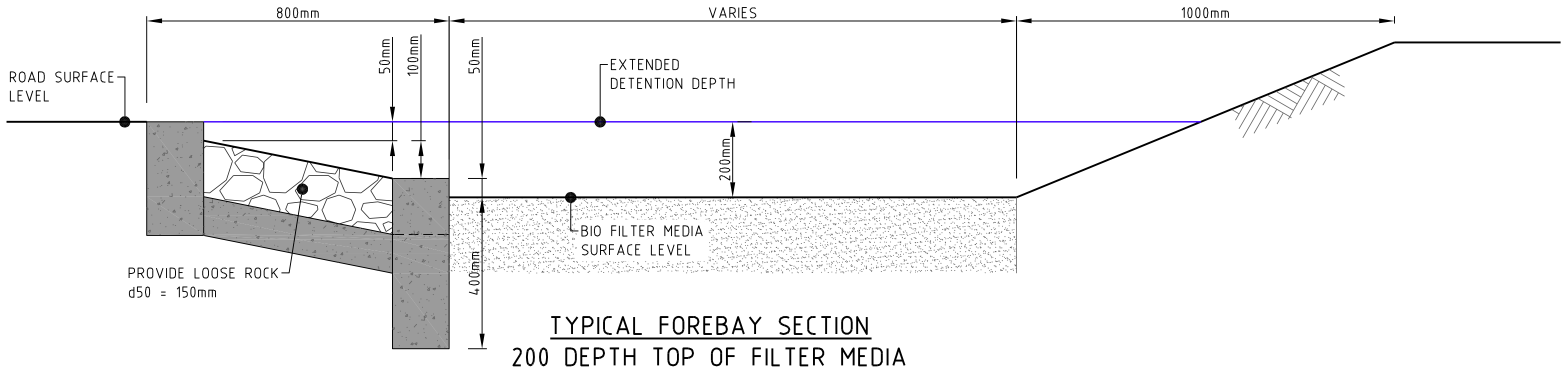
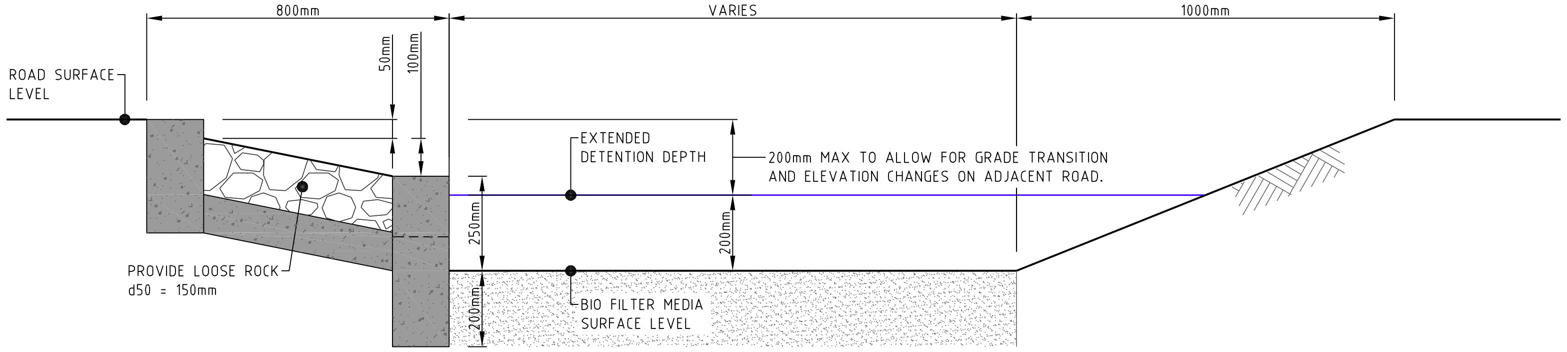
DESIGNED PP
DRAWN SF
APPROVED
NER 906726
DATE 22-08-22
DRAWING NUMBER 33801-PR2-661
AMEND. C



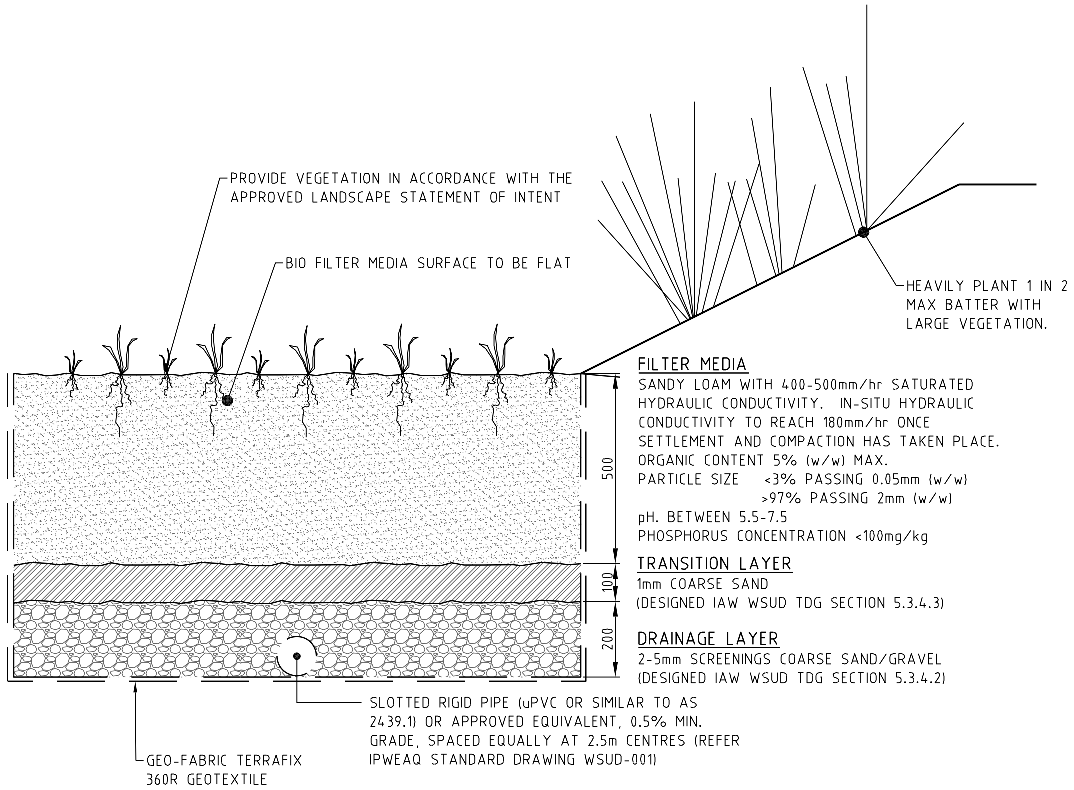
TYPICAL FOREBAY SECTION
200 DEPTH TOP OF FILTER MEDIA

N.T.S.



TYPICAL FOREBAY SECTION
400mm DEPTH TO TOP OF FILTER MEDIA

N.T.S.



FILTER MEDIA
SANDY LOAM WITH 400-500mm/hr SATURATED HYDRAULIC CONDUCTIVITY. IN-SITU HYDRAULIC CONDUCTIVITY TO REACH 180mm/hr ONCE SETTLEMENT AND COMPACTION HAS TAKEN PLACE.
ORGANIC CONTENT 5% (w/w) MAX.
PARTICLE SIZE <3% PASSING 0.05mm (w/w)
>97% PASSING 2mm (w/w)
pH. BETWEEN 5.5-7.5
PHOSPHORUS CONCENTRATION <100mg/kg

TRANSITION LAYER
1mm COARSE SAND
(DESIGNED IAW WSUD TDG SECTION 5.3.4.3)

DRAINAGE LAYER
2-5mm SCREENINGS COARSE SAND/GRAVEL
(DESIGNED IAW WSUD TDG SECTION 5.3.4.2)

TYPICAL BIO-RETENTION MEDIA CROSS SECTION

N.T.S.

PROJECT NAME

YAMBA GARDENS

PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT
KAHUNA NO. 1
PTY LTD

ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

PRE	DATE	AMENDMENT
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL

ASSOCIATED CONSULTANTS

BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE

STORMWATER
TYPICAL BIO-POD
DETAILS

MORTONS
urbansolutions
Urban & Regional Planning
Civil Engineering
Project Coordination

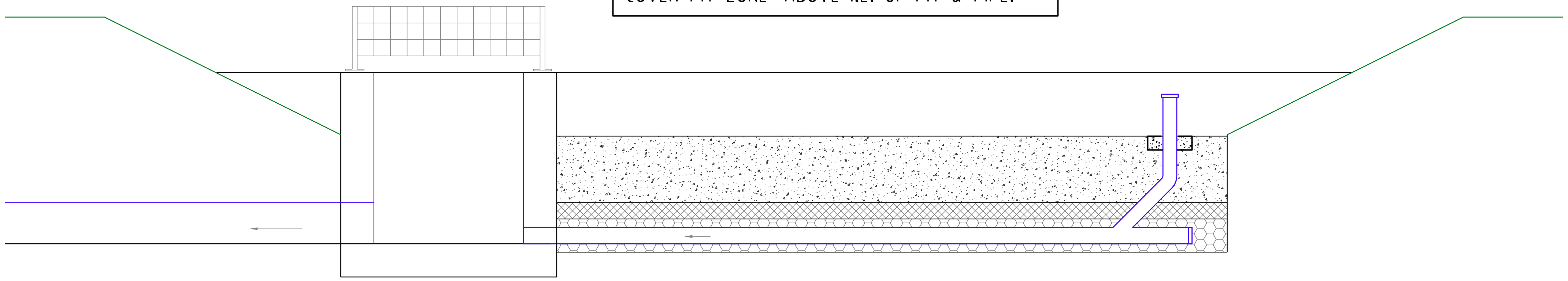
MUS Pty Ltd T/As:
Mortons-Urban Solutions
ABN: 39 116 375 065
mortons@urbansolutions.net.au
www.urbansolutions.net.au
Tel 07 5571 1099

Postal Address
PO Box 2484
Southport QLD 4215

Gold Coast Office
Suite 9, 19 Short St
Southport QLD 4215

DESIGNED PP
DRAWN SF
APPROVED Vs
NER 906726
DATE 22-08-22
DRAWING NUMBER 33801-PR2-663
AMEND. B

TREATMENT OCCURS IN THE NORMAL 'PIPE AND COVER PIT ZONE' ABOVE I.L. OF PIT & PIPE.



TYPICAL BIO-POD TREATMENT ARRANGEMENT

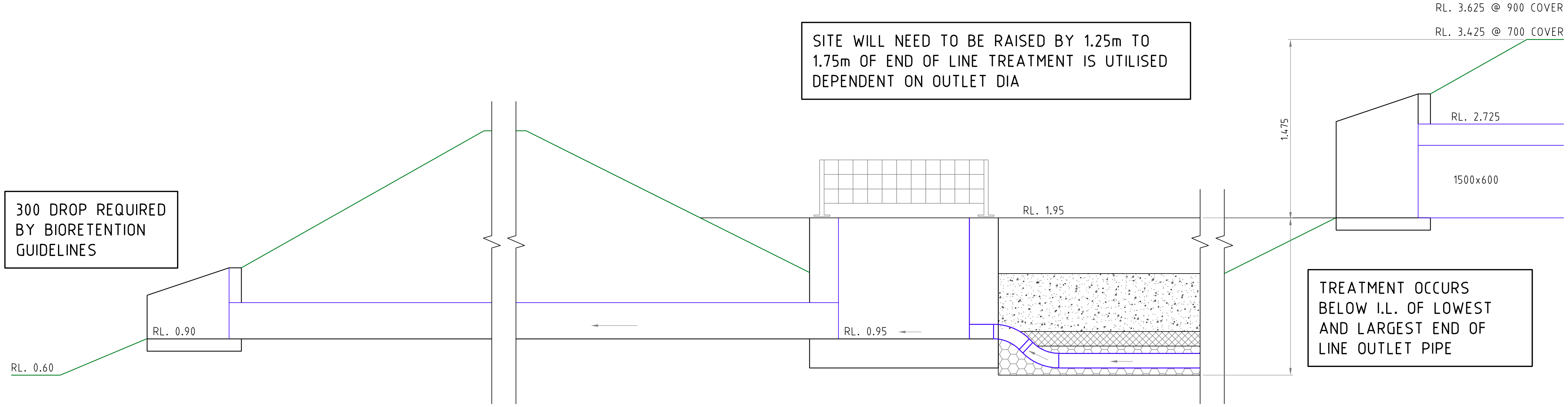
N.T.S.

Q100 MINIMUM ROAD LEVEL WITHIN ESTATE IS 2.10m WITH END OF LINE TREATMENT ROAD WOULD START AT APPROX 3.425

SITE WILL NEED TO BE RAISED BY 1.25m TO 1.75m OF END OF LINE TREATMENT IS UTILISED DEPENDENT ON OUTLET DIA

300 DROP REQUIRED BY BIORETENTION GUIDELINES

TREATMENT OCCURS BELOW I.L. OF LOWEST AND LARGEST END OF LINE OUTLET PIPE



TYPICAL END OF LINE TREATMENT ARRANGEMENT

N.T.S.

Y:\338 - Kahuna No. 1 Pty Ltd (Yamba)\01 - West Yamba Subdivision\Overall\Engineering Drawings\Preliminary 2\CURRENT\33801-PR2-664.dwg, CONCEPT BIO-POD vrs END OF LINE TREATMENT, 12/12/2022 8:47:54 PM, 1:2

PROJECT NAME

YAMBA GARDENS

PRELIMINARY

RP DESCRIPTION
Lot 46 & 47 on DP751395.
MILES ST, YAMBA NSW 2464
LOCALITY OF CLARENCE VALLEY
LOCAL AUTHORITY - CLARENCE VALLEY COUNCIL

CLIENT

KAHUNA NO. 1 PTY LTD

NORTH

0 2 4 6 8 10m
Scale 1:200 - A1 (1:400 - A3)

ISSUES	DATE	
TENDER		
COUNCIL	22-08-22	
CONSTRUCTION		

PRE	DATE	AMENDMENT
B	22-08-22	RFI AMENDMENTS
A	28-05-21	ISSUED FOR APPROVAL

DO NOT SCALE FROM THIS DRAWING.

ASSOCIATED CONSULTANTS

BIOME
WATER AND ENVIRONMENTAL CONSULTING

DRAWING TITLE

CONCEPT
BIO-POD vrs
END OF LINE TREATMENT

MORTONS urbansolutions
Urban & Regional Planning
Civil Engineering
Project Coordination

MUS Pty Ltd T/As:
Mortons-Urban Solutions
ABN: 39 116 375 065

mortons@urbansolutions.net.au
www.urbansolutions.net.au
Tel 07 5571 1099

Postal Address
PO Box 2484
Southport QLD 4215

Gold Coast Office
Suite 9, 19 Short St
Southport QLD 4215

DESIGNED PP
DRAWN SF
APPROVED
NER 906726
DATE 22-08-22

DRAWING NUMBER
33801-PR2-664

AMEND.
B

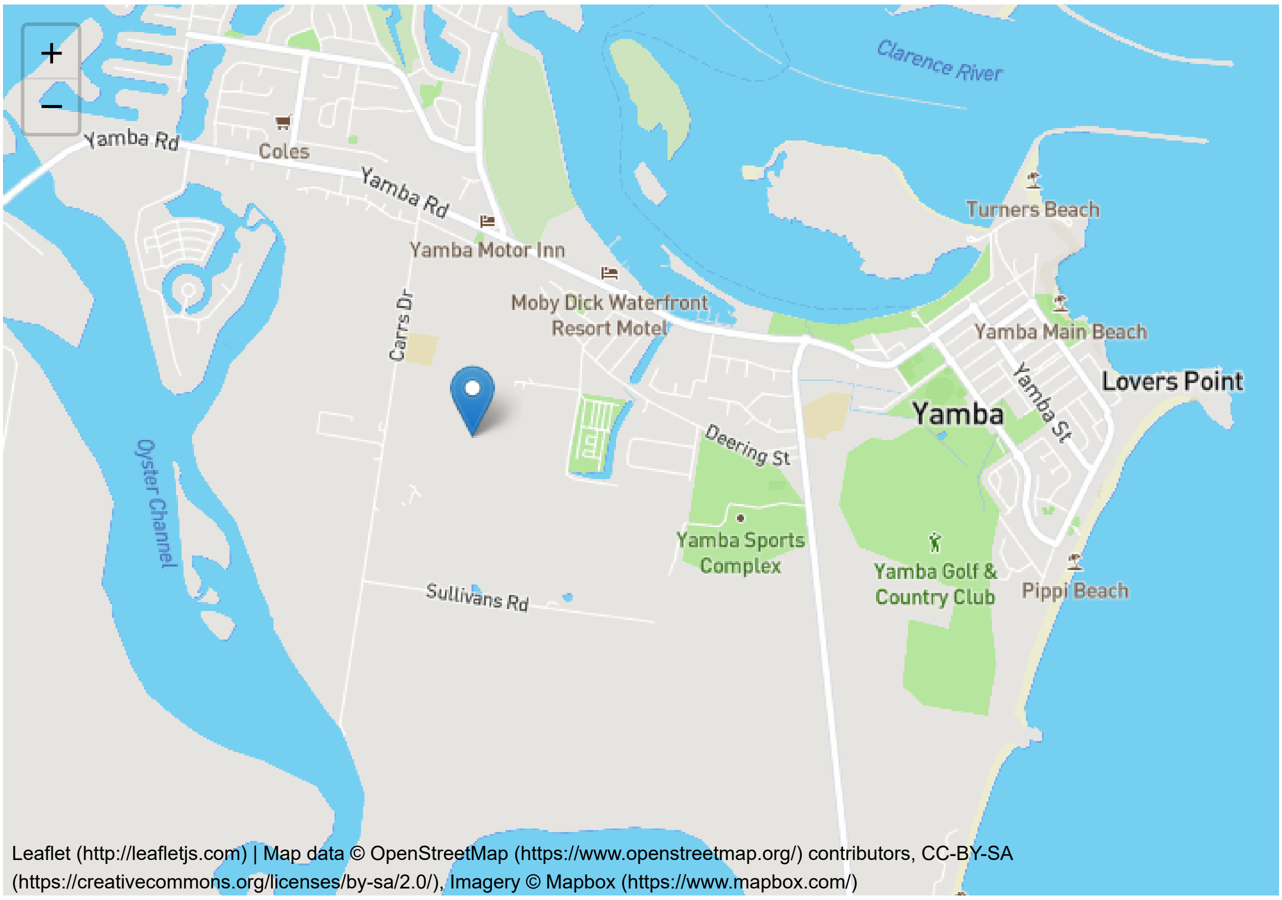
Appendix C

ARR Data Hub Summary Output

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	153.336
Latitude	-29.441
Selected Regions (clear)	
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show



Leaflet (http://leafletjs.com) | Map data © OpenStreetMap (https://www.openstreetmap.org/) contributors, CC-BY-SA (https://creativecommons.org/licenses/by-sa/2.0/), Imagery © Mapbox (https://www.mapbox.com/)

Data

ARF Parameters

$$\begin{aligned} ARF = Min\Big\{1, \Big[&1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} \\ &+ eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) \\ &+ h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\Big]\Big\} \end{aligned}$$

Zone	a	b	c	d	e	f	g	h	i
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

Short Duration ARF

$$\begin{aligned} ARF = Min\Big[1, 1 - &0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} \\ &+ 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) \\ &+ 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^{2}}{1440}}\left(0.3 + \log_{10}(AEP)\right)\Big] \end{aligned}$$

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	16670.0
Storm Initial Losses (mm)	24.0
Storm Continuing Losses (mm/h)	3.6

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECsouth.zip)

code	ECsouth
Label	East Coast South

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECsouth.zip)

code	ECsouth
arealabel	East Coast South

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-29.441&longitude=153.336&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	05 May 2021 09:33AM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	1.5 (0.040)	4.2 (0.085)	6.3 (0.109)	8.3 (0.125)	6.4 (0.081)	6.1 (0.069)
90 (1.5)	4.7 (0.106)	6.2 (0.108)	7.3 (0.108)	8.3 (0.107)	12.4 (0.135)	15.5 (0.150)
120 (2.0)	6.6 (0.137)	10.3 (0.163)	12.8 (0.172)	15.1 (0.176)	19.2 (0.188)	22.3 (0.193)
180 (3.0)	11.4 (0.207)	19.2 (0.261)	24.3 (0.280)	29.2 (0.290)	35.0 (0.290)	39.3 (0.286)
360 (6.0)	8.2 (0.116)	21.9 (0.228)	31.0 (0.269)	39.7 (0.293)	60.8 (0.370)	76.6 (0.407)
720 (12.0)	9.5 (0.102)	24.5 (0.189)	34.5 (0.218)	44.1 (0.234)	63.1 (0.274)	77.3 (0.292)
1080 (18.0)	7.2 (0.066)	16.2 (0.104)	22.1 (0.115)	27.8 (0.121)	51.2 (0.183)	68.8 (0.213)
1440 (24.0)	6.4 (0.052)	14.4 (0.081)	19.7 (0.090)	24.8 (0.095)	37.6 (0.117)	47.1 (0.128)
2160 (36.0)	1.5 (0.010)	7.0 (0.033)	10.7 (0.041)	14.2 (0.045)	27.1 (0.071)	36.9 (0.085)
2880 (48.0)	0.1 (0.000)	3.9 (0.017)	6.5 (0.022)	8.9 (0.026)	18.1 (0.043)	25.0 (0.052)
4320 (72.0)	0.0 (0.000)	1.3 (0.005)	2.2 (0.007)	3.1 (0.008)	6.6 (0.014)	9.3 (0.017)

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.001)	0.2 (0.004)	0.3 (0.006)	0.4 (0.007)	0.2 (0.003)	0.2 (0.003)
90 (1.5)	0.2 (0.004)	0.3 (0.006)	0.4 (0.006)	0.5 (0.006)	0.5 (0.006)	0.5 (0.005)
120 (2.0)	0.0 (0.000)	0.2 (0.004)	0.4 (0.005)	0.6 (0.007)	0.7 (0.007)	0.8 (0.007)
180 (3.0)	0.0 (0.000)	1.4 (0.018)	2.3 (0.026)	3.1 (0.031)	2.3 (0.019)	1.7 (0.012)
360 (6.0)	0.0 (0.000)	3.1 (0.032)	5.1 (0.044)	7.0 (0.052)	9.3 (0.057)	11.0 (0.058)
720 (12.0)	0.0 (0.000)	4.8 (0.037)	8.1 (0.051)	11.1 (0.059)	20.0 (0.087)	26.7 (0.101)
1080 (18.0)	0.0 (0.000)	2.0 (0.013)	3.3 (0.017)	4.6 (0.020)	10.2 (0.036)	14.5 (0.045)
1440 (24.0)	0.0 (0.000)	1.2 (0.007)	2.0 (0.009)	2.7 (0.010)	11.5 (0.036)	18.0 (0.049)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.8 (0.005)	3.1 (0.007)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.1 (0.003)	2.0 (0.004)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	54.0 (1.415)	39.5 (0.792)	40.7 (0.699)	41.9 (0.627)	34.5 (0.438)	36.9 (0.418)
90 (1.5)	51.9 (1.186)	47.8 (0.833)	45.1 (0.671)	42.5 (0.550)	70.9 (0.774)	92.2 (0.893)
120 (2.0)	44.5 (0.924)	51.1 (0.807)	55.5 (0.746)	59.8 (0.695)	97.9 (0.957)	126.5 (1.093)
180 (3.0)	54.0 (0.981)	72.2 (0.985)	84.2 (0.971)	95.7 (0.951)	122.0 (1.012)	141.7 (1.034)
360 (6.0)	64.7 (0.918)	81.1 (0.842)	91.9 (0.796)	102.2 (0.753)	131.5 (0.800)	153.5 (0.815)
720 (12.0)	39.3 (0.425)	68.3 (0.525)	87.5 (0.553)	106.0 (0.562)	142.5 (0.619)	169.9 (0.641)
1080 (18.0)	39.5 (0.361)	73.9 (0.474)	96.7 (0.505)	118.5 (0.517)	126.9 (0.452)	133.1 (0.413)
1440 (24.0)	30.4 (0.247)	51.3 (0.290)	65.2 (0.299)	78.4 (0.300)	98.4 (0.307)	113.3 (0.308)
2160 (36.0)	16.2 (0.112)	32.0 (0.152)	42.5 (0.164)	52.5 (0.168)	81.0 (0.213)	102.3 (0.235)
2880 (48.0)	7.0 (0.043)	25.6 (0.109)	37.9 (0.131)	49.8 (0.143)	69.2 (0.164)	83.8 (0.174)
4320 (72.0)	0.1 (0.000)	12.7 (0.048)	21.1 (0.064)	29.1 (0.074)	47.3 (0.100)	60.9 (0.113)

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	151.8 (3.978)	130.9 (2.624)	120.5 (2.068)	110.5 (1.655)	143.8 (1.827)	220.7 (2.500)
90 (1.5)	151.3 (3.458)	156.7 (2.732)	160.3 (2.386)	163.8 (2.119)	219.6 (2.398)	261.4 (2.533)
120 (2.0)	167.0 (3.471)	172.7 (2.726)	176.5 (2.370)	180.1 (2.096)	210.4 (2.057)	233.1 (2.015)
180 (3.0)	135.3 (2.456)	171.9 (2.346)	196.1 (2.263)	219.3 (2.180)	265.5 (2.202)	300.1 (2.190)
360 (6.0)	127.4 (1.805)	146.3 (1.521)	158.9 (1.377)	170.9 (1.260)	253.0 (1.539)	314.6 (1.671)
720 (12.0)	77.9 (0.841)	128.6 (0.989)	162.1 (1.024)	194.3 (1.031)	250.7 (1.088)	293.0 (1.106)
1080 (18.0)	96.0 (0.877)	132.2 (0.847)	156.2 (0.816)	179.2 (0.782)	206.9 (0.738)	227.7 (0.706)
1440 (24.0)	99.2 (0.805)	127.7 (0.721)	146.5 (0.672)	164.6 (0.629)	187.5 (0.585)	204.7 (0.555)
2160 (36.0)	73.6 (0.508)	90.7 (0.432)	102.0 (0.394)	112.9 (0.362)	160.8 (0.423)	196.8 (0.451)
2880 (48.0)	41.9 (0.260)	67.2 (0.287)	83.8 (0.290)	99.9 (0.288)	135.2 (0.320)	161.8 (0.335)
4320 (72.0)	24.7 (0.134)	49.2 (0.184)	65.4 (0.199)	81.0 (0.206)	90.9 (0.191)	98.3 (0.182)

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	11.8	7.3	8.4	7.9	7.5	4.5
90 (1.5)	11.5	7.6	8.4	7.8	6.2	3.1
120 (2.0)	11.4	7.4	7.9	6.8	6.6	2.2
180 (3.0)	10.2	6.3	6.7	6.6	6.6	2.1
360 (6.0)	10.8	6.7	6.6	6.5	7.8	2.8
720 (12.0)	12.8	7.1	6.5	6.7	6.4	4.1
1080 (18.0)	14.4	8.8	9.7	8.3	8.3	4.6
1440 (24.0)	15.8	10.5	10.0	9.6	7.7	5.6
2160 (36.0)	19.1	12.9	13.5	11.4	11.8	5.9
2880 (48.0)	21.8	14.7	15.0	12.5	13.9	6.5
4320 (72.0)	24.4	18.2	17.4	13.8	17.3	7.0

Layer Info

Time Accessed	05 May 2021 09:33AM
Version	2018_v1
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/f6535101-12c4-429e-b6fc-2cd0015f631c.txt)

Download JSON (downloads/6a2123df-4c9c-42b1-a6be-f9a362098097.json)

Generating PDF... (downloads/a4e37d56-d998-4139-8e0b-bcf70a722eef.pdf)

Australian Government
Bureau of Meteorology

Location

Label: Yamba Gardens

Latitude: -29.441 [Nearest grid cell: 29.4375 (S)]

Longitude:153.336 [Nearest grid cell: 153.3375 (E)]

IFD Design Rainfall Intensity (mm/h)

Issued: 05 May 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	160	177	232	271	311	364	406
2 min	136	149	192	223	255	301	338
3 min	126	139	180	210	240	282	317
4 min	119	131	171	200	229	269	301
5 min	113	125	164	191	219	257	287
10 min	90.9	101	133	155	178	208	232
15 min	76.6	84.9	112	131	149	175	194
20 min	66.5	73.6	96.8	113	129	151	168
25 min	59.0	65.3	85.6	99.9	114	134	149
30 min	53.2	58.8	77.0	89.9	103	120	134
45 min	41.6	45.9	60.0	70.0	80.2	94.2	105
1 hour	34.6	38.1	49.9	58.3	66.8	78.7	88.3
1.5 hour	26.4	29.2	38.2	44.8	51.5	61.0	68.8
2 hour	21.8	24.1	31.7	37.2	43.0	51.1	57.8
3 hour	16.6	18.4	24.4	28.9	33.5	40.2	45.7
4.5 hour	12.7	14.1	19.0	22.7	26.5	32.0	36.5
6 hour	10.5	11.8	16.0	19.2	22.6	27.4	31.4
9 hour	8.13	9.17	12.7	15.4	18.2	22.2	25.5
12 hour	6.81	7.72	10.8	13.2	15.7	19.2	22.1
18 hour	5.33	6.08	8.67	10.6	12.7	15.6	17.9
24 hour	4.48	5.13	7.38	9.09	10.9	13.4	15.4
30 hour	3.91	4.49	6.50	8.01	9.63	11.8	13.5
36 hour	3.50	4.02	5.83	7.20	8.65	10.6	12.1
48 hour	2.91	3.36	4.88	6.02	7.23	8.80	10.1
72 hour	2.22	2.56	3.71	4.57	5.46	6.60	7.49
96 hour	1.80	2.07	3.00	3.67	4.38	5.25	5.92
120 hour	1.51	1.74	2.51	3.06	3.63	4.33	4.86
144 hour	1.30	1.50	2.15	2.61	3.10	3.67	4.10
168 hour	1.13	1.31	1.87	2.28	2.69	3.17	3.53

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD.
Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD.
Rather it corresponds to the 4.48 ARI.

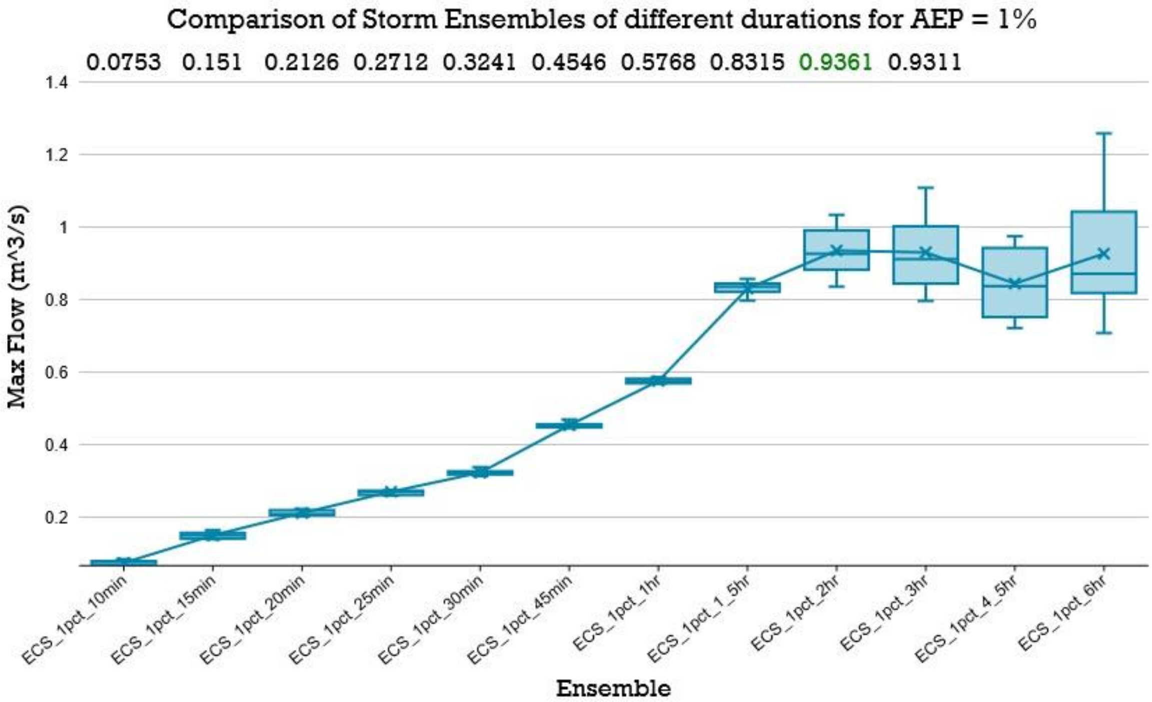
This page was created at **9:37 on Wednesday 05 May 2021 (AEST)**

Appendix D

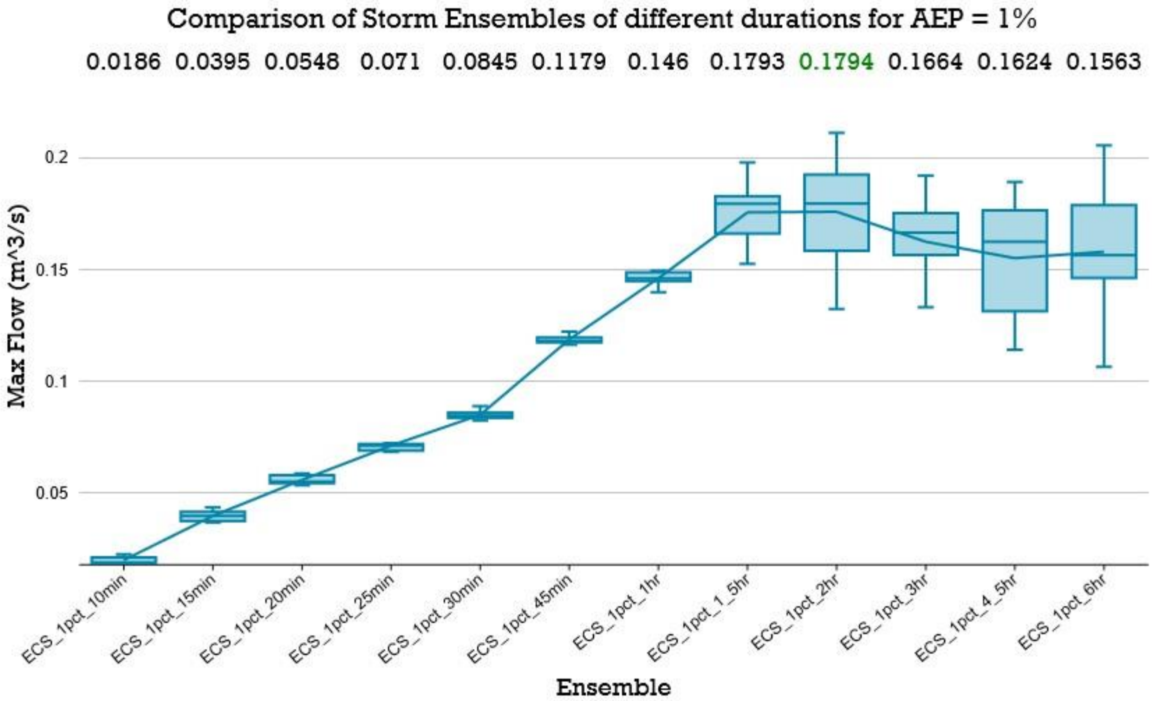
1 % AEP Box and Whisker Plots for Modelled Durations

PD-A Catchments (Existing Case)

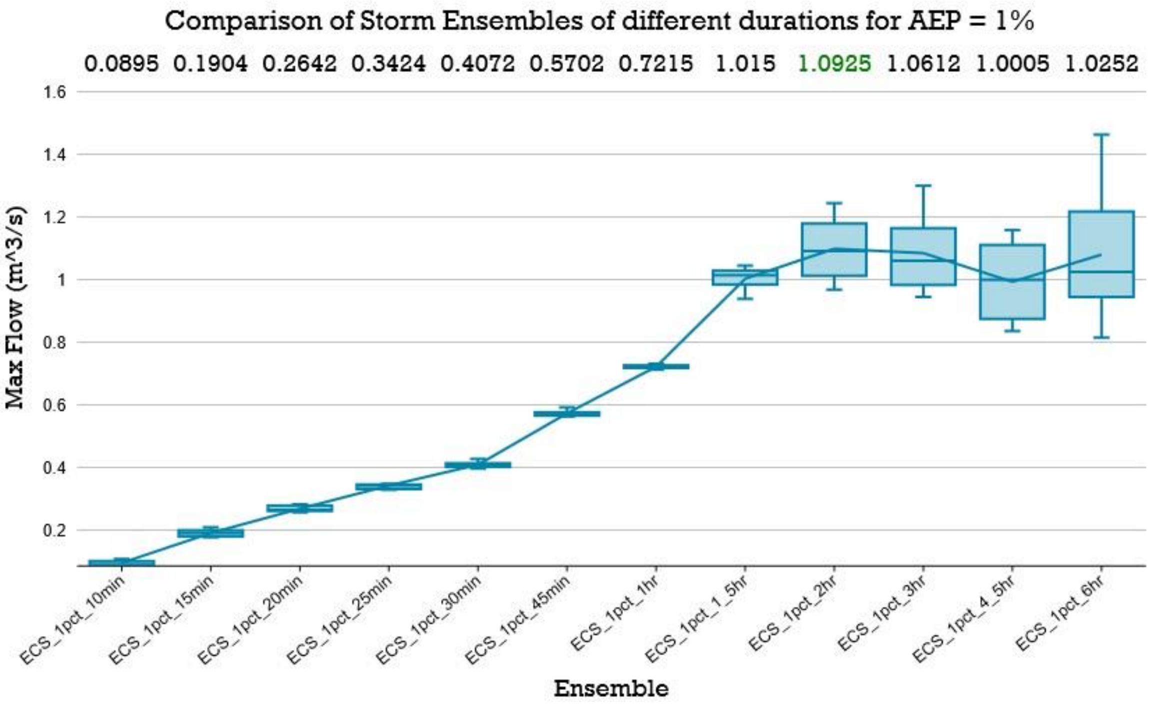
Ext A(1)



A

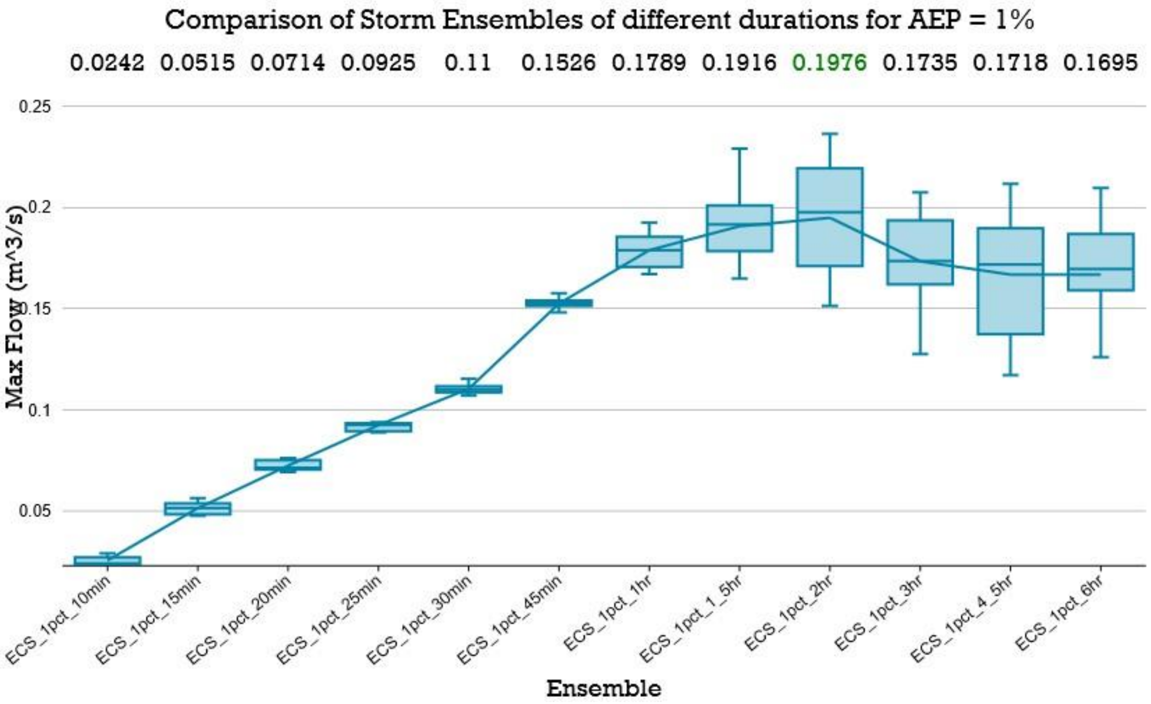


PD-A

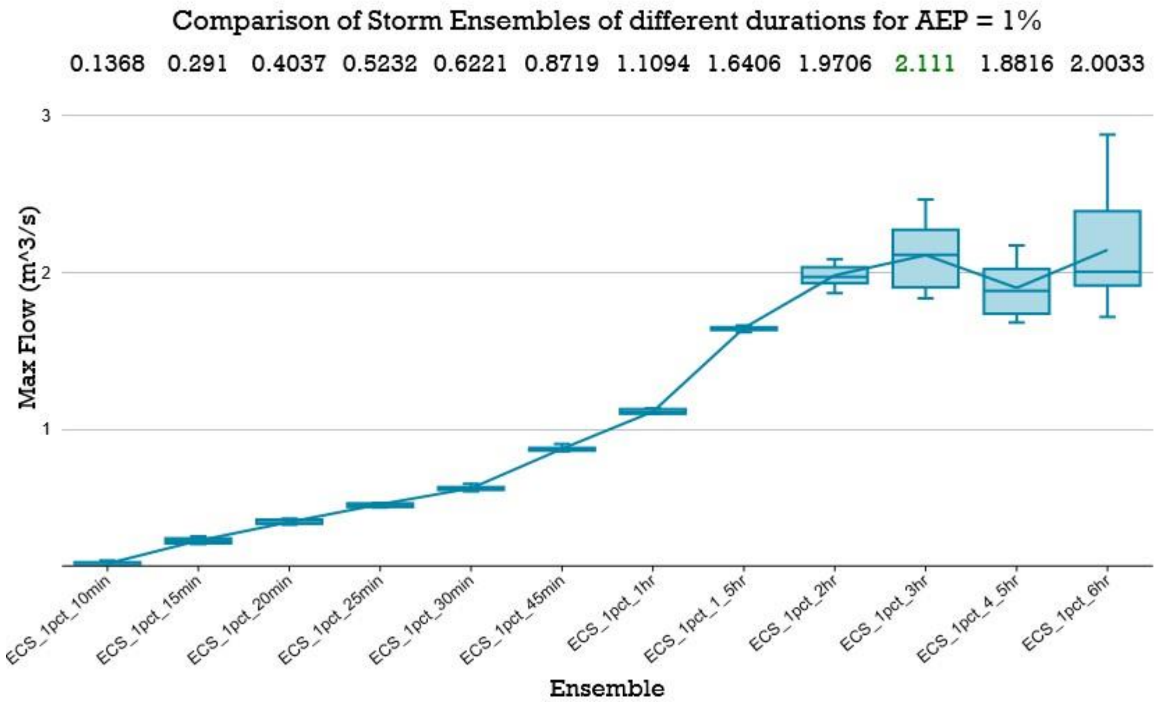


PD-B Catchments (Existing Case)

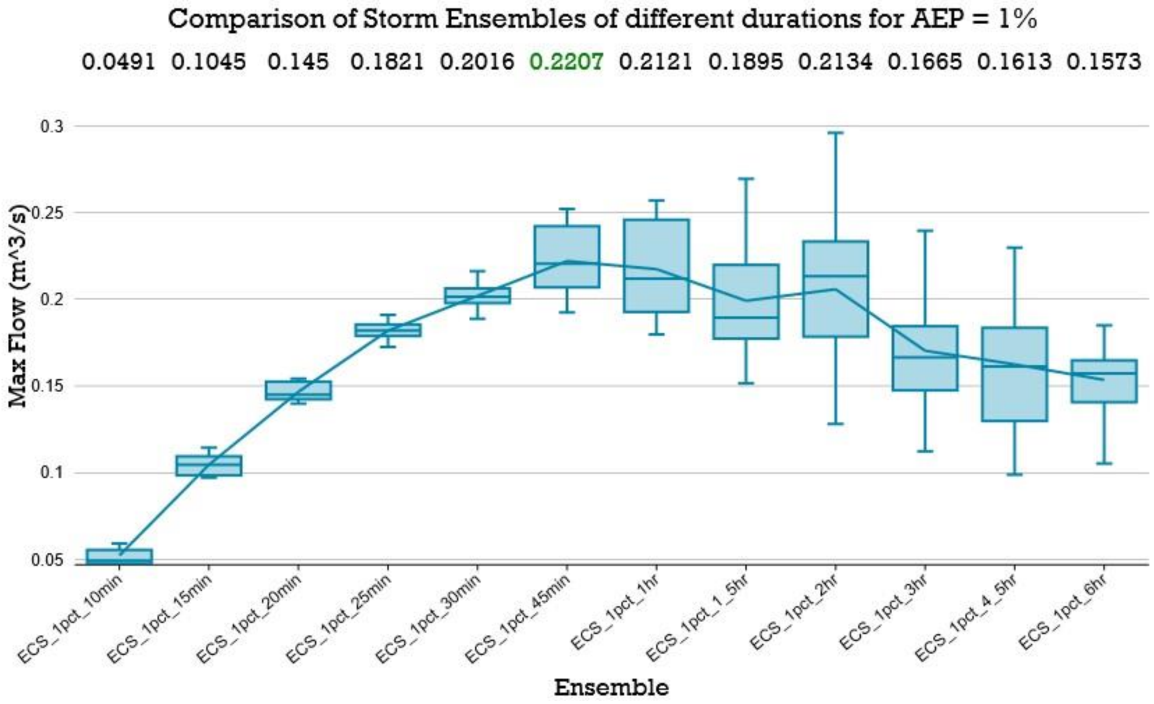
B1



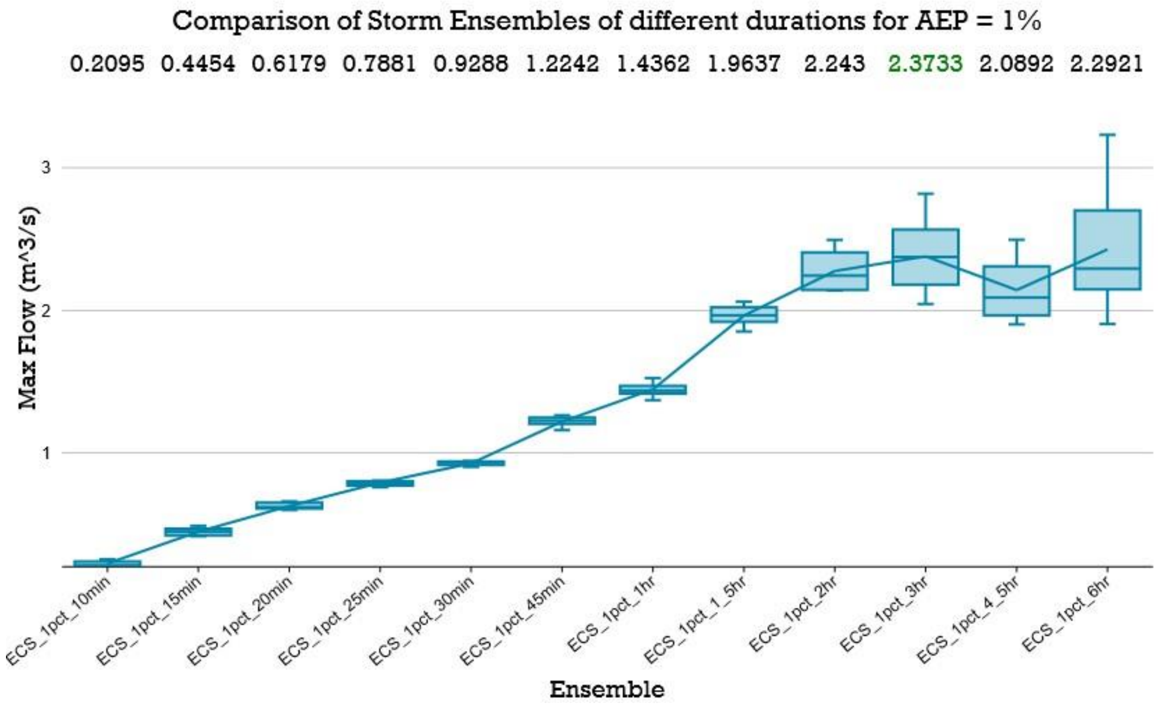
B2


Comparison of Storm Ensembles of different durations for AEP = 1%
0.1368 0.291 0.4037 0.5232 0.6221 0.8719 1.1094 1.6406 1.9706 2.111 1.8816 2.0033
Max Flow (m^3/s)
3
2
1
ECS_1pct_10min
ECS_1pct_15min
ECS_1pct_20min
ECS_1pct_25min
ECS_1pct_30min
ECS_1pct_45min
ECS_1pct_1hr
ECS_1pct_1_5hr
ECS_1pct_2hr
ECS_1pct_3hr
ECS_1pct_4_5hr
ECS_1pct_6hr
Ensemble

B3

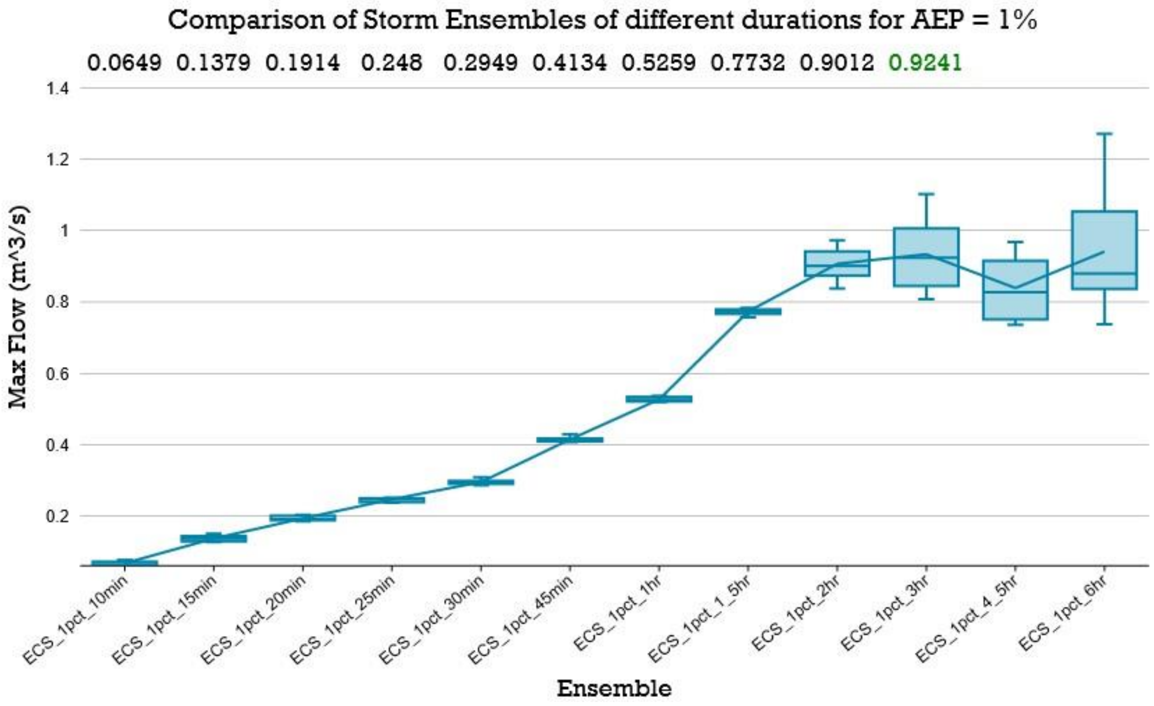

Comparison of Storm Ensembles of different durations for AEP = 1%
0.0491 0.1045 0.145 0.1821 0.2016 0.2207 0.2121 0.1895 0.2134 0.1665 0.1613 0.1573
Max Flow (m^3/s)
0.3
0.25
0.2
0.15
0.1
0.05
ECS_1pct_10min
ECS_1pct_15min
ECS_1pct_20min
ECS_1pct_25min
ECS_1pct_30min
ECS_1pct_45min
ECS_1pct_1hr
ECS_1pct_1_5hr
ECS_1pct_2hr
ECS_1pct_3hr
ECS_1pct_4_5hr
ECS_1pct_6hr
Ensemble

PD-B

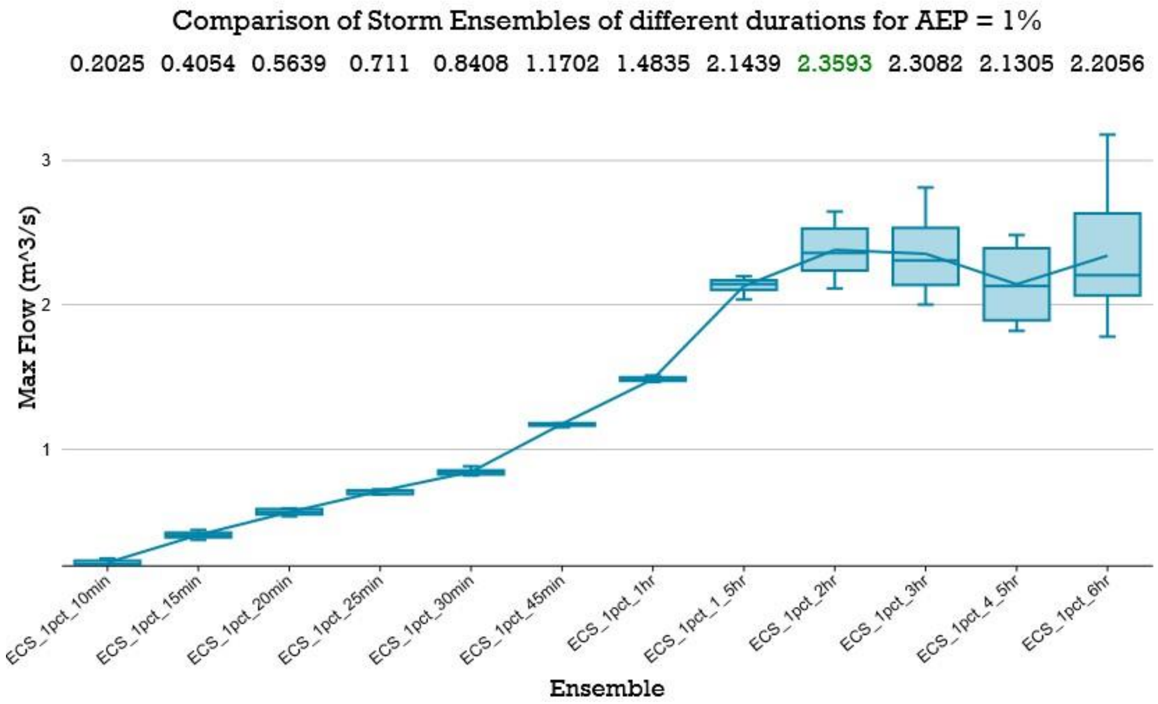


PD-C Catchments (Exisitng Case)

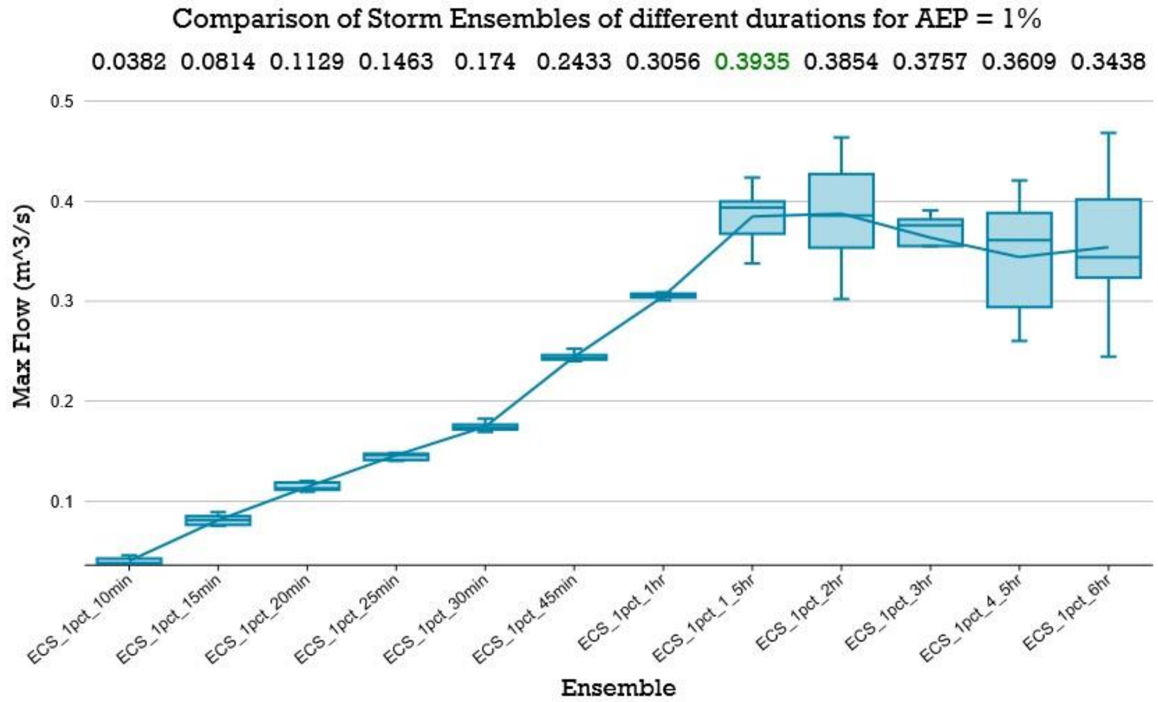
Ext C(1)



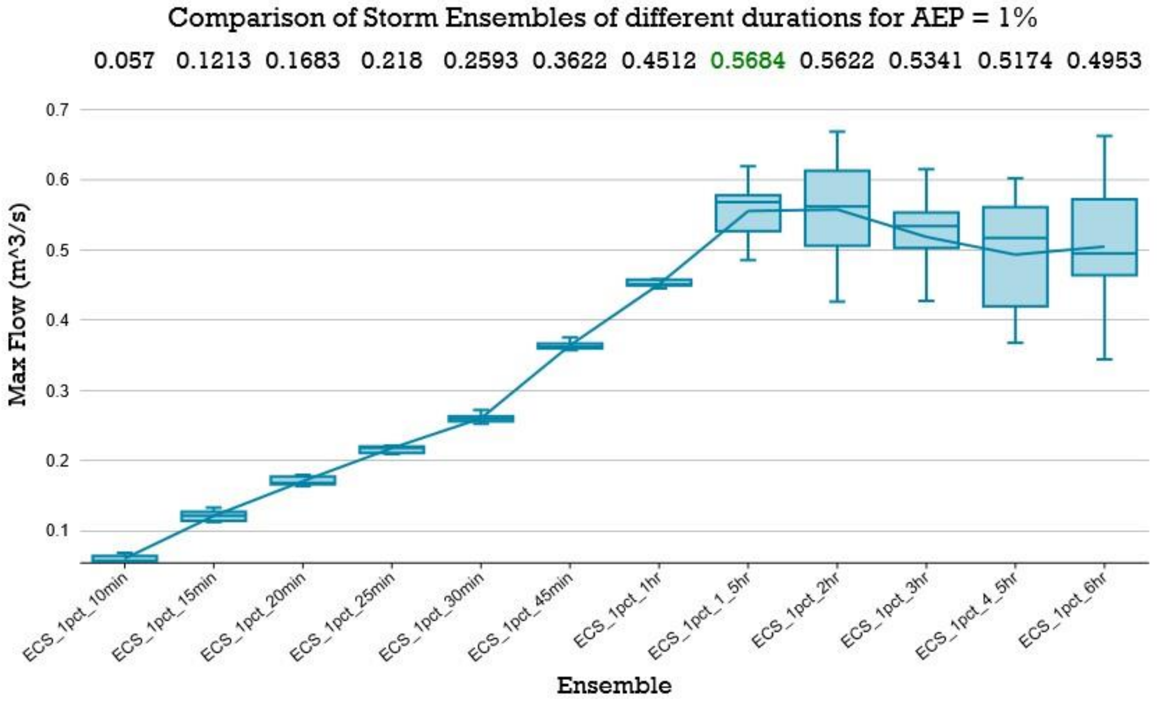
C



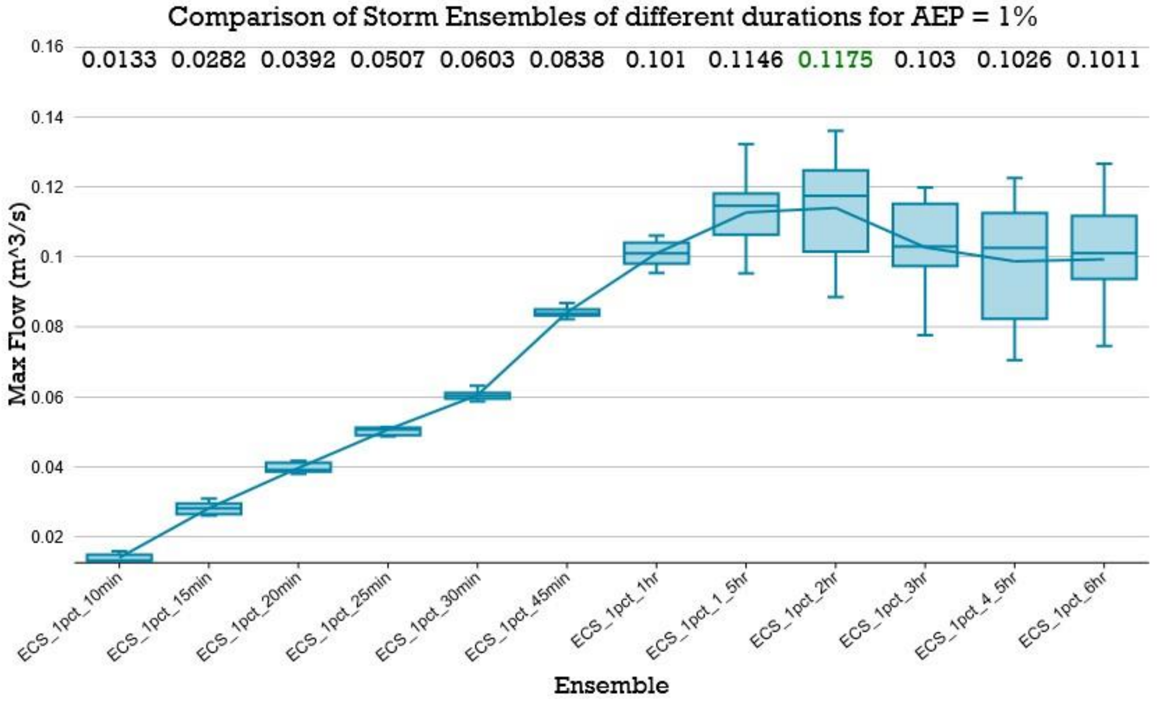
D (Existing Case)



E (Existing Case)



F(Existing Case)



Appendix E

Rational Method Model Validation

The Rational Method has been relied upon to validate the flows reported within *xpstorm* for both the pre and post development cases. In accordance with QUDM 2016 Section 4, the Rational Method provides a simple means of estimating peak discharge and is therefore considered suitable for validation purposes. Equation 4.2 from QUDM has been relied upon.

$$Q_y = (C_y \, . \, {}^{t}I_y \, . \, A)/360$$

where:

Q_y = peak flow rate (m^3/s) for annual exceedance probability (AEP) of 1 in '*y*' years
C_y = coefficient of discharge for AEP of 1 in '*y*' years
A = area of catchment (ha)
${}^{t}I_i$ = average rainfall intensity (mm/h) for a design duration of '*t*' hours and an AEP of 1 in '*y*' years
t = the nominal design storm duration as defined by the time of concentration (t)

Coefficient of Discharge

Based on the infiltration characteristics of the internal and external catchments, the following discharge coefficients have been calculated using the method presented within Book 8 of Australian Rainfall and Runoff (1998) and based on Equation 4.3 from QUDM (2016).

$$C_y = F_y \, . \, C_{10}$$

where:

C_y = coefficient of discharge for AEP of 1 in '*y*' years
F_y = frequency factor for AEP of 1 in '*y*' years
C_{10} = 10 year discharge coefficient value for Tables 4.5.3 and 4.5.4 of QUDM

Fraction impervious (f_i) values for the existing and developed catchments were derived from aerial photography and development plans, respectively. Using these values, and the local ${}^{1}I_{10}$ (1 hour rainfall intensity for the 10 year ARI) value sourced from BOM, the C_{10} for each catchment was determined and utilised to calculate the runoff coefficients for each nominated event. C_{10} values have been based on QUDM values for land of good grass cover with medium to high soil permeability.

The fraction impervious and coefficient of discharge values for the nominated AEP's for the existing case and developed case are contained within Tables C.1 and C.2, respectively.

Table C.1 Coefficient of Discharge – Existing Case

Catchment ID		f_i	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
External	Ext A(1)	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	Ext C(1)	0.00	0.34	0.38	0.40	0.42	0.46	0.48
Internal	A	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	B1	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	B2	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	B3	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	C	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	D	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	E	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	F	0.00	0.34	0.38	0.40	0.42	0.46	0.48

Table C.2 Coefficient of Discharge – Developed Case

Catchment ID		f_i	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
Internal	A	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	B	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	B(Access Road)	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	B2	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	C1	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	C2	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	C3	0.00	0.34	0.38	0.40	0.42	0.46	0.48
	D	0.70	0.67	0.75	0.79	0.83	0.91	0.95
	E	0.00	0.34	0.38	0.40	0.42	0.46	0.48
External	Ext A(1)	0.22	0.52	0.58	0.61	0.64	0.70	0.73
	Ext C(1)	0.13	0.40	0.45	0.47	0.49	0.54	0.56

Time of Concentration

The time of concentration (t_c) for each catchment was calculated in accordance with Section 4.6 of QUDM (2016).

A standard inlet time of concentration of 5 min has been adopted within the relevant developed catchments as per Table 4.6.2 of QUDM.

The time of concentration (t_c) for the overland flow length within the undeveloped catchments and the relevant developed catchments was estimated using Friend's Equation for overland flow (QUDM Section 4.6.6).

$$t_c = (107nL^{0.333})/S^{0.2}$$

where:

t_c = Time of concentration (min)
n = Horton's roughness value (estimated using QUDM Table 4.6.5)
L = Overland sheet flow path length (m)
S = Slope (%)

For channel flow, times where estimated using Manning's equation as provided in the Technical notes for Figure 4.6 of QUDM, shown below:

$$t_c = 0.025L/S^{0.5}$$

where:

t_c = Time of concentration (min)
L = Length of gutter flow (m)
S = Slope (%)

Tables C.3 and C.4 below present the parameters relied upon to calculate the time of concentration (t_c) to the discharge point of each catchment (site's PD) for the existing and developed case, respectively.

Table C.3 t_c Parameters – Existing Case

Parameter	External		Internal						
	Ext A(1)	Ext C(1)	A	B1	B2	B3	D	E	F
Standard Inlet Time									
t (min)	-	-	-	-	-	-	-	-	-
Sheet Flow									
Flow Length (m)	200	200	90	66	200	46	200	85	90
Horton's Roughness Value	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Slope (%)	0.3	0.2	0.2	0.3	0.3	1.2	0.3	0.2	0.2
t (min)	37.1	38.4	28.9	25.2	36.3	16.6	36.0	30.5	28.9
Channel Flow									
Flow Length (m)	300	94	0	0	111	0	21	140	0
Velocity (m/s)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Slope (%)	0.3	0.2	0.2	0.3	0.4	1.2	0.3	0.6	0.0
t (min)	16.7	5.2	0.0	0.0	6.2	0.0	1.2	7.8	0.0
TOTAL t_c (min)	**53.8**	**43.6**	**28.9**	**25.2**	**42.4**	**16.6**	**37.2**	**38.3**	**28.9**

Table C.4 t_c Parameters – Developed Case

Parameter	Internal									External	
	A	B	B(Access Road)	B2	C1	C2	C3	D	E	Ext A(1)	Ext C(1)
Standard Inlet Time											
t (min)	5	5	5	-	5	5	-	-	-	-	-
Sheet Flow											
Flow Length (m)	-	-	-	31	-	-	110	83	85	140	200
Horton's Roughness Value	-	-	-	0.045	-	-	0.045	0.045	0.045	0.045	0.045
Slope (%)	-	-	-	31	-	-	110	83	85	140	200
t (min)	-	-	-	13.93	-	-	24.9	26.7	30.5	32.9	38.4
Channel Flow											
Flow Length (m)	25	-	-	120	80	-	425	-	140	360	94
Velocity (m/s)	0.3	-	-	0.3	0.3	-	0.3	-	0.3	0.3	0.3
Slope (%)	0.3	-	-	0.3	0.3	-	0.1	-	0.6	0.3	0.2
t (min)	1.4	-	-	6.7	4.4	-	23.6	-	7.8	20.0	5.2
Pipe Flow											
Flow Length (m)	100	350	60	-	80	250	-	-	-	-	-
Velocity (m/s)	1.0	1.0	1.0	-	1.0	1.0	-	-	-	-	-
Slope (%)	1.0	1.0	1.0	-	1.0	1.0	-	-	-	-	-
t (min)	1.7	5.8	1.0	-	1.3	4.2	-	-	-	-	-
TOTAL t_c (min)	**8.1**	**10.8**	**6.0**	**20.6**	**10.8**	**9.2**	**48.5**	**26.7**	**38.3**	**52.9**	**43.6**

Rainfall Intensity

Based on the calculated t_c for each catchment, Intensity-Frequency-Duration data (IFD) has been obtained from the Bureau of Meteorology for nominated AEP's and the existing and developed cases are presented in Tables C.5 and C.6, respectively.

Table C.5 Rainfall Intensity (mm/h) – Existing Case

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
External	Ext A(1)	45.9	55.2	63.2	72.4	85.1	95.2
	Ext C(1)	52.3	62.8	71.8	82.3	96.6	107.6
Internal	A	66.9	80.5	92.1	105.4	123.1	137.3
	B1	72.1	86.9	99.4	113.5	133.3	148.3
	B2	53.5	64.2	73.4	84.1	98.6	110.0
	B3	90.4	109.2	125.4	142.8	167.5	185.9
	D	58.5	70.3	80.4	92.1	107.7	120.1
	E	57.4	69.0	78.9	90.4	105.8	118.0
	F	66.9	80.5	92.1	105.4	123.1	137.3

Table C.6 Rainfall Intensity (mm/h)– Developed Case

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
Internal	A	122.5	147.4	169.0	193.9	227.0	253.3
	B	109.1	131.5	151.0	173.2	202.5	225.7
	B(Access Road)	133.6	160.6	183.8	210.8	247.2	276.0
	B2	80.3	96.9	110.8	126.6	148.1	164.9
	C1	109.2	131.7	151.3	173.5	202.9	226.1
	C2	116.5	140.3	161.0	184.8	216.1	241.1
	C3	49.0	58.8	67.3	77.1	90.6	101.1
	D	70.1	84.4	96.5	110.3	129.3	144.0
	E	57.4	69.0	78.9	90.4	105.8	118.0
External	Ext A(1)	46.4	55.7	63.8	73.1	86.0	96.2
	Ext C(1)	52.3	62.8	71.8	82.3	96.6	107.6

Peak Discharge

Based on the above parameters, estimates of the expected peak discharge generated for the site's existing and developed catchments for nominated AEP's have been calculated, and are presented in Tables C.7 and C.8, respectively.

Table C.7 Peak Discharge (m^3/s) – Existing Case

Catchment ID		Annual Exceedance Probability (AEP)					
		39.3%	18.1%	10%	5%	2%	1%
External	Ext A(1)	0.299	0.401	0.483	0.582	0.749	0.875
	Ext C(1)	0.357	0.478	0.576	0.693	0.891	1.036
Internal	A	0.064	0.087	0.104	0.125	0.160	0.187
	B1	0.069	0.092	0.111	0.133	0.172	0.199
	B2	0.853	1.145	1.379	1.658	2.130	2.478
	B3	0.065	0.088	0.107	0.128	0.164	0.190
	D	0.130	0.174	0.210	0.253	0.323	0.377
	E	0.179	0.241	0.290	0.349	0.447	0.520
	F	0.039	0.052	0.063	0.076	0.097	0.113

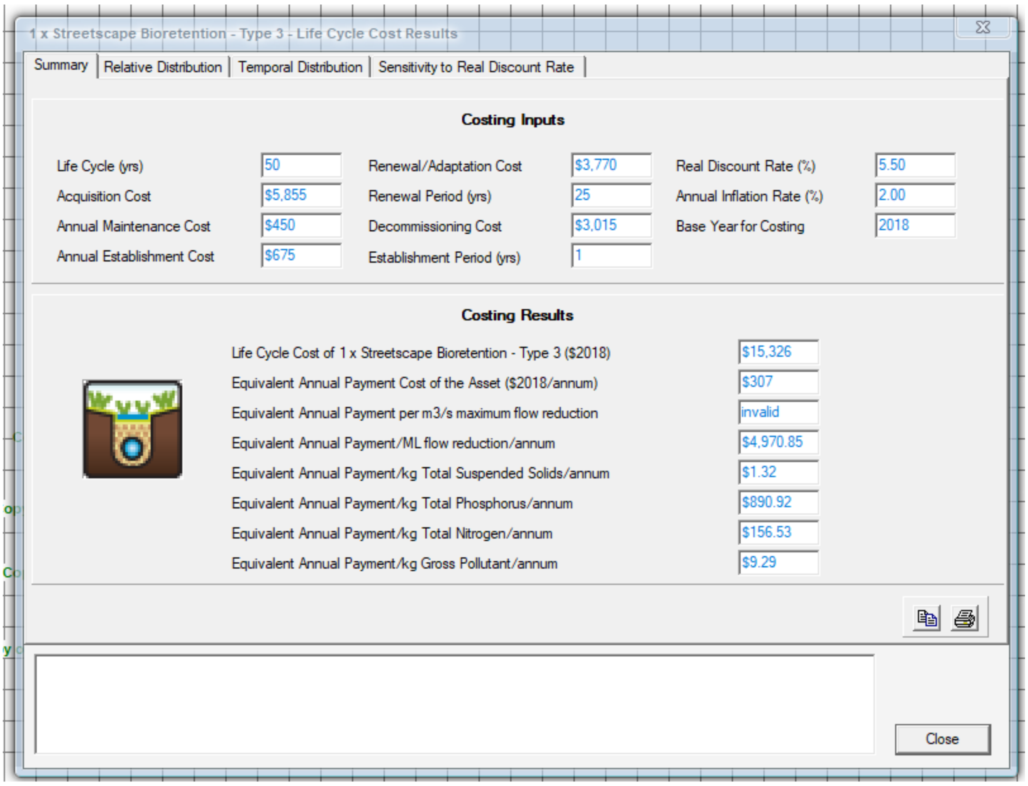
Table C.8 Peak Discharge (m^3/s) – Developed Case

Catchment ID		Annual Exceedance Probability (AEP)					
		39.3%	18.1%	10%	5%	2%	1%
Internal	A	0.114	0.154	0.185	0.223	0.286	0.334
	B	3.566	4.806	5.809	6.995	8.958	10.417
	B(Access Road)	0.031	0.042	0.050	0.061	0.078	0.091
	B2	0.039	0.052	0.063	0.075	0.096	0.112
	C1	0.106	0.144	0.174	0.209	0.267	0.311
	C2	1.584	2.133	2.576	3.105	3.977	4.630
	C3	0.518	0.695	0.836	1.006	1.295	1.509
	D	0.038	0.051	0.062	0.074	0.095	0.110
	E	0.153	0.206	0.248	0.299	0.382	0.445
External	Ext A(1)	0.491	0.659	0.794	0.955	1.230	1.436
	Ext C(1)	0.428	0.574	0.692	0.832	1.069	1.244

Appendix F

MUSIC Modelling - Life Cycle Costing Results

RESULTS SUMMARY



Costing Inputs

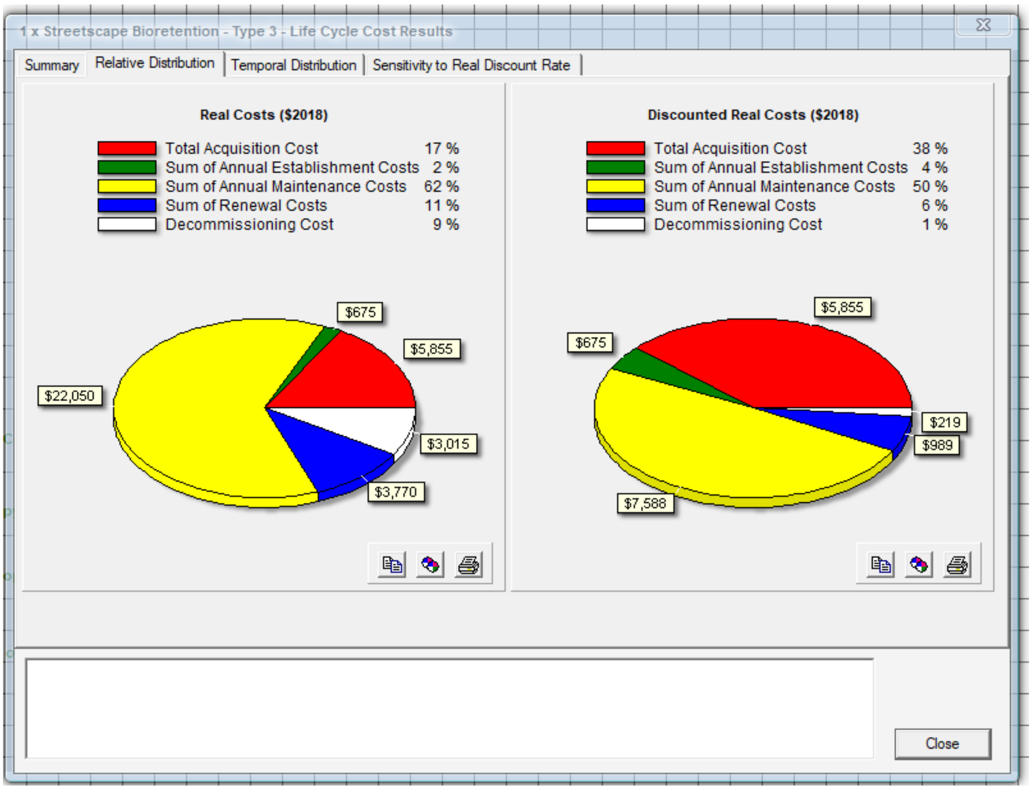
Life Cycle (yrs)	50	Renewal/Adaptation Cost	$3,770	Real Discount Rate (%)	5.50
Acquisition Cost	$5,855	Renewal Period (yrs)	25	Annual Inflation Rate (%)	2.00
Annual Maintenance Cost	$450	Decommissioning Cost	$3,015	Base Year for Costing	2018
Annual Establishment Cost	$675	Establishment Period (yrs)	1		

Costing Results

Life Cycle Cost of 1 x Streetscape Bioretention - Type 3 ($2018)	$15,326
Equivalent Annual Payment Cost of the Asset ($2018/annum)	$307
Equivalent Annual Payment per m3/s maximum flow reduction	invalid
Equivalent Annual Payment/ML flow reduction/annum	$4,970.85
Equivalent Annual Payment/kg Total Suspended Solids/annum	$1.32
Equivalent Annual Payment/kg Total Phosphorus/annum	$890.92
Equivalent Annual Payment/kg Total Nitrogen/annum	$156.53
Equivalent Annual Payment/kg Gross Pollutant/annum	$9.29

RELATIVE DISTRIBUTION RESULTS

Real Costs ($2018)	Cost ($)	% of Total Cost
Total Acquisition Cost	$5,855	17%
Sum of Annual Establishment Costs	$675	2%
Sum of Annual Maintenance Costs	$22,050	62%
Sum of Renewal Costs	$3,770	11%
Decommissioning Cost	$3,015	9%
TOTAL	$35,366	
Discounted Real Costs ($2018)	Cost ($)	% of Total Cost
Total Acquisition Cost	$5,855	38%
Sum of Annual Establishment Costs	$675	4%
Sum of Annual Maintenance Costs	$7,588	50%
Sum of Renewal Costs	$989	6%
Decommissioning Cost	$219	1%
Total	$15,326	



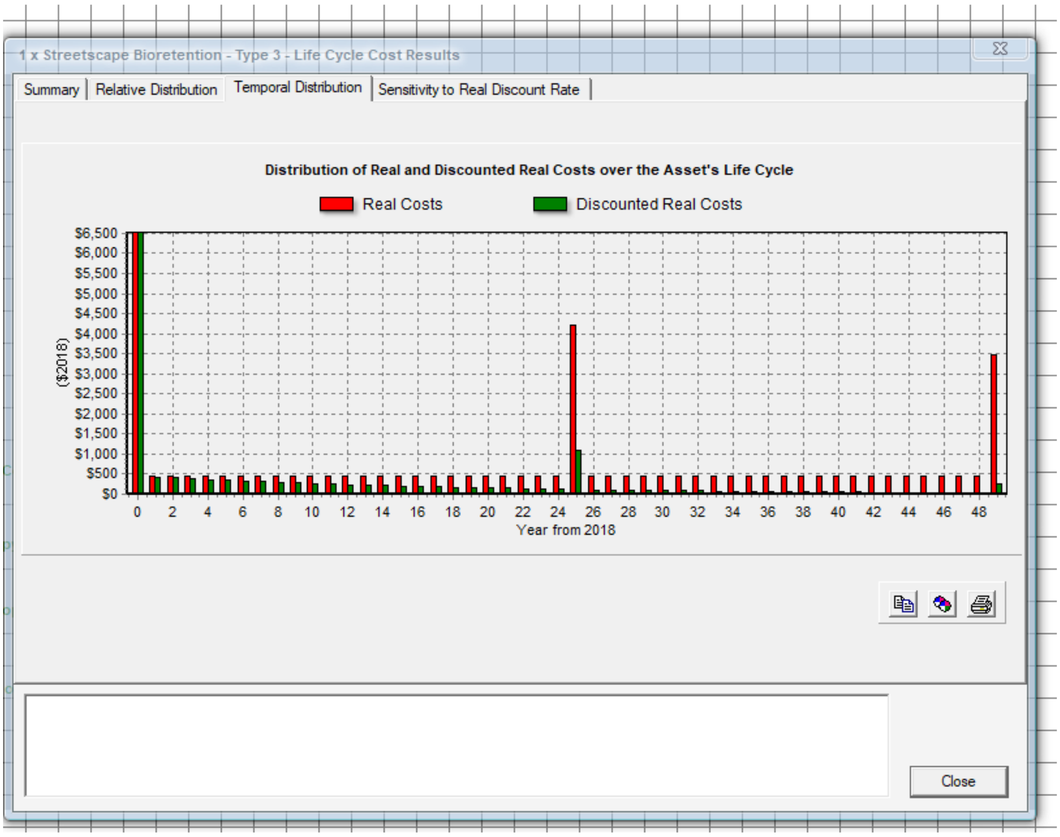
Real Costs ($2018)

🟥	Total Acquisition Cost	17 %
🟩	Sum of Annual Establishment Costs	2 %
🟨	Sum of Annual Maintenance Costs	62 %
🟦	Sum of Renewal Costs	11 %
☐	Decommissioning Cost	9 %

Discounted Real Costs ($2018)

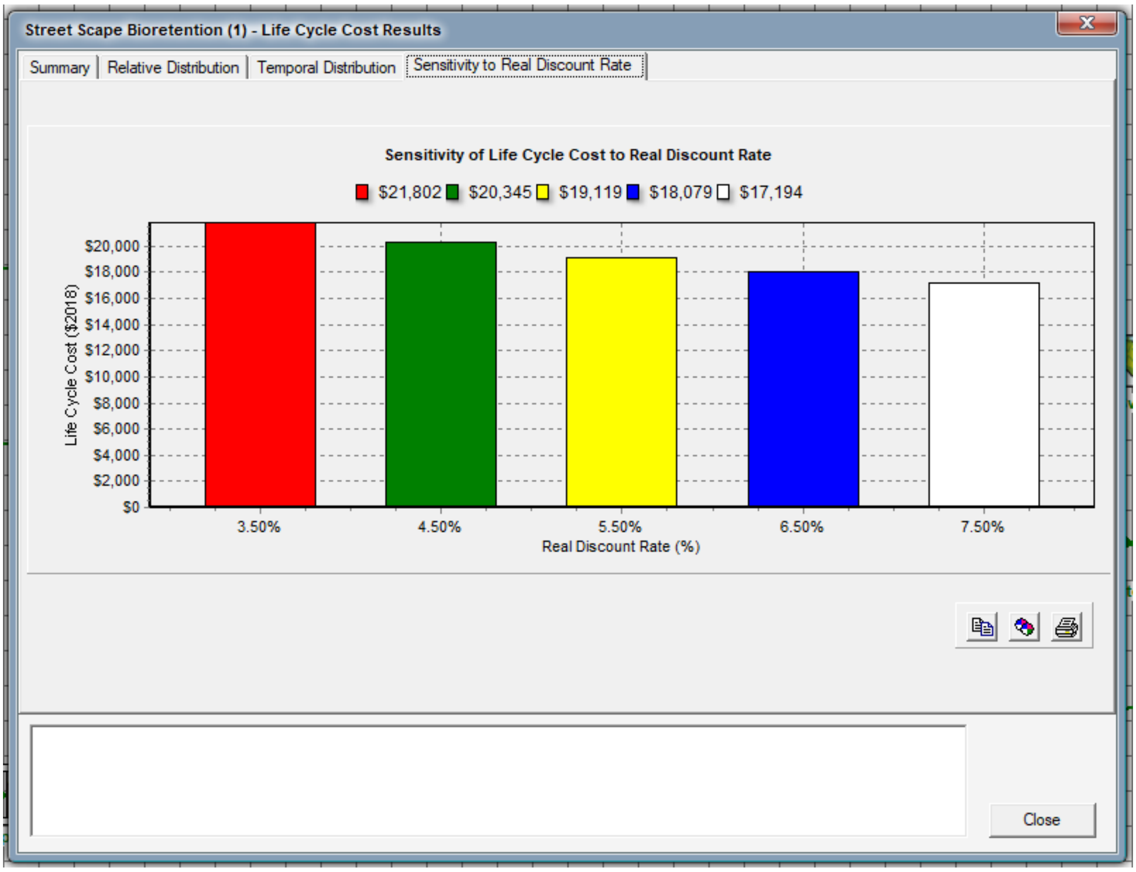
🟥	Total Acquisition Cost	38 %
🟩	Sum of Annual Establishment Costs	4 %
🟨	Sum of Annual Maintenance Costs	50 %
🟦	Sum of Renewal Costs	6 %
☐	Decommissioning Cost	1 %

TEMPORAL DISTRIBUTION COSTS



Distribution of Real and Discounted Real Costs over the Asset's Life Cycle

SENSITIVITY TO REAL DISCOUNT RATE



Appendix G

Bioretention System Maintenance Checklist

Bioretention System Maintenance Checklist			
Inspection frequency		**Date of Visit**	
Date of last rainfall		**Weather**	
Location		**Asset ID**	
Site visit by		**Signature**	

Asset Plan:

Site Photo Explanatory notes:

1.
2.
3.
4.
5.
6.

General Comments/Sketches

What to Look For	Performance Indicator	Condition Rating*	Maintenance Undertaken**	Additional Work Needed
SURROUNDS				
Damage or removed structures	No damage that poses a risk to public or structural integrity.	.		
INLET				
Erosion	Inlet is structurally sound and there is no evidence of erosion or subsidence/settlement.			
Damage or removed structures	No damage that poses a risk to public or structural integrity.			
Sediment, litter or debris	No blockage.			
COARSE SEDIMENT/ ROCK SCOUR PAD				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended.			
Sediment	<75% full and no litter.			
BATTER SLOPES AND BASE INVERT				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended.			
Crust of fine sediment	No surface crusting.			
Depression or mounds	No surface depressions or mounds > 100 mm.			
Hydraulic conductivity or permeability	Filter media is draining freely, whereby water is not ponded on the surface for more than 12 hours after rainfall and there is no obvious impermeable or			

What to Look For	Performance Indicator	Condition Rating*	Maintenance Undertaken**	Additional Work Needed
	clay-like surface on the filter media.			
Underdrains/clean out points	Clean out points not damaged and end caps securely in place.			
Litter	Maximum 1 piece per 4 $m^{2.}$			
Unusual odours, colours or substances (e.g. oil and grease)	None Detected.			
Vegetation	Minimum 95% vegetation cover.			
	Plants healthy and free from disease.			
	Average plant height > 500 mm.			
	No declared weeds.			
	Maximum 10% cover weeds.			
Algal or moss growth	Maximum 10% of surface covered in algae.			
	No Moss growth.			
OUTLET				
Erosion	Outlet is structurally sound and there is no evidence of erosion or subsidence/settlement, including around edges or rock protection or toe of weir.			
Damage or removed structures	No damage that poses a risk to public or structural integrity.			
Sediment, litter debris	No blockage.			
Outlet Freely Draining	No downstream impediments to the release of water, no erosion or damage to the outfall structure and no evidence of malfunction.			

* 1 = PI met; 2 = PI met after maintenance activity undertaken; 3 = Additional maintenance needed; 4 = Rectification may be needed; NI = not inspected; NA = not applicable

** Quantify where possible e.g. amount of sediment or litter removed

Appendix H

Clarence Valley Residential Zones Development Control Plan 2011 (DCP) Assessment (Part X, H, & J)

Table Part X – Urban Release Area Controls – Stormwater Management & Water Quality

Objectives	Does Development Proposal Meet Requirements?
01. Ensure stormwater management associated with the WYURA has regard to the findings of and complements flood modelling and assessment across the entire WYURA.	The SMP & DA by BIOME Consulting considers downstream boundary conditions based on the regional modelling undertaken by BMT over the West Yamba study area. Refer to Section 6.3.5 of the SMP & DA by BIOME Consulting.
02. Ensure that stormwater management areas incorporate functional passive open space.	The proposal includes large open vegetated detention basins with frontage road reserves and footpaths. These basins provide central passive open space to the development.
03. Emphasise a stormwater management system across the entire WYURA that treats and manages stormwater as close to the source(s) as possible.	The development includes at source treatment of runoff within streetscape bioretention systems (pods). Rainwater tanks have also been included for the beneficial reuse of stormwater and are connected to the roof catchment area within each allotment.
04. Ensure that stormwater discharge from residential subdivisions does not compromise the health of nearby natural waterways or the integrity of nearby endangered ecological communities (EECs) or other vegetation communities.	The proposed stormwater treatment train has been designed to achieve the water quality targets specified in Table H2 of the DCP. These load based reduction represent best practice Water Sensitive Urban Design (WSUD).
05. Ensure that a WSUD approach to stormwater management is consistently applied to development and integrated across the entire WYURA.	WSUD has been incorporated within the development proposal. The development proposes numerous streetscape bioretention systems (pods) for incorporation within the road reserve. This design concept will promote at source treatment of runoff from the road network. Rainwater tanks have been included for the beneficial reuse of stormwater and are connected to the roof catchment area within each allotment. It is envisioned that a similar approach could be incorporated into the greater WYURA area, however would be subject to detailed assessment of specific site conditions.
Controls	**Does Development Proposal Meet Requirements?**
C1. All development applications for subdivision are to be generally in accordance with the conceptual Stormwater Network Plan except where more detailed and approved Stormwater Management Plan/s (SMP) justify variation.	The development proposal includes upgrades to Miles Street as shown on Figure x1.3 of the DCP. An assessment of the proposed drainage design for the development has been provided as part of the SMP & DA by BIOME Consulting and has demonstrated a non-worsening impact (Refer to section 6.3.5 of the report).
C2. A SMP or SMPs for the WYURA must be completed to the satisfaction of (and lodged with) the consent authority outlining appropriate management practices to ensure the maintenance of existing hydrological and water quality conditions.	Refer to the attached SMP & DA by BIOME Consulting. Stormwater detention has been included to mitigate peak flows from the development. Stormwater treatment measures have also been included to meet the load based requirements set out in Table H2 of the DCP.

Note – Clause 1.03 Stormwater Management Plans of NRDC Section D10 Handbook of Stormwater Drainage Design setouts out the specific requirements that a SMP must address.	
C3. When lodging detailed design outcomes with various DAs for subdivision the SMP will require the following to meet the following objectives and measures:	Refer to the attached SMP & DA by BIOME Consulting.
a. Details of drainage works, to be in accordance with NRDC, and BMT WBM flood impact assessments and consistent with the outcomes presented in the DCP – including demonstrating that there will be no worsening of flood impacts and to the satisfaction of Council.	a. Details of drainage works and demonstrates there will be no worsening of flood impacts.
b. An overall conceptual / strategic plan of the development area including drainage network solutions for both minor and major systems is required, including calculations.	b. An overall conceptual plan of the proposed drainage network has been included.
c. Any upgrades to existing infrastructure or the construction of new control structures to facilitate the operation of the flooding and drainage system for any development area is to be identified, documented and costed. The future risk, liability and maintenance cost to Council should be considered - for example any ‘causeway’ crossing of Golding Street.	c. Details of the proposed stormwater detention structures and stormwater treatment measures have been provided.
d. life cycle cost analysis and include a maintenance management plan of WSUD facilities in public domain areas.	d. Life cycle cost have been provided for the treatment devices.
e. The proposed lot layout must provide a flood impact assessment and consider existing natural and proposed flow-paths and 1% AEP flood widths.	e. Refer Flood Assessment by BMT WBM.
f. Water quality and quantity issues are to be identified and addressed in accordance with NRDC and demonstrate compliance to NSW Water Quality Objectives in NSW Office of Environment and Heritage. A neutral or beneficial affect is to be achieved (NorBe) for stormwater quality and quantity throughout the WYURA.	f. The report includes proposed designs for both stormwater quantity and quality control measures. Detention has been provided to ensure that peak discharge is mitigated for all modelled events at each discharge location. Stormwater quality devices have been included to achieve load based reductions in accordance with DCP Table H2.
g. Gross pollutant traps and first flush systems shall be provided to protect downstream wetlands, water-bodies and waterways.	g. Street pods have been provided as at source treatment.
C4. Construction of the required stormwater management system/infrastructure (including its various components) and any required upgrades of existing stormwater management system/infrastructure are to be at the expense of developers.	Noted.

C5. Construction water quality impacts are to be mitigated through appropriate erosion and sediment controls in accordance with Managing Urban Stormwater - Soils and Construction ('The Blue Book').	Noted. A Construction Stormwater Management Plan dated July 2021 has been prepared and submitted to Council for the north western portion of the development. A Construction Stormwater Management Plan is to be submitted as part of the application for a construction certificate over the remaining earthworks stages.

Table H1 – ‘Sustainable Water’ Requirements for Development in Residential Zones

Objectives	Development with impermeable surface >500m2 post development Subdivision greater than 25 lots Requirements	Does Development Proposal Meet Requirements?
The principles of Water Sensitive Urban Design are to be applied. (As described in “Sustainable Water Requirements: Information For Applicants” Section 4.2)	√	**Complies** Development is not proposed within waterway corridors. Instead at source stormwater treatment is promoted via the inclusion of streetscape treatment measures. Rainwater tanks have been proposed to promote reuse of stormwater.
Grass swales are to be used in place of kerb and gutter where conditions are suitable.	√	**Complies** Whilst kerbs will be included within the road design for conveyance, at source stormwater treatment is promoted via the inclusion of streetscape treatment measures.
The drainage, road and open space networks are to comply with any requirements of any master plan in place for the area.	√	There is currently a conceptual stormwater network plan for the WYURA (Figure x1.3 of the DCP). The development proposal includes upgrades to Miles Street as shown on this plan.
In the absence of a master plan the drainage network must plan, design and implement infrastructure in recognition of connectivity, restrictions and impacts upstream, neighbouring and downstream infrastructure and environment which extends beyond the boundaries of the proposed development.	√	**Complies** The proposed drainage design has been designed and assessed to achieve a non-worsening in terms of hydraulic impacts. Refer to Section 6.3 of the SMP & DA by BIOME Consulting for the site.
Stormwater quality is to meet the water quality targets for development as outlined in TABLE H2.	√	**Complies** Stormwater management measures (bioretention pods) have been included within the development and sized to meet the water quality targets outlined in Table H2.
Stormwater quality is to be achieved through the adoption of Water Sensitive Urban Design principles and/or Stormwater Quality Improvement Devices. (As described in “Sustainable Water Requirements : Information for Applicants” Sections 6 and 7.)	√	**Complies** Stormwater management measures (bioretention pods) have been included within the development and sized to meet the water quality targets outlined in Table H2. Bioretention measures are considered a dry system (i.e. they drain dry as opposed to a wet sump system). General maintenance requirements are specified within Section 8 of the SMP & DA by BIOME Consulting for the site.

Reinstatement of Vegetation in Riparian and Stream Buffer Zones in accordance with Council improvements.	√	The development retains the central riparian waterway and provides buffer zones.
Impermeable areas to be limited by using porous/modular pavers for all external paving where conditions are suitable.	√	The stormwater treatment train includes at source bioretention pods which will promote infiltration. The two large detention basins will also allow for infiltration of frequent flows.
Water efficient landscaping to be implemented. (As described in "Sustainable Water Requirements : Information For Applicants" Section 4.4.)	√ Subdivision	The stormwater treatment train includes at source bioretention pods within the road reserves. These landscape areas will capture frequent flows and support ephemeral plant species.
Stormwater runoff volumes and frequency reduced or maintained to the pre development through application of Harvesting, Retention, Infiltration and Detention as appropriate. (As described in "Sustainable Water Requirements : Information For Applicants.")	o increase in impermeable surface	**Complies** Reuse of stormwater is promoted via roof collection into rainwater tanks (lot based). Two (2) Detention basins have been proposed for mitigation of peak flows from the development site. These basins have been designed with purpose built outlet structures to maintain pre-development peak flows.
Limit cut or fill used on site (pylons, piers, posts, walls etc to be used in place where possible).	√	The site is in a low lying/flooded area. Filling of the site is required to raise the development such that lots achieve the required flood immunity.
Post development peak flows not to exceed pre development peak flows specified within council policy and design standards.	√	**Complies** Detention of stormwater flows from the development site is proposed within two (2) detention basins. Thes basins and associated outlet structures have been designed to mitigate peak flows to the pre-developed scenario. Refer to Section 6 of the SMP & DA by BIOME Consulting for the site.
A Site Plan must be submitted. (As described in "Sustainable Water Requirements : Information For Applicants" Section 2)	Detailed	**Complies – Stormwater.** Refer to the SMP & DA by BIOME Consulting for the site. This report includes site plans, hydrological & hydraulic assessments, sizing & details of stormwater quantity & quality management measures and maintenance requirements.

Key: √ = Must Comply x = Does not comply o = Optional

J10 – Stormwater Management (Part J – Subdivision & Engineering Controls

Objectives	Does Development Proposal Meet Requirements?
J10.1 Stormwater management and drainage systems should be an integral part of the subdivision design. Stormwater management, open space networks and habitat corridors should be integrated. Stormwater should be managed so there is minimal or no impact on the natural environment.	**Complies** Development is not proposed within existing waterway/natural corridors. At source stormwater treatment is promoted via the inclusion of streetscape treatment measures and rainwater tanks have been proposed to promote reuse of stormwater. The stormwater treatment train has been designed to achieve the load-based reductions required in Table H2 of the DCP. Detention measures have been proposed to mitigate peak flows from the development such that pre-developed peak flows area maintained at the nominated discharge locations. The detention basins are integrated into the development and are central located and provide passive open space opportunities. Refer to advice provided by the Ecological Consultant for information relating to the potential for impact to the natural environment.
J10.2 Stormwater management should be based on the principles of 'water sensitive urban design'. This approach requires managing water use and runoff at the lot level and emphasises the reuse of stormwater and wastewater.	**Complies** At source stormwater treatment is promoted via the inclusion of streetscape treatment measures and rainwater tanks have been proposed to promote reuse of stormwater. The stormwater treatment train has been designed to achieve the load-based reductions required in Table H2 of the DCP.
J10.3 A flood study may be required by Council in circumstances where development may be impacted by flooding from nearby local catchment flow paths or drainage systems.	**Complies** A flood study has been completed for the West Yamba study area by BMT WBM.
J10.4 Stormwater design must take into account future maintenance. Compliance with the sustainable water controls in Part H of this DCP is required.	**Complies** All streetscape stormwater treatment measures can be accessed via the internal road network/reserves. 3.0m wide maintenance 1:4 accesses have been proposed for the detention basins within the site (Refer to dwgs 311 & 312 of the SMP & Drainage Assessment Report by BIOME).
J10.5 In the R5 Large Lot Residential zones at least 2.5 metres of the footpath area must be available for pedestrians and service authorities. Some longitudinal drainage may be required to keep the table drain to a size to provide for the pedestrian area. Table drains should have a maximum batter of 1 in 6.	**N/A** The subject site is not located within the R5 Large Lot Residential Zone.

Appendix I

Preliminary Geotechnical Assessment (Regional Geotechnical Solutions, 26 July 2018)

REGIONAL GEOTECHNICAL SOLUTIONS

Manning-Great Lakes
Port Macquarie
Coffs Harbour

RGS31546.1-AB

26 July 2018

Garrard Building Pty Ltd
PO Box 538
YAMBA NSW 2464

Attention: Neil Garrard

Dear Neil

RE: Proposed Residential Development – 52-54 Miles Street, Yamba NSW

Preliminary Geotechnical Assessment

1 INTRODUCTION

Regional Geotechnical Solutions Pty Ltd (RGS) has undertaken a geotechnical assessment for a development that is proposed to be constructed at 52-54 Miles Street, Yamba NSW (Lots 46 and 47 DP751395).

The proposed development is understood to involve large scale earthworks to raise the site levels to at least RL3m AHD (fill depths of generally 1.5 to 2m) which will allow the site to be subdivided for residential development. Specific details such as final fill depths, the type of fill material or the proposed lot layout have not yet been provided. It has been assumed that either single or double storey residential structures are likely to be constructed at the site following earthworks.

The purpose of the work as presented herein was to provide comments and recommendations on the following:

- Subsurface profile including depth of topsoil, presence of marine clays or silts, and groundwater level (where encountered) in the upper approximately 1m of the subsurface profile;
- Thickness of unsuitable materials (including topsoil, silt deposits or low strength marine clays, etc.) that would require stripping prior to fill placement;
- Preliminary earthworks recommendations; and
- In-situ permeability for stormwater infiltration pond design (design to be undertaken by others).

2 METHODOLOGY

Field work for the assessment was undertaken by a Geotechnical Engineer on 26 June 2018 and included:

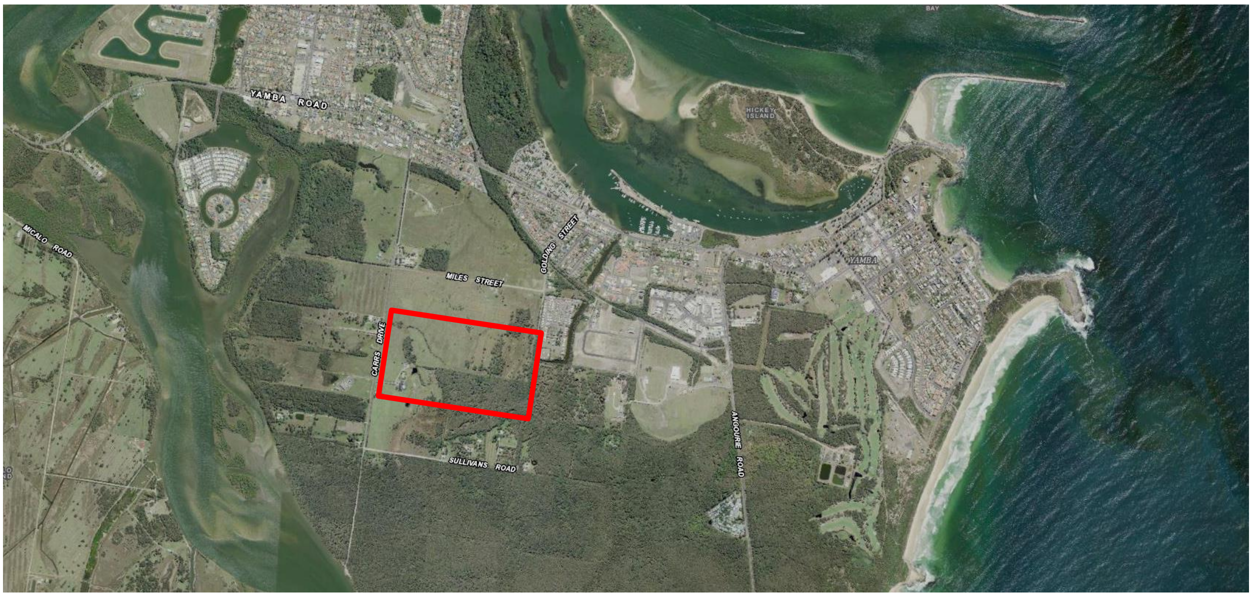
- Observation of site features and surrounding features relevant to the geotechnical conditions of the site;
- Eleven test pits (TP1 to TP11) with a 2 tonne excavator to depths of between 1 and 1.35m;
- Dynamic Cone Penetrometer (DCP) testing adjacent to selected test pits; and
- In-situ falling head permeability testing adjacent to TP5 and TP7.

Engineering logs of the test pits and the in-situ permeability test result sheets are attached. The locations of the test pits are illustrated on Figure 1 and were measured with a hand held GPS. The test locations were nominated by Paul Paskins of Mortons Urban Solutions.

3 SITE CONDITIONS

3.1 Surface Conditions

The approximately 42ha rectangular site is bound by Miles Street to the north, Carrs Drive to the west, Golding Street to the east, and by rural-residential lots and bushland to the south. An aerial photograph that illustrates the site location and site setting is shown below.



Site location and setting is illustrated on the NSW Government 'Six Maps'. The approximate boundary of the site is shown by a red box

The site is located within a region characterised by low lying sand flats with localised swamp deposits in lower lying areas and depressions across the site. The provided survey indicates that site levels are generally between about RL1.0 to 1.4m (AHD) with lower lying depressions and drainage lines having elevations of between about 0.5 to 1.0m. The intermittent drainage lines drain to both the northeast towards the Clarence River and to the southwest towards Oyster Channel. In addition to the drainage lines, surface waters were observed to be ponding in a number of lower areas across the site and the extents of the larger areas are estimated approximately on Figure 1. These areas were untrafficable on the day of the site investigation. Smaller untrafficable areas were also scattered across the site in localised depressions.

Two residential dwellings are located in the northeast of the site. Typical site photographs are presented below.

 *Looking west from the southeast corner of the site. Groups of trees are scattered across this area.*	 *Looking south across the northwest portion of the site. This area was trafficable*
 *A row of trees can be seen which are located on the edge of a drainage line in the southwest of the site that drains into Oyster Channel*	 *Looking north from the central portion of the site at open farmland. Lower lying depressions were untrafficable.*

 *Untrafficable boggy ground near the central portion of the southern boundary*	 *Surface water ponding in the southwest portion of the site*
 *A row of trees is present on the edge of a drainage line in the southwest of the site. Water was present within the drainage line*	 *Looking south along the eastern site boundary. Boggy areas were encountered in lower lying portions of the site.*

3.2 Subsurface Conditions

The 1:25,000 Yamba Quaternary Geology Map indicates that the site is predominantly underlain by a Holocene tidal-delta flat that comprises marine sand, silt, clay, shell and gravel. The lower lying drainage lines that are located at the site are underlain by a Holocene saline swamp that comprises organic mud, peat, clay, silt and sand, that overlies the tidal-delta flat outline above.

The subsurface conditions encountered within the test pits are summarised in Table 1. Test pit logs and photographs of each of the test pits are attached.

Table 1: Summary of Subsurface Conditions Encountered in Test Pits

Material Name	Material Description	Depth to Base of Material Layer (m)										
		TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11
Topsoil	Silty SAND, dark grey, higher organic content in the upper approximately 50mm.	0.2	0.25	--	--	0.25	0.2	0.25	--	--	0.25	0.2
	Sandy SILT was encountered in TP3 and TP9, and Sandy CLAY in TP4 and TP8			0.1	0.2				0.15	0.25		
Alluvial Clay	Silty CLAY, medium to high plasticity, firm	--	--	0.4	0.4	--	--	--	0.35	0.55	--	--
Alluvial Sand	SAND, fine to medium grained, medium dense to dense	≥1.1	≥1.2	≥1.1	≥1.1	≥1.3	≥1.0	≥1.2	≥1.3	≥1.3	≥1.1	≥1.3

Notes: -- indicates that the material was not encountered at the test location
≥ indicates that the base of the material layer was not encountered at the test location

Groundwater was encountered within all the test pits excavated during the investigation. Groundwater levels do fluctuate due to inclement weather, seasonal variations, tidal influences, or due to reasons that may not have been apparent at the time of the site investigation. A summary of the groundwater levels inflows encountered during the investigation is presented in Table 2.

Table 2: Summary of Groundwater Inflow Depths

Summary of Groundwater Inflow Depths (m)										
TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11
0.7	0.9	0.7	0.65	0.9	0.8	1.0	0.95	0.7	0.8	0.8

4 PROPOSED DEVELOPMENT

The proposed development is understood to involve raising the site level to above RL3m (AHD) and subdividing the approximately 42Ha site for residential development which will include the construction of roads, the installation of underground services and likely single and/or double storey residential dwellings.

Earthworks associated with the development will include the placement of generally between 1.5 to 2m of imported fill and at this stage it is understood that a source of fill material has not yet been confirmed. Two stormwater detention ponds are proposed at the site within the general vicinity of TP3 and TP5 and localised excavations (after fill placement) are likely to be required for the construction water/sewer services and the like.

5 SITE APPRECIATION & GEOTECHNICAL CONSTRAINTS

The site is generally underlain by 0.2 to 0.25m of sandy topsoil that overlies medium dense to dense sands. Alluvial clays were encountered within four of the eleven test pits to depths of between 0.35 and 0.55m and the overlying topsoil within these areas comprises clay and silt materials. The clay materials can be generalised as being located within or closely adjacent to the naturally lower lying areas of the site that are identified on Figure 1. Groundwater inflows were encountered within all eleven test pits at depths of between 0.65 and 1.0m.

Several geotechnical constraints have been identified during the assessment that will need to be addressed during the planning and design stages of the development as well as during construction. A summary of the identified constraints is presented below. Further details and recommendations are presented in subsequent sections of this report.

- The site is poorly drained. The test pit investigation was undertaken after a wet weather event and surface waters were present within lower lying areas of the site. Untrafficable 'boggy' areas were identified to be surrounding the surface waters and in isolated depressions that are scattered across the site. Initial site preparation works will be critical to improve drainage conditions during the initial stages of construction;
- Between 200 and 250mm of topsoil was generally encountered within the test pits that were excavated during the investigation. The topsoil was generally a Silty SAND material with a high organic content within the upper approximately 100mm. CLAY and SILT topsoil materials were encountered within four of the test pits that overlie low strength clays as discussed below;
- Firm normally consolidated clays were encountered within four of the eleven test pits excavated during the investigation. This material is likely to undergo both elastic and consolidation settlement during and following fill placement;
- The site investigation was undertaken with a small tracked excavated and the test pits were terminated within wet sands at depths of between 1 and 1.3m. Deeper investigations involving either boreholes or Cone Penetration Tests (CPTs) have not been undertaken and there is the potential for thick normally consolidated clay deposits to be located at depth. If present these layers would likely undergo consolidation settlement due to the surcharge load that is to be applied by the fill and the proposed structures both during and post construction; and
- Groundwater was encountered at depths of between 0.65 and 1.0m. Careful consideration will therefore be required during the planning of the initial fill placement and with the selection and maintenance of haul roads and high trafficked areas.

6 EARTHWORKS

6.1 Site Preparation

Surface waters and saturated 'boggy' ground is present over large portions of the site. The site is poorly drained and extended delays should be expected during the initial stages of earthworks during and after rainfall events and potentially after king tides. The implementation of good site drainage during the initial stages of the development will reduce the risk and extent of delays and will be essential for the successful completion of the initial earthworks stages at the site. The principle aim of the drainage is to promote controlled surface water run-off, reduce the velocity of flow and to reduce the potential for water to pond. During the initial stages of earthworks it may be necessary to construct localised sump points and swale drains to enable surface water to be pumped and removed from the site. Given the size of the site and extent of works it may be necessary to construct multiple onsite sedimentation basin as part of the overall site erosion and sediment control plan.

Earthworks should be carefully planned and scheduled to maintain suitable cross-falls so as to promote controlled runoff of surface water. Adequate silt control and dissipation measures will need to be employed to reduce the potential for silt entering the storm water system to the south and west of the site. An earthworks management plan (EMP), including an erosion and sediment control plan should be prepared prior to site works commencing.

6.2 Stripping, Fill Placement & Compaction Control

6.2.1 Stripping Options

Site preparation works will therefore generally require the removal of vegetation including the stripping of all organic and root affected material. Any deleterious material or material that appears potentially contaminated should also be stripped and disposed of. These materials are not considered suitable for reuse as engineered fill and should be disposed of offsite, pending appropriate waste classification or exemption, or stockpiled on site where appropriate for later reuse in landscaping areas only.

Based on the results of the assessment and following discussions with you, two options are presented to address the required degree of stripping of unsuitable materials at the site:

Option 1 – Stripping of Organic Rich Materials & Alluvial Clays

This option involves stripping the upper organic rich topsoil and the underlying firm alluvial clay materials that were encountered to depths of up to 0.55m. Based on the results of the site investigation, areas of the site that are not underlain by shallow alluvial clay deposits are likely to require stripping of about 100mm of organic rich materials, however, thicker organic layers may be encountered between the test pit locations.

Option 1 is the preferred option as it removes the risk of consolidation settlement post construction of the shallow alluvial clay layers.

Option 2 – Stripping of organic rich materials only

This option includes stripping the upper organic rich topsoil materials that have an estimated thickness of about 100mm based on the result of the test pits, without removing the firm clay materials that were encountered within TP3, TP4, TP8 and TP9. Selection of this option will involve accepting the risk of differential settlements across the site due to the likely consolidation of the firm alluvial clay layer, however, the degree of risk could be reduced by undertaking regular monitoring of the surface height of the fill (relative to a fixed point outside of the site) over a period of months and potentially years after the completion of earthworks. If this option is selected then it is recommended that the extents of the firm alluvial clay layer which are likely to be identifiable following the initial stripping be recorded by a surveyor.

6.2.2 Fill Placement & Compaction Control

Where fill is required to raise the site to design levels for the placement of high level footings or pavements, following removal of topsoil and other unsuitable materials as discussed above the following outlines the recommended fill placement procedures:

- The site has a shallow water table and careful consideration will be required during the design of the earthworks program to reduce the potential for construction traffic to 'pump' water up into the shallow subgrade soils and the lower fill layers. It is therefore recommended that nominated haul routes be selected and an allowance be made for the placement of rock bridging layers within these areas. It is also recommended that only static compaction be used until at least 1.2m of fill has been placed;
- After unsuitable material has been stripped to expose the underlying alluvial soils (either Option 1 or Option 2 as outlined in Section 6.2.1), the exposed natural subgrade should be proof roll tested (with a large grader, loaded water cart or the like) in the presence of a suitably experienced geotechnical practitioner to highlight any soft, wet or excessively deflecting areas. Where these are encountered, it is recommended that a Geotechnical Engineer be engaged to provide advice regarding appropriate remedial measures and the required extents. Such measures will be dependent on the depth of the water table, the thickness and type of the low strength material, the depth of fill that is to be placed, and the end use of the area (i.e. supporting structures or pavements, etc.). Remedial measures may include:
    - Removing the low strength material and replacing with granular fill such as select fill, crushed concrete or pavement gravel (DGS40);
    - Rock bridging layers which would typically comprise about 400mm of very high strength clean angular no fines rock with a particle size of between about 50 and 150mm, or alternatively clean crushed concrete. The bridging layer should be fully wrapped in a heavy duty geofabric such as Bidim A34 or equivalent;
    - Placement of a 40kN biaxial or triaxial geogrid over the exposed material and covered with at least say 300mm of granular fill; and
    - A combination of some of the above measures.
- Due to the shallow water table it is recommended that two 300mm thick layers of clean granular fill be placed across the site to provide a suitable platform to aid in the placement of the overlying fill layers;
- If a rock bridging layer (wrapped in geofabric) or a geogrid layer is to be placed at the site (as discussed above) consideration should be given to the potential implications to future excavation of service trenches such as sewer/water etc.;
- Where filling is required beneath structures, approved fill should be placed in layers not exceeding 250 mm loose thickness and compacted to a minimum dry density ratio of not less than 98% of standard compaction. Clay fill should be placed and maintained within ±2% of standard optimum moisture content. Unless non-reactive fill is used the surface movement characteristics may change significantly and the site classification should be revised;
- Where filling is required beneath pavement layers, suitable fill should be placed in layers not exceeding 300 mm loose thickness and compacted to a minimum dry density ratio of 95% standard compaction, with the upper 300mm of the subgrade being compacted to at least 100% SMDD. Clay fill should be placed and maintained within 2% of standard optimum moisture content; and

- Where filling is required on batters, the material should be over-placed, compacted, and then trimmed back to the required batter to ensure that compaction is achieved to edge of batter.

In accordance with AS3798-2007, it is recommended that Level 1 control be implemented for areas of the site that are filled to support structures, while areas of the site that are filled to support pavements should be filled under Level 2 supervision and testing. Level 1 control will be required to avoid the future residential lots being classified as Class 'P' sites in accordance with AS2870-2011 '*Residential Slabs and Footings*'.

6.2.3 Deep Consolidation Settlements

As discussed in Section 5, the preliminary geotechnical investigation presented herein was limited to a depth of 1.3m. The site is located within the Clarence coastal delta and is underlain by deep alluvial and marine deposits that extend to depths of up to at least about 30 to 40m. There is therefore a risk that normally consolidated marine clays underlie the site at depth which may undergo consolidation settlement due to the loads imposed by the fill and the residential structures.

The amount of consolidation settlement and the lateral extent and potential for deep seated differential settlements have not been assessed as part of this assessment and would require deep geotechnical investigations, laboratory testing and detailed analysis. Consolidation settlements would be expected to be induced during fill placement and may continue to occur for a number of months and potentially years after the completion of bulk earthworks at the site.

7 STORMWATER INFILTRATION

Two falling head infiltration tests were undertaken within the alluvial sands at the site. The locations of the tests are nominated on Figure 1 as TP5 and TP7. The testing indicated that the alluvial sands have an infiltration rate of between about 2×10^{-4}m/s and 7×10^{-4}m/s. Calculation sheets are attached.

The site is considered suitable for bioretention of stormwater and it is recommended that a design infiltration rate of 2×10^{-4}m/s be adopted.

8 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical and pavement design practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If site conditions encountered during construction vary significantly from those discussed in this report, Regional Geotechnical Solutions Pty Ltd should be contacted for further advice.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Simon Keen

Senior Geotechnical Engineer

Attachments:	Figure 1 – Test Pit Location Plans Test Pit Logs & Photographs

REGIONAL
GEOTECHNICAL
SOLUTIONS

Client:	Garrard Building PTY LTD	Job No.	RGS31546.1
Project:	Proposed Development	Drawn By:	LD
	52-54 Miles Street Yamba NSW	Date:	9-Jul-18
Title:	Test Pit Location Plan	Drawing No.	**FIGURE 1**

ENGINEERING LOG - TEST PIT

TEST PIT NO: TP1
CLIENT: Garrad Building Pty Ltd
PAGE: 1 of 1
PROJECT NAME: Proposed Development
JOB NO: RGS31546.1
SITE LOCATION: 52-54 Miles Street, Yamba
LOGGED BY: LD
TEST LOCATION: Refer to Figure 1
DATE: 26/6/18

EQUIPMENT TYPE: 2t Excavator
EASTING: 532334 m
SURFACE RL:
TEST PIT LENGTH: 1.6 m **WIDTH:** 0.3 m
NORTHING: 6743389 m
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey	M		DCP (0-1.7m)	1	TOPSOIL
							0.20m				1	
						SP	**SAND:** Fine to medium grained, grey, some Silt	M	MD		2	ALLUVIAL SOIL
											3	
				0.5							3	
	2:09:00 PM						0.60m				3	
						SP	**SAND:** Fine to medium grained, pale grey				4	
	►						0.80m	W			4	
						SP	**SAND:** Fine to medium grained, grey				4	
									D		6	
				1.0			1.10m				6	
							Hole Terminated at 1.10 m				6	
											5	
											5	
				1.5							4	
											3	
											2	

LEGEND:

Water

▼ Water Level (Date and time shown)
► Water Inflow
◄ Water Outflow

Strata Changes

– – – Gradational or transitional strata
——— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP1 encountered 0.2m of topsoil overlying sand. Groundwater was encountered at 0.7m.

Excavated material from TP1

Client:	Garrard Building Pty Ltd		Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba		Drawn By:	SK
			Scale:	NTS
			Date:	26-Jul-18
Title:	Test Pit Photographs - TP1		Drawing No.	

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP2**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**	532669 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.6 m	**WIDTH:**	0.3 m	**NORTHING:**	6743315 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey	M		DCP (0-1.6m)	2	TOPSOIL:GRASS
											2	
							0.25m				2	
						SP	**SAND:** Fine to medium grained, grey, with some Silt	M	MD		3	ALLUVIAL SOIL
											2	
				0.5		SP	0.50m **SAND:** Fine to medium grained, pale grey, pale yellow				2	
											3	
											2	
	10:00:00 AM										3	
	▶—							W			5	Test Pit collapsing below water table
				1.0							4	
											4	
							1.20m Hole Terminated at 1.20 m				2	
											3	
											4	
				1.5							5	

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP2 encountered 0.25m of topsoil overlying sand. Groundwater was encountered at 0.9m.

Excavated material from TP2

	Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
	Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
			Scale:	NTS
			Date:	26-Jul-18
	Title:	Test Pit Photographs - TP2	Drawing No.	

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP3**
		PAGE:	1 of 1
PROJECT NAME:	Proposed Development	**JOB NO:**	RGS31546.1
SITE LOCATION:	52-54 Miles Street, Yamba	**LOGGED BY:**	LD
TEST LOCATION:	Refer to Figure 1	**DATE:**	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**		**SURFACE RL:**	
TEST PIT LENGTH:	1.6 m	**WIDTH:**	0.3 m	**NORTHING:**		**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						ML	**TOPSOIL:** Sandy SILT, low plasticity, dark brown	M > W_P		DCP (0-0.7m)	1	TOPSOIL
				0.10m		CH	**Silty CLAY:** Medium to high plasticity, grey, pale brown	M > W_P	F		3	ALLUVIAL SOIL
											12	
											5	
				0.40m		SM	**Silty SAND:** Fine to medium grained, grey	W	D		6	
				0.5							8	
				0.60m		SP	**SAND:** Fine to medium grained, pale grey				10	
	1:30:00 PM ▶											
				1.0								
				1.10m			Hole Terminated at 1.10 m					
				1.5								

LEGEND:

Water

Water Level (Date and time shown)
▶— Water Inflow
—◀ Water Outflow

Strata Changes

— — Gradational or transitional strata
—— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP3 encountered 0.1m of topsoil overlying firm clay to 0.4m, overlying sand. Groundwater was encountered at 0.7m.

Excavated material from TP3

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP3	Drawing No.	

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - TEST PIT

CLIENT: Garrad Building Pty Ltd
PROJECT NAME: Proposed Development
SITE LOCATION: 52-54 Miles Street, Yamba
TEST LOCATION: Refer to Figure 1

TEST PIT NO: **TP4**
PAGE: 1 of 1
JOB NO: RGS31546.1
LOGGED BY: LD
DATE: 26/6/18

EQUIPMENT TYPE: 2t Excavator
TEST PIT LENGTH: 1.7 m **WIDTH:** 0.3 m
EASTING: 532384 m
NORTHING: 6743163 m
SURFACE RL:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator				0.20m		CL	**TOPSOIL:** Sandy CLAY, medium plasticity, dark grey	M > W_P				TOPSOIL
				0.40m		CL	**Sandy Silty CLAY:** Medium plasticity, grey, brown, with trace coarse gravel	M < W_P	F	HP	100	ALLUVIAL SOIL
	2:40:00 PM ▶			0.5 1.0 1.10m		SP	**SAND:** Fine to medium grained, pale grey, pale brown	M W	MD	HP	90	
				1.5			Hole Terminated at 1.10 m					

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP4 encountered 0.2m of topsoil overlying firm clay to 0.4m, overlying sand. Groundwater was encountered at 0.65m.

Excavated material from TP4

	Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
	Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
			Scale:	NTS
			Date:	26-Jul-18
	Title:	Test Pit Photographs - TP4	Drawing No.	

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP5**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**	532634 m	**SURFACE RL:**	
TEST PIT LENGTH:	2.0 m	**WIDTH:**	0.3 m	**NORTHING:**	6743129 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey	M				TOPSOIL:GRASS
							0.25m					
						SM	**SAND:** Fine to medium grained, grey, with some Silt	M	MD			ALLUVIAL SOIL
							0.40m					
				0.5		SP	**SAND:** Fine to medium grained, pale grey, pale brown					
	10:30:00 AM ▶							W				
				1.0			1.00m					
						SP	**SAND:** Fine to medium grained, grey, pale brown		D			
							1.30m					
							Hole Terminated at 1.30 m					
				1.5								

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP5 encountered 0.25m of topsoil overlying sand. Groundwater was encountered at 0.9m.

Excavated material from TP5

	Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
	Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
			Scale:	NTS
			Date:	26-Jul-18
	Title:	Test Pit Photographs - TP5	Drawing No.	

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP6**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator	**EASTING:**	532813 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.7 m **WIDTH:** 0.3 m	**NORTHING:**	6743105 m	**DATUM:**	AHD

Drilling and Sampling				Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator				0.20m	SM	**TOPSOIL:** Clayey Silty SAND, fine grained, grey, dark grey	M	L	DCP (0-1.4m)	1 1	TOPSOIL
				0.5 0.50m	SP	**SAND:** Fine to medium grained, grey, with some silt	M	MD		2 3 3	ALLUVIAL SOIL
	11:40:00 AM			1.0 1.00m	SP	**SAND:** Fine to medium grained, pale grey, pale brown	W			4 4 4 4 5	
				1.5		Hole Terminated at 1.00 m				6 6 7 5	

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP6 encountered 0.2m of topsoil overlying sand. Groundwater was encountered at 0.8m.

Excavated material from TP6

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP6	Drawing No.	

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP7**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**	533034 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.7 m	**WIDTH:**	0.3 m	**NORTHING:**	6743047 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator				0.25m		SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey	M		DCP (0-1.3m)	2 3 2	TOPSOIL:GRASS
				0.5 0.50m		SM	**SAND:** Fine to medium grained, grey, with some silt and trace of roots	M	MD		3 4	ALLUVIAL SOIL
				0.80m		SP	**SAND:** Fine to medium grained, grey, pale brown				4 5 4	
	12:50:00 PM ▶—			1.0 1.20m		SP	**SAND:** Fine to medium grained, pale grey, pale brown	 W	 D		5 7 6 8	
				1.5			Hole Terminated at 1.20 m				7	

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP7 encountered 0.25m of topsoil overlying sand. Groundwater was encountered at 1m.

Excavated material from TP7

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP7	Drawing No.	

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP8**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator		**EASTING:**	532348 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.6 m	**WIDTH:** 0.3 m	**NORTHING:**	6743066 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						CL	**TOPSOIL:** Silty CLAY, medium plasticity, dark grey 0.15m	M > w_P		HP	100	TOPSOIL:GRASS
						CH	**Silty CLAY:** High plasticity, grey, mottled pale brown 0.35m	M > w_P	F	HP	100	ALLUVIAL SOIL
				0.5		SC	**SAND:** Fine to medium grained, pale grey, pale brown, with trace clay	M	MD			
	3:40:00 PM ▶—							W				
				1.0		SP	1.00m **SAND:** Fine to medium grained, grey 1.30m					
							Hole Terminated at 1.30 m					
				1.5								

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- ——— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP8 encountered 0.15m of topsoil overlying firm clay to 0.35m, overlying sand. Groundwater was encountered at 0.95m.

Excavated material from TP8

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP8	Drawing No.	

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP9**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**	532256 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.6 m	**WIDTH:**	0.3 m	**NORTHING:**	6742998 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator				0.25m		ML	**TOPSOIL:** Clayey SILT, low plasticity, dark brown, with trace of fine grained sand	M > w_P				TOPSOIL:GRASS
				0.5 0.55m		CH	**Silty CLAY:** High plasticity, grey, orange-brown, with some rootlets	M > w_P	F	HP	80	ALLUVIAL
	4:00:00 PM ►			1.0 1.00m		SP	**SAND:** Fine to medium grained, pale grey, pale brown	M	MD			
				1.35m		SP	**SAND:** Fine to medium grained, grey, pale brown	W				
				1.5			Hole Terminated at 1.35 m					

LEGEND:

Water

- Water Level (Date and time shown)
- ► Water Inflow
- ◄ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP9 encountered 0.25m of topsoil overlying firm clay to 0.55m, overlying sand. Groundwater was encountered at 0.7m.

Excavated material from TP9

Client:	Garrard Building Pty Ltd		Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba		Drawn By:	SK
			Scale:	NTS
			Date:	26-Jul-18
Title:	Test Pit Photographs - TP9		Drawing No.	

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP10**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator			**EASTING:**	532605 m	**SURFACE RL:**	
TEST PIT LENGTH:	2.0 m	**WIDTH:**	0.3 m	**NORTHING:**	6742975 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey	M				TOPSOIL:GRASS
						SM	0.25m **SAND:** FIne to medium grained, grey, with some silt	M	MD			ALLUVIAL SOIL
				0.5		SP	0.45m **SAND:** Fine to medium grained, pale grey, pale brown					
	11:00:00 AM ▶							W				
				1.0		SP	0.90m **SAND:** Fine to medium grained, grey, pale brown					
							1.10m Hole Terminated at 1.10 m					
				1.5								

LEGEND:

Water

- ▼ Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

TP10 encountered 0.25m of topsoil overlying sand. Groundwater was encountered at 0.8m.

Excavated material from TP10

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP10	Drawing No.	

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - TEST PIT

CLIENT:	Garrad Building Pty Ltd	**TEST PIT NO:**	**TP11**
PROJECT NAME:	Proposed Development	**PAGE:**	1 of 1
SITE LOCATION:	52-54 Miles Street, Yamba	**JOB NO:**	RGS31546.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	LD
		DATE:	26/6/18

EQUIPMENT TYPE:	2t Excavator	**EASTING:**	532987 m	**SURFACE RL:**	
TEST PIT LENGTH:	1.6 m **WIDTH:** 0.3 m	**NORTHING:**	6742868 m	**DATUM:**	AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
Excavator						SM	**TOPSOIL:** Clayey Silty SAND, fine to medium grained, dark grey	M		DCP (0-0.9m)	2	TOPSOIL:GRASS
											2	
						SM	0.20m **Silty SAND:** Fine to medium grained, grey	M	MD		2	ALLUVIAL SOIL
						SP	0.30m **SAND:** Fine to medium grained, pale grey, pale brown				1	
											4	
				0.5							4	
									D		7	
	1:10:00 PM										7	
	▶—							W			6	
				1.0		SP	0.90m **SAND:** Fine to medium grained, pale brown					
				1.5			1.30m Hole Terminated at 1.30 m					

LEGEND:

Water

- Water Level (Date and time shown)
- ▶— Water Inflow
- —◀ Water Outflow

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		**UCS (kPa)**
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

RG LIB 1.04.3.GLB Log RG NON-CORED BOREHOLE - TEST PIT RGS31546.1 LOGS DRAFT.GPJ <<DrawingFile>> 20/07/2018 14:41 8.30.004 Datgel Lab and In Situ Tool

TP11 encountered 0.2m of topsoil overlying sand. Groundwater was encountered at 0.8m.

Excavated material from TP11

Client:	Garrard Building Pty Ltd	Job No.	RGS31546.1
Project:	Proposed Residential Development 52-54 Miles Street, Yamba	Drawn By:	SK
		Scale:	NTS
		Date:	26-Jul-18
Title:	Test Pit Photographs - TP11	Drawing No.	

FALLING HEAD INFILTRATION TEST - CASED HOLE

CLIENT: Garrard Building Pty Limited
PROJECT: Proposed Residential Development
LOCATION: 52-54 Miles Street, Yamba NSW

Job No.: RGS31546.1
Date: 26-Jun-18
By: LD

Test number:	TP5	Test Location:	Refer to Figure 1
Hole radius (m):	0.35	Surface RL:	Not measured
Hole depth(m):	0.54	Casing stickup(m):	0.00
Depth to water table (m):	Unknown	Water table RL(m)	Unknown

Reading	Time elapsed (min)	Depth to water (m)	Height of water (m)
1	0.5	0.094	0.45
2	1	0.156	0.38
3	2	0.175	0.83
4	3	0.200	0.80
5	4	0.211	0.79
6	5	0.240	0.76
7	8.5	0.298	0.70
8	10	0.316	0.68
9	12.5	0.344	0.66
10	15	0.369	0.63
11	29	0.459	0.54
12	30	0.470	0.53
13	35	0.540	0.46
14			
15			

Calculations

Constant loss time period:

Reading 1:	2	Time 1:	1	Height 1:	0.384
Reading 2:	7	Time 2:	8.5	Height 2:	0.702

Total time (min): 7.50

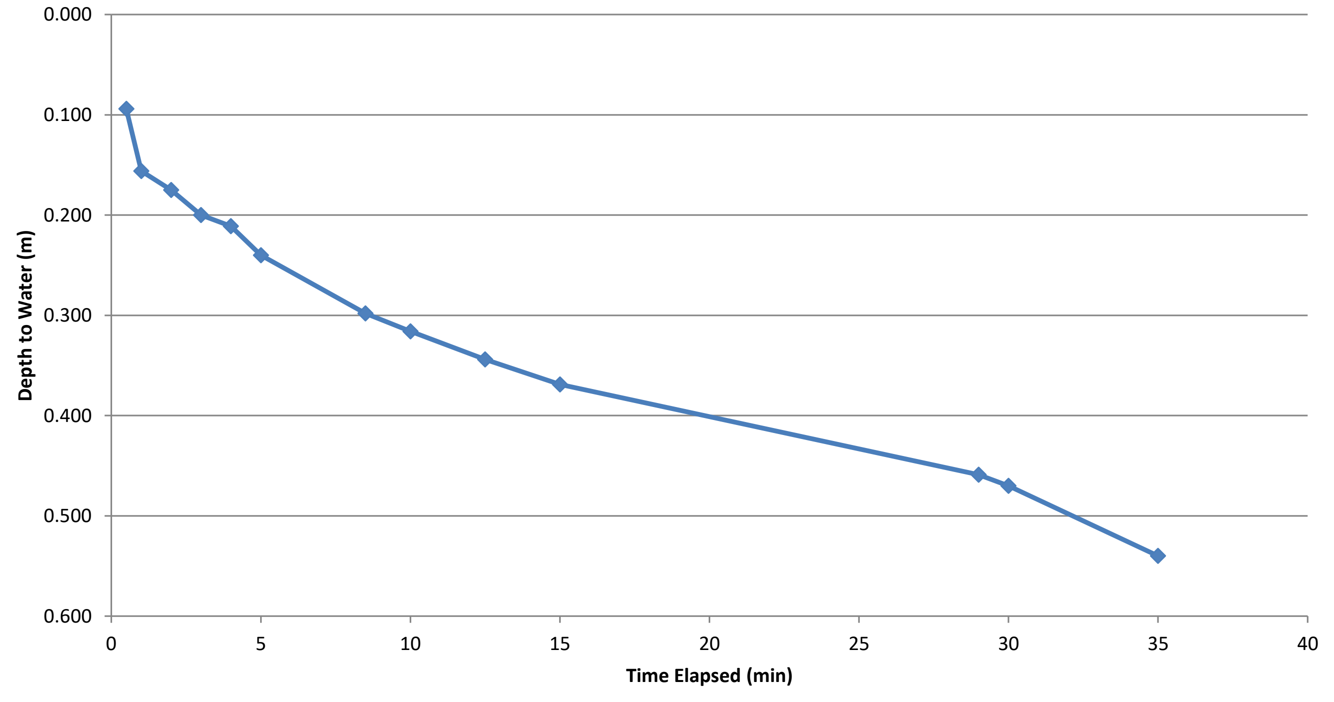
Total head loss (m): 0.318

In situ Permeability:

$$K = \frac{(Height\ 2 - Height\ 1)}{(Time\ 2 - Time 1)}$$

K= 7.07E-04 m/sec

(x 10m/sec)



FALLING HEAD INFILTRATION TEST - CASED HOLE

CLIENT: Garrard Building Pty Limited
PROJECT: Proposed Residential Development
LOCATION: 52-54 Miles Street, Yamba NSW

Job No.: RGS31546.1
Date: 26-Jun-18
By: LD

Test number:	TP7	Test Location:	Refer to Figure 1
Hole radius (m):	0.35	Surface RL:	Not measured
Hole depth(m):	0.54	Casing stickup(m):	0.00
Depth to water table (m):	Unknown	Water table RL(m)	Unknown

Reading	Time elapsed (min)	Depth to water (m)	Height of water (m)
1	0.5	0.040	0.50
2	1	0.063	0.48
3	1.5	0.084	0.46
4	2	0.099	0.44
5	3	0.134	0.41
6	4	0.165	0.38
7	5	0.192	0.35
8	7.5	0.234	0.31
9	10	0.272	0.27
10	15	0.343	0.20
11	21	0.395	0.15
12	24	0.434	0.11
13	27	0.460	0.08
14	30	0.494	0.05
15			

Calculations

Constant loss time period:

Reading 1:	7	Time 1:	5	Height 1:	0.348
Reading 2:	14	Time 2:	30	Height 2:	0.046

Total time (min): 25.00

Total head loss (m): -0.302

In situ Permeability:

$$K = \frac{(Height\ 2 - Height\ 1)}{(Time\ 2 - Time 1)}$$

K= 2.01E-04 m/sec

(x 10m/sec)