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# Waterway Impact Statement

Allambie Heights Village Project 2

181 Allambie Road, Allambie Heights 2100

Total Earth Care Pty Ltd

July 18

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July 18

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| **Quality Control** | © Total Earth Care Pty Ltd 2018 | | |
| **Revision/Version No.** | REV 0 | **Date of revision** | 25 July 2018 |
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| **TEC Job No.** | C10803.2 | | |

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## Executive Summary

The proposed development plan, DP752038, of a retirement village at Lot 2615, 181 Allambie Road, Allambie Heights occurs on "Waterways and Riparian Lands" as mapped in the Warringah Development Control Plan 2011. Any lands within 40 meters of a creek falls under the requirements set by Office of Environment and Heritage (OEH) and subsequently, under the provisions of integrated development OEH has concurrent requirements for any development, along with the Local Government Authority (for this subject site, the recently formed Northern Beaches Council).The proposal is also situated near two artificial creeklines, one being mapped as a headwater of Curl Curl Creek in the Warringah Creek Management Study 2004.

Potential impacts of the proposal are restricted to issues of stormwater runoff, erosion and sedimentation during the construction phase, and removal of native vegetation. Impacts on the existing channel form, erosion rate, or bank stability of the artificial creeklines are not expected as they have been excavated into sandstone bedrock.

These drains are assessed as having low ecological value due to their "urban modified" river styles and that their geomorphic attributes have been altered so much that they function as drains not creeks.

Mitigation measures have been proposed which will maintain and enhance riparian landscapes, stabilise erosion and downstream sedimentation, reduce stormwater runoff, and preserve the natural components that contribute to ecological value of the site. These include Water Sensitive Urban Design (WSUD) measures such as vegetated swales, On-site Stormwater Detention (OSD) systems such as detention and retention basins, and site rehabilitation through bush regeneration and riparian revegetation, amongst others.

This Waterway Impact Statement provides a waterways analysis, assessment of impacts, assessment of compliance with the Warringah DCP 2011, and provision of mitigation measures in regards to the proposal and surrounding environment.

The proposed development will, on balance, have positive impacts on the waterway and will result in better onsite detention, reduced flow rates, better aquatic habitat, healthier bushland and a reduced weed seed source to the catchment below.

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# 1 Introduction

## 1.1 Background

Total Earth Care (TEC) has been commissioned by Allambie Heights Village to prepare a Waterway Impact Statement (WIS) for the development proposal at 181 Allambie Road, Allambie Heights 2100. Allambie Heights Village is located within the Northern Beaches Council Local Government Area (LGA).

## 1.2 Objectives

The objective of the Waterway Impact Statement (WIS) is to conduct an adequate environmental assessment of development works so as to protect, maintain and enhance waterways and riparian lands. This includes undertaking

1. Waterway Analysis;
2. Assessment of Impacts;
3. Assessment of Compliance with the Warringah Development Control Plan, and;
4. Provision of Mitigation Measures.

## 1.3 Relevant legislation and guidelines

The legislation and guidelines relevant to this WIS include the:

- *Biodiversity Conservation Act 2016* (NSW);
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth);
- Protection of Waterways and Riparian Land Policy PL 740 (Warringah Council) ;
- Warringah Creek Management Study (Warringah Council 2004);
- Warringah Development Control Plan (DCP) 2011;
- Warringah Local Environmental Plan (LEP) 2011;
- *Water Management Act 2000* (NSW), and;
- Waterway Impact Statement Guidelines (Warringah Council)

## 1.4 Subject Site and Study Area

The subject site is defined as 181 Allambie Road, Allambie Heights (Lot 2615 DP752038) and includes the area directly affected by the proposal. The study area includes additional areas which are likely to be affected by the proposal, either directly or indirectly. See Map 1 for subject site, study area, and property boundaries.

# 2 Waterway analysis

## 2.1 Site description

### *2.1.1 Physical Characteristics*

The majority of the study area is mapped as Waterways and Riparian Lands (Warringah DCP 2011) which is based on the Riparian Buffer around Curl Curl Creek (Warringah Creek Management Study (WCMS 2004).

Within the study area two drainage lines have been artificially excavated into sandstone bedrock and have created de-facto creeks. These artificial creeks are not mapped by the Office of Water as streams recognised by the Strahler System (i.e. they do not appear as blue lines on a 1:25,000 topographic map as held by the Land Information Centre). The creekline to the west of the site is approximately 80m long and the creekline in the centre of the site is approximately 60m long. Both creeks flow in a north-south direction.

The central creekline is mapped as forming part of the upper headwaters of Curl Curl Creek within the Manly Creek sub-catchment (WCMS 2004). Council has determined the beginning of Curl Curl Creek on site to be the culvert below the existing road (see Map 2).

The river styles of both of these creeklines is “urban modified”, meaning their channels have been modified to the extent that they no longer function as rivers (WCMS 2004). The creeks function as open drainage lines to transport the flow of stormwater (see Figures 1 and 2). They are both ephemeral and only flow after rain events.

The vegetation along the creeklines is not distinctly riparian in contrast with the surrounding bushland. An artificial detention basin is located below the eastern creekline and is sparsely vegetated with riparian species.

**Figure 1. Western creekline during flow event**

**Figure 2. Eastern creekline dry**

### *2.1.2 Connectivity*

The artificial creeks are situated within the upper Manly Creek sub-catchment and are approximately 1km upstream from Manly Dam. Although there is no direct connectivity between the creeklines on site with the permanent tributaries that flow into Manly Reservoir, there is continuous connectivity of bushland from the site to Manly Dam Reserve (i.e. Manly Warringah War Memorial Park).

According to the WCMS 2004, “Manly Dam Reserve covers approximately 375ha of which 78% is bushland (Nelson Consulting Pty Ltd, 1998). This provides a high level of connectivity of natural vegetation in the floodplain and riparian zone of Curl Curl Creek and reasonable habitat for dispersal of

native terrestrial fauna species. Geomorphic diversity is also very high, providing a wide range of habitats and supporting excellent native species richness. Curl Curl Creek and its tributaries also provide high landscape and passive recreation value to the area".

### 2.1.3 Threatened aquatic flora and fauna

No threatened or endangered aquatic flora and fauna have been located within the subject site or study area. For details see the Development Constraints Report (TEC 2017) and the Biodiversity Development Assessment Report (BDAR) (TEC 2018).

### 2.1.4 Existing erosion and sediment conditions

The existing artificial detention basin collects any sediment that may be carried down the eastern creekline. The use of sandstone boulders in the landscaping around the detention basin prevents further erosion in this area.

The creeklines themselves are cut directly into sandstone bedrock and are not prone to erosion. There are no signs of bank erosion or head cut on either creeklines.

The majority of the site is vegetated or turfed. A thick layer of leaf litter in the existing bushland prevents soil erosion except where disturbance has occurred.

Minor siltation is evident in the catch drains on the northern side of the road that runs through the centre of the site and in the northern fire trail.

### 2.1.5 Channel form, erosion rate and bank stability

The defined channels of the creeks have an unnatural shape and location which reflect the property boundaries rather than the natural topography of the site.

There are no issues of erosion or bank stability due to the channels being cut into sandstone bedrock.

### 2.1.6 Stormwater discharge points and stormwater treatment measures

The artificial creeks function as stormwater drainage points. The eastern creekline discharges into the artificial detention basin which is a stormwater treatment measure approved as part of a previous DA on Council land. The western creekline discharges into the managed bushland downslope. No significant siltation issues are evident in either creekline.

**Figure 3. Existing artificial detention basin**

**Figure 4. Western creekline discharging into bushland**

## 2.2 Ecological Value

The central creekline forms part of the upper headwaters of Curl Curl Creek within the Manly Creek sub-catchment (WCMS 2004). Council has determined the beginning of Curl Curl Creek on site to be the culvert below the existing road (see Map 2).

Curl Curl Creek is classified as a Group A creek meaning it has very high ecological value and less than 10% connected impervious area (WCMS 2004). It has received an Overall Ecological Value of 3.6/5 meaning that the naturalness, rarity and diversity of the creek's ecosystem structures and functions are considered to be high to very high (WCMS 2004).

It should be noted that the western creekline on site is not mapped as being part of Curl Curl Creek and that the section of Curl Curl Creek that is mapped within the study area is approximately 40m long. The river styles of both of these creeklines is "urban modified", meaning their channels have been modified to the extent that they no longer function as rivers. As noted above, they function as open drainage lines to transport the flow of stormwater. Due to these artificial geomorphic attributes the ecological value of creeklines on site are greatly diminished and are considered low for the purposes of the current assessment. Even so, they may still provide limited foraging and breeding habitat for amphibians, reptiles and invertebrates.

### *2.2.1 Water Quality*

Curl Curl Creek contains elevated concentrations of total and dissolved nitrogen which exceed the ANZECC (2000) Trigger Levels, while concentrations of suspended solids are relatively low (WCMS 2004). Stormwater runoff from residential areas within Allambie Heights and Manly Vale, open spaces along the creek line, use of fertilisers in the upper catchment, and polluted groundwater are likely causes of this (WCMS 2004). These results suggest that surrounding bushland does little to trap pollutants before they enter Curl Curl Creek (WCMS 2004).

Water quality testing for the artificial creeklines on site will be undertaken as part of the Construction Environmental Management Plan (CEMP). Samples will be taken of water entering and water exiting the creeklines. These will be tested for: M17 Total, pHEC, TSS, Turbidity, COD, TOG, TOC, TN, TP, M17 dissolved, TRH/BTEX, PAH, OC/OP/PCB, NH4, Chlorophyl-a, and various metals. Results will be assessed in comparison to the ANZECC (2000) Trigger Levels. See CEMP for results.

### *2.2.2 Risks to Ecological Value*

Generally, Group A creeks can sustain very little further development before their aquatic ecosystems will change substantially, especially when they are close to natural condition and minor perturbations can have a major impact (WCMS 2004). In the case of the artificial creeklines on site, however, these are not close to natural condition, have already been substantially modified, and are situated within existing developments or managed areas.

Group A creeks are at high risk of vegetation clearing and weed proliferation, medium risk of urban development (sedimentation, erosion, water pollution), and low risk of industrial and commercial operations (WCMS 2004).

**Figure 5. Weeds such as *A. adenophora* and *P. quadrifarium* pose a risk to the existing creeklines**

**Figure 6. Example of "urban modified" river style**

## 2.3 The Proposal

### *2.3.1 Nature and extent of proposed activities during construction*

Proposed activities during construction include but are not limited to:

- Excavation works following the existing road line;
- Installation of stockpiles;
- Phytophthora controls, e.g. shake-down bays and cleaning of all machinery entering and exiting the site, and;
- Establishment of exclusion zones around creeklines, etc.

For full details of proposed construction activities relevant to the creeklines and surrounding bushland, see the CEMP. See also Map 2 for the extent of the proposed development.

### *2.3.2 Nature and extent of proposed activities during operation*

Allambie Heights Village Ltd, an aged care organisation, has taken a lease over 3.72ha of Crown lands at 181 Allambie Rd, Allambie Heights (Allambie Heights Village). These lands are contiguous to a property that they currently own at Martin Luther Place, Allambie Heights.

A master plan is being produced by Allambie Heights Village with the intention of building a retirement village adjacent to its aged care facility, Allambie Heights Village, at Martin Luther Place. The development will be a state-of-the-art retirement village infrastructure precinct which will augment its current capacity, and service a burgeoning need for retirement needs. The site is currently being used as a Residential Aged Care Facility.

Development of the land was substantially started by the past lessees and it is the intention of the new current lessees to continue with what they consider to be an existing use right. The western end of the property has not been fully developed and a significant portion of the site is remnant bushland.

See Map 2 for the extent and location of proposed construction and operational activities relative to the mapped riparian lands and creeklines.

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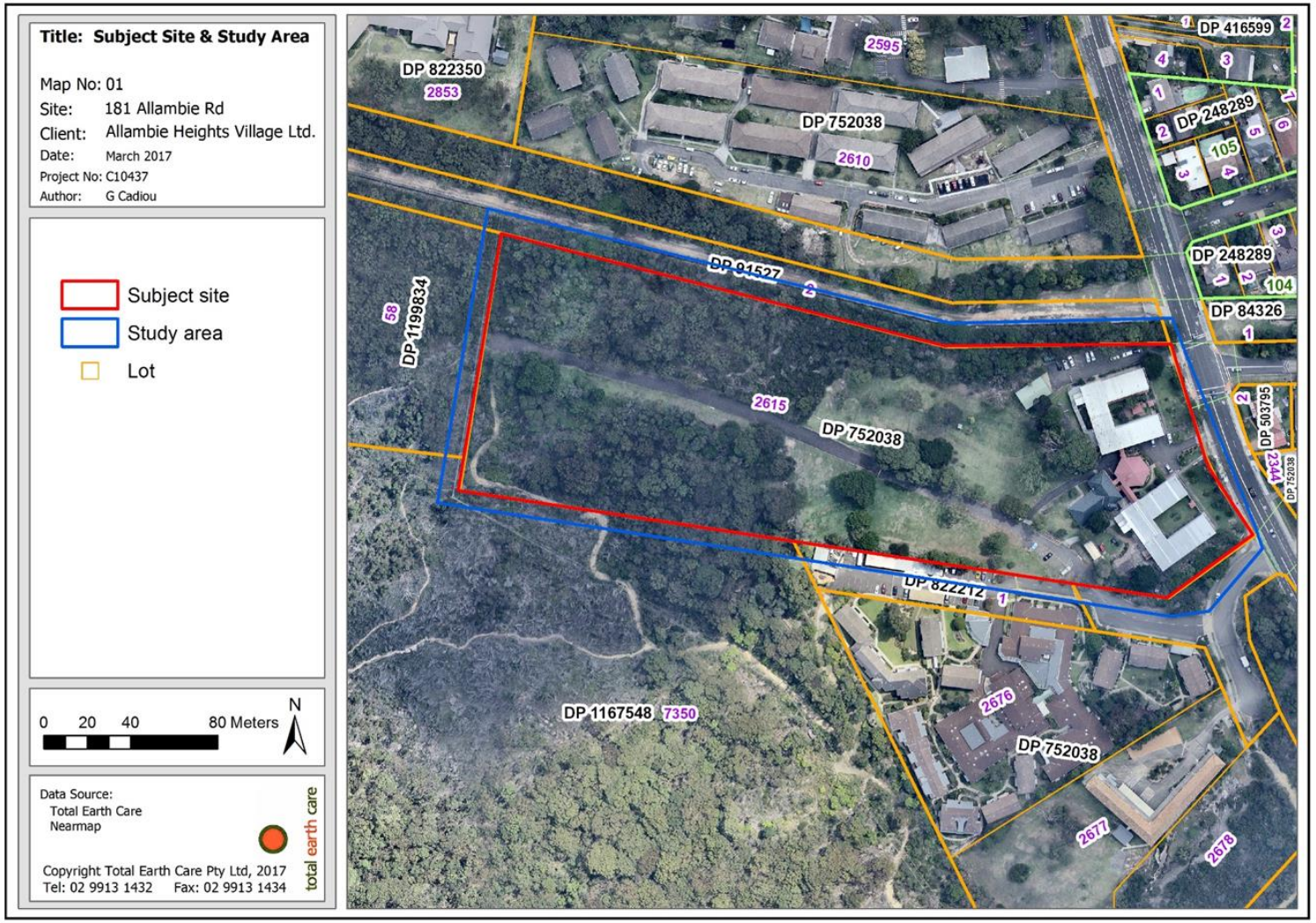

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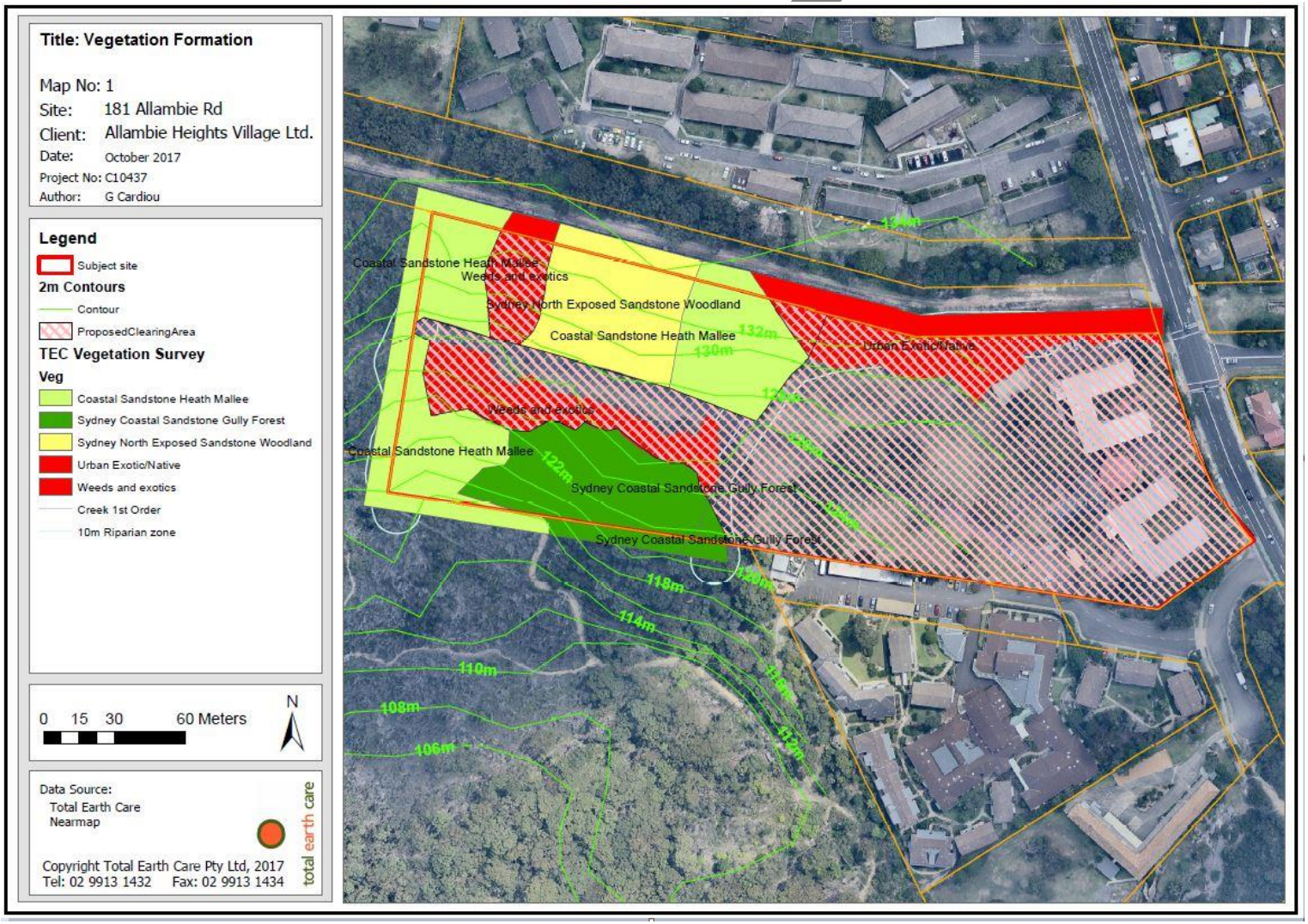

# 3 Assessment of Impacts

## 3.1 Impact upon water quality

The development site is substantially located on two managed vegetation types:

Vegetation Type 1:

Above the existing access road vegetation is a managed grassland with well separated local non-local and exotic trees which are growing on the shallow sandy colluvial soils of the Hawkesbury Soil landscape as per Soil Landscape Series Sheet 9130 (1983).

Managed grassland below the access road covers soil who's profile appear to have been altered through filling. This soil is supporting weed tree species. The fill material is assumed to be locally sourced sandy soils from the original development which has been installed over the natural soil profile. This has increased the soil depth and absorptive capacity of the natural soil.

The impact on this vegetation type is limited to the loss of a small number of trees, please refer the arborists report for details.

Vegetation Type 2:

Highly modified / managed bushland is located along the eastern bank of the man-made drain and reek.

It is proposed that the vegetation within the drain be supplemented with instream plantings into newly created pool and riffle zones. Above the banks the drain/creek will be managed as native grassland with tree over storey to provide creek bank access to the residents while concurrently managing bushfire risks. The bushland on the eastern side of the creek below the access track has already been substantially modified and is currently heavily infested with non-native grass and tree species.

The removal of weeds and the regeneration of a native plant community will increase the water quality by removing weed species which have a deleterious effect on ecological function.

This landscape zone will be planted with species with deeper roots than the grass species will improve plant evapotranspiration and reduce soil evaporation through the creation of plant windbreaks.

The net impact of the proposal on water quality due to the loss/modification of this vegetation is positive.

Soil water absorption

Soil absorptive capacity of the existing sandy soils under the grass is very low and soil nutrients and biological activity in the soil is lower than healthy bushland. By establishing deep soil planter beds and by establishing a bushland community of plants along the creek/drainage line the soil absorption capacity will be increased and water quality improved.

Deep excavations and surface water catchments

Deep excavations and surface water flow will be intercepted and directed in to detention and holding tanks. Some of the water in these tanks will be pumped up slope to a header tank and released slowly through Landscape water features and into the vegetated drain/creek this will

increase flow through the whole riparian landscape. The passage of this water through the creek and water features will cleanse and aerate the water.

The water quality of the artificial creeklines and stormwater flowing offsite is predicted to be minimally impacted during the construction of the proposal and will have a net benefit in the long term.

Water contamination

It is not anticipated that any water will be contaminated by the ongoing use of the site:

Water contamination will be minimised by following the procedures below:

- Minimise the risk to public health and safety by installing temporary exclusion fencing and erosion/sediment controls as per the CEMP;
- Protect Council's stormwater drainage assets during construction by implementing all the measures contained in the CEMP;
- Minimise the quantity of stormwater runoff on Council's drainage system by directing discharge into the existing sediment basin, and;

## 3.2 Impacts on channel form, erosion rate and bank stability

In order to be consistent with the objectives and requirements of C4 – Stormwater of the Warringah Development Control Plan 2011, the proposal will:

- Reduce the risk to life and property from flooding lower in the catchment by installing stormwater detention tanks which adequately cater for the volume of water that might be generated in a 1:100 stormwater event;
- Manage and minimise stormwater overland flow, (sheet flooding) and groundwater related damage to properties by channelling stormwater within the existing artificial drainage lines;
- Design, install, and maintain the stormwater drainage system in accordance with Council's Water Management Policy. Please refer to Appendix B.

The water detention measures outlined above will mitigate any potential increase in flow rate or volumes.

The proposal is not expected to alter the main channels existing form, erosion rate, or bank stability. This channel is on the western edge of the development area and feeds into the creek. It is proposed that the main channel will be broadened and deepened above the access road to create a series of pools and riffles. As with the rest of the creek /drain this will be excavated into solid rock, so channel form will be substantially improved and the bank stability and erosion rates will not be effected.

The creation of pools and riffles will detain water and improve ecological function and reduce volume and flow rates to the creek downstream positively impacting on the downstream reaches of the creek.

The informal drainage line in Figure7 below will be decommissioned and all water that is currently flowing uncontrolled into the existing detention basin will be captured and detained in underground tanks.

The existing detention basin is on council land and will be upgraded with council permission.

**Figure 7. Existing culvert and beginning of informal overland drainage swale**

**Figure 8. Informal overland drainage swale further downstream**

## 3.3 Impacts on stormwater discharge points and stormwater treatment measures

Currently the site is turfed and under laid by a thin topsoil profile over bedrock. The stormwater infiltration capacity of this is minimal and will be improved by the installation of stormwater detention and retention systems relating to the proposal. .

A hydrological engineer will design these systems which will function to decrease peak flow rates into the existing creeks. A solar power water storage tank which will cycle water to another tank at the top of the site is to be confirmed by the landscape architect. Alteration of the drain near the existing detention basin is also anticipated (see Appendix B). The stormwater treatment during construction will be managed by the CEMP which aims to clean all water prior to its release.

## 3.4 Ecological impacts of the development

For full details of the ecological impacts of the development see the Development Constraints Report (TEC 2017) and the Biodiversity Development Assessment Report (BDAR) (TEC 2018).

- Protect and improve the ecological condition of the surrounding bushland by requiring site rehabilitation (i.e. bush regeneration) of any areas disturbed or otherwise affected by the development, reduced weed densities will significantly benefit the bushland downstream ;
- Integrate Water Sensitive Urban Design (WSUD) measures by including vegetated swales, and pools and riffles within the existing drain. Install and maintain, sediment basins, these will also protect the downstream aquatic environment;

## 3.5 Landscape impacts of the development

The construction phase of the proposed development will require excavation works including cutting into the existing bedrock / slope. The impact of these works will be detailed in the hydrological engineer's report including alterations to flow rates, the impact of impermeable surfaces, and mitigation measures such as detention tanks. Any visual impacts will be addressed in the landscape architect's plan.

## 3.6 Flood impact assessment

The proposed development is not located on Flood Prone Land. The proposal has been engineered to mitigate increased flows as a result of the development and no adverse effects on floodplains downstream are predicted. For full details see the hydrological engineer's report.

## 3.7 Bank stability assessment

Bank stability will not be affected by the proposed development. The banks of the existing artificial creeklines are carved into sandstone bedrock and are not prone to further erosion.

Erosional processes outside of the creeklines may be temporarily exacerbated during the construction phase, however these well be effectively mitigated by implementing the measures set out in the CEMP.

## 3.8 Extent of native vegetation proposed to be removed

An intermittent 5 metre wide strip of native vegetation will be removed in order to gain access to install pools and riffles in the main channel above the access road. This vegetation will be modified to remove the shrub layer and create a native grassland with a native tree canopy.

See Map 3 for the full extent of native vegetation proposed to be removed.

## 3.9 Any modifications to natural creeklines or overland flow

There are no natural creeklines within the study area the man made creek below the access road will . remain unchanged. Overland flows are expected to change as a result of excavation works and new walls paths and roads. All water overland flows in the development area will be directed to a detention system as outlined in the SMP (see Appendix B).

# 4 Assessment of compliance with the Warringah Development Control Plan

This section assesses compliance with the objectives and requirements of the Warringah Development Control Plan 2011.

**Table 1. Assessment of proposal's compliance with Warringah DCP (2011)**

| Clause | Clause Title | Impact level (negligible, low, medium or high, negative or positive, or N/A) | Discussion of compliance |
|---|---|---|---|
| C4 | Stormwater | **During construction:** medium negative<br><br>**During operation:** negligible | The proposal will:<br>• Minimise the risk to public health and safety by installing temporary exclusion fencing and erosion/sediment controls as per the CEMP;<br>• Reduce the risk to life and property from flooding by constructing a stormwater detention tank which adequately caters for the volume of water that might be generated in a 1:100 stormwater event;<br>• Integrate Water Sensitive Urban Design measures by including vegetated swales, sediment basins, etc.;<br>• Manage and minimise stormwater overland flow, nuisance flooding and groundwater related damage to properties by channeling stormwater within the existing artificial drainage lines;<br>• Protect Council's stormwater drainage assets during construction by implementing all the measures contained in the CEMP;<br>• Minimise the quantity of stormwater runoff on Council's drainage system by directing discharge into the existing sediment basin, and;<br>• Design, install, and maintain the stormwater drainage system in accordance with Council's Water Management Policy.<br>Together these measures will ensure that stormwater runoff will not cause downstream flooding and will have minimal environmental impact. |
| C5 | Erosion and Sedimentation | **During construction:** medium negative<br><br>**During operation:** negligible | • An Erosion and Sediment Control Plan will be prepared in accordance with Landcom's Managing Urban Stormwater: Soil and Construction Manual (2004). It will detail types of control, methods of installation, locations, maintenance regimes, responsibilities, stockpile storage, silt fencing, vehicle shake-down, floating silt boom, stabilisation access for machinery, etc. These measures will be installed and maintained until the site is fully established.<br>• A Soil and Water Management Plan will be prepared in accordance with Landcom's Managing Urban Stormwater: Soil and Construction Manual (2004). The measures contained therein will be installed and maintained until the site is fully established.<br>• A Construction Environment Management Plan (CEMP) will be written by the construction contractor and approved by Council before commencement of works. Mitigation measures proposed during the construction phase will include, amongst others:<br>o Construction of a temporary stormwater detention basin where silted water can be flocculated and sediment removed prior to release into bushland below;<br>o Installation of measures to mitigate potential erosion on site and to stop the flow of silted water off site;<br>o The requirement that any erosion and sedimentation is to be managed at the source, and;<br>o Compliance of all erosion, sediment and pollution controls with Council's Water Management Policy. |
| E2 | Prescribed Vegetation | Low negative | • Protect and improve the ecological condition of the surrounding bushland by requiring site rehabilitation (i.e. bush regeneration) of any areas disturbed or otherwise affected by the development;<br>• The vast majority of the development is situated so as to minimise impact on prescribed vegetation including remnant canopy trees, understorey vegetation, and ground cover species.<br>• The modification of a narrow bushland buffer zone for an APZ is expected between the development and existing vegetation<br>• No trees shall be removed from this zone. Only the shrub layer will be removed to prevent connectivity between vegetation layers and reduce the fire ladder. |

| Clause | Clause Title | Impact level (negligible, low, medium or high, negative or positive, or N/A) | Discussion of compliance |
|---|---|---|---|
| | | | • Several planted trees are to be removed from the turfed area on the high side of the road. See Arboists rep[ort landscape architect's plans for full details. |
| E3 | Threatened species, populations, ecological communities listed under State or Commonwealth legislation, or High Conservation Habitat; | Low negative | A Biodiversity Development Assessment Report (BDAR) (i.e. a Flora and Fauna Assessment) will be prepared in accordance with the relevant guideless and will demonstrate that the objectives of the clause have been met.<br><br>A Vegetation Management Plan (VMP) (i.e. a Biodiversity Management Plan) will also be prepared in accordance with the relevant guideless and will protect, manage, and (where appropriate) promote the recovery of threatened species, populations and ecological communities and areas of high conservation habitation within the subject property. |
| E4 | Wildlife Corridors | Low negative | A Biodiversity Development Assessment Report (BDAR) (i.e. a Flora and Fauna Assessment) will be prepared in accordance with the relevant guideless and will demonstrate that the objectives of the clause have been met.<br><br>A Vegetation Management Plan (VMP) (i.e. a Biodiversity Management Plan) will also be prepared in accordance with the relevant guideless and will protect, manage and enhance wildlife corridors, and where appropriate reconstruct wildlife corridor areas on the subject property. |
| E5 | Native Vegetation | Low negative | A Biodiversity Development Assessment Report (BDAR) (i.e. a Flora and Fauna Assessment) will be prepared in accordance with the relevant guideless and will demonstrate that the objectives of the clause have been met.<br><br>A Vegetation Management Plan (VMP) (i.e. a Biodiversity Management Plan) will also be prepared in accordance with the relevant guideless and will protect native vegetation on the subject property. |
| E6 | Retaining unique environmental features on site | Negligible | In order to conserve the remnant bushland and trees on site, the proposed development will:<br>• Be located largely on parts of the site where remnant bushland and trees are not present;<br>• Minimise on-site disturbance by implementing the measures detailed in the CEMP, Erosion and Sediment Control Plan, and Soil and Water Management Plan;<br>• Employ materials that complement the site e.g. sandstone;<br>• Avoid the introduction of soil from outside the site;<br>• Select provenance specific native plant species for revegetation works, and;<br>• Select plant species that enhance resident fauna habitat as per see Council's tree replacement guide. |
| E8 | Waterways and Riparian Lands | Low negative | • As well as the submission of this Waterway Impact Statement, the proposed development complies with Council's Protection of Waterways and Riparian Land Policy including the following sections:<br>o 3.1(a) Seeing as the two creeklines onsite are artificially constructed, the full range of natural ecological processes that would be present in natural watercourses and riparian land are not present. Even so, the proposal will not significantly alter these existing creeklines and natural area restoration will be implemented to improve their ecological function and the surrounding plant communities.<br>o 3.1(c) An informal overland drainage swale currently discharges into the existing detention basin. This will be upgraded with bank and bed control structures plus pool and riffle zones to improve water holding capacity, stability, and ecological function. It will also be vegetated to reduce the risk of erosion and siltation downslope. |

| Clause | Clause Title | Impact level (negligible, low, medium or high, negative or positive, or N/A) | Discussion of compliance |
|---|---|---|---|
| | | | ○ 3.1(d) Cultural heritage and public access is not affected by the proposal.<br>○ 3.2(a) Riparian setback distances are not applicable. The artificial creeks are not mapped by the Office of Water as streams recognised by the Strahler System, i.e. they do not appear as blue lines on a 1:25,000 topographic map as held by the Land Information Centre. For the same reason a "controlled activity approval" pursuant to the *Water Management Act 2000* (NSW) is not required.<br>○ 3.2(b) The development is sighted and designed not to negatively impact the stability of the existing creeklines.<br>○ 3.2(c) These are not relevant to the current proposal.<br>• The proposed development also complies with Council's Water Management Policy. See the hydrological engineer's report for full details.<br>• Infrastructure such as roads, drainage, and stormwater structures are already located inside land identified as Waterways and Riparian Land. These were approved as part of a previous DA on Council land.<br>• Almost the entire property is located on land mapped as Waterways and Riparian Lands. The APZ necessarily intersects with some of these mapped areas due to the location of bushland on site. |

# 5 Provision of mitigation measures

## Outcome 1: Protecting native species and communities

### Table 2. Outcome 1: Protecting native species and communities

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Maintain natural habitats | - Improvement of Endangered Ecological Communities<br>- Improvement of riparian vegetation OR<br>- Compensatory habitat provided for any disturbance | - Protect and improve the ecological condition of the surrounding bushland by requiring site rehabilitation (i.e. bush regeneration) of any areas disturbed or otherwise affected by the development;<br>- Site rehabilitation will protect any remnant local native riparian vegetation at the Site and restore any riparian zones, disturbed or otherwise affected by the development, to a state that is reasonably representative of the natural ecotone of the protected waters system and as required in a Vegetation Management Plan;<br>- Revegetation, in accordance with the standards required by these conditions, is to be undertaken in this 10m wide area if it is significantly degraded or is likely to give rise-to weed invasion due to lack of native vegetation cover before or after weed control.<br>- The creekline will be reshaped and revegetated to improve ecological function. |
| Provide fauna movement routes | - Improved connection of riparian zones AND<br>- Improved fish movement through removal of barriers OR<br>- Install fishways on any temporary or permanent barriers | - There are no fences or walls which stop animal movement across the site.<br>- An informal overland drainage swale currently discharges into the existing detention basin. This will be upgraded with bank and bed control structures plus pool and riffle zones to improve water holding capacity, stability, and ecological function. It will also be vegetated to reduce the risk of erosion and siltation downslope.<br>- No fish inhabit the ephemeral artificial creeklines, however revegetation and site rehabilitation will improve habitat function for other riparian fauna species.<br>- Streamflow is expected to increase in frequency within the creeklines and impacts to water quality will be mitigated by effective OSD and WSUD measures (see hydrological engineer's report).<br>Migration routes are not expected to be affected. |
| Prevent unnatural erosion or sediment deposition | - No increase in peak flows AND<br>- No increase in total sediment loads | No increase in peak flows and no increase in total sediment loads will be achieved by implementing the following:<br>- A Soil and Water Management Plan will be prepared in accordance with Landcom's Managing Urban Stormwater: Soil and Construction Manual (2004). The measures contained therein will be installed and maintained until the site is fully established.<br>- A Construction Environment Management Plan (CEMP) will be written by the construction contractor and approved by Council before commencement of works. Mitigation measures proposed during the construction phase will include, amongst others:<br>- Construction of a temporary stormwater detention basin where silted water can be flocculated and sediment removed prior to release into bushland below;<br>- Installation of measures to mitigate potential erosion on site and to stop the flow of silted water off site;<br>- The requirement that any erosion and sedimentation is to be managed at the source. |

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Maintain acceptable water quality | - Council approved sediment and erosion control plan | A Council approved Erosion and Sediment Control Plan will be prepared in accordance with Landcom's Managing Urban Stormwater: Soil and Construction Manual (2004). It will detail types of control, methods of installation, locations, maintenance regimes, responsibilities, stockpile storage, silt fencing, vehicle shake-down, floating silt boom, stabilisation access for machinery, etc. These measures will be installed and maintained until the site is fully established. |
| Maintain connectivity between waterways and floodplains | - Reduction of barriers between waterways and floodplains | No barriers between waterways and floodplains are proposed as part of the development. After being treated in detention basins, water captured in the artificial creeklines will be released into surrounding bushland and floodplains downslope. |

## Outcome 2: Prevent loss of natural diversity through protecting waterway and riparian vegetation (including non-native vegetation)

**Table 3. Outcome 2: Prevent loss of natural diversity through protecting waterway and riparian vegetation (including non-native vegetation)**

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Avoid introducing plants or animals which may displace natural species | - Construction activities must not introduce new weeds species or allow weeds to spread (Bio-diversity Management Plan) | An approved Vegetation Management Plan (VMP) (i.e. a Biodiversity Management Plan) will be prepared including hygiene protocols to prevent the introduction of new weeds species and the spread of existing weeds.<br><br>The VMP will also include the removal of all noxious weeds and conduct primary weeding using bush regeneration techniques of all areas of retained vegetation on the site. |
| No increase in nutrient loads to riparian soils and waterways | - Use of best practice Water Sensitive Urban Design to capture net increase in nutrient loads following development | WSUD measures will be integrated into the proposal to capture net increase in nutrient loads including: vegetated swales, sediment basins, stormwater retention and detention basins, use of porous sandstone boulders in landscaping, etc. |
| Avoid displacing species by habitat changes | - No development within the riparian buffer OR<br>- Provision of compensatory habitat | Besides the several planted trees to be removed on the turfed area of the site, the only impact to habitat will be the modification of the bushland buffer zone for an APZ with regard to the WIS. No trees shall be removed from this zone. Only the shrub layer will be removed to prevent connectivity between vegetation layers and reduce the fire ladder. Compensatory habitat will be provided by regenerating weed infested area of bushland on site as per the approved VMP. |
| Protect natural areas from contamination | - No activities within the riparian buffer<br>- which may contaminate soils or vegetation<br>- No storage of chemicals, fuels or oils within riparian buffers OR<br>- Adequate bunding of stored materials | An Erosion and Sediment Control Plan will be prepared in accordance with Landcom's Managing Urban Stormwater: Soil and Construction Manual (2004). It will prescribe that no activities are to be undertaken within the riparian buffer which may contaminate soils or vegetation, that there is to be no storage of chemicals, fuels or oils within riparian buffers, and that there is adequate bunding of stored materials. It will also detail types of control, methods of installation, locations, maintenance regimes, responsibilities, stockpile storage, silt fencing, vehicle shake-down, floating silt boom, stabilisation access for machinery, etc. These measures will be installed and maintained until the site is fully established. |
| Prevent the loss of any rare or threatened natural features | - No loss of any species, community or habitat listed under relevant conservation legislation<br>- No loss of natural features identified in the DCP/LEP as rare or threatened | No loss of any listed species, community, habitat, or natural feature listed is expected as a result of the proposed development. For full details see the BDAR and for mitigation measures see the VMP. |
| Protect downstream protected areas, such as National Parks | - On-site detention through On-site stormwater detention (OSD) technical specification or infiltration through best | OSD systems such as detention and retention basins are proposed as well as WSUD features such as vegetated swales and sediment basins. See Appendix |

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| | practice Water Sensitive Urban Design AND<br>- On-site sediment capture through best practice Water Sensitive Urban Design | B for OSD flow diagram. See also hydrological engineer's report for full details. |

## Outcome 3: Minimise damage to public and private property by waterway processes through maintaining the relative stability of the bed and banks

**Table 4. Outcome 3: Minimise damage to public and private property by waterway processes through maintaining the relative stability of the bed and banks**

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Avoid increases in peak channel flows and sediment exports for events smaller than 2 year Average Recurrence Interval (ARI). | - On-site detention through On-site stormwater detention (OSD) technical specification or infiltration through best practice Water Sensitive Urban Design AND<br>- On-site sediment capture through best practice Water Sensitive Urban Design | OSD systems such as detention and retention basins are proposed as well as WSUD features such as vegetated swales and sediment basins. See Appendix B for OSD flow diagram. See also hydrological engineer's report for full details. |
| Avoid local erosion at Stormwater outlets | - Energy dissipation at stormwater outlets entering waterways AND<br>- Infiltration and on site detention with minimal use of pipes or lined drains AND<br>- Stabilisation of actively eroding banks using best practice Natural Channel Design Principles (as per Warringah Creek Management Study 2004 – Appendix F s.3) | - Stormwater will be channeled into the existing creeklines and vegetated swale to dissipate the volume and velocity of water entering stormwater pipes;<br>- Infiltration and on site detention will occur through the use of retention and detention tanks;<br>- Stabilisation of the existing informal overland swale will occur through WSUD compliant landscaping and riparian revegetation works. |
| Avoid export of weeds from private properties into waterways | - No disposal of garden refuse in riparian lands. | The VMP will contain a management action preventing the disposal of garden refuse in riparian lands. |
| Channel banks are not over steepened | - Stabilisation of actively eroding banks using best practice Natural Channel Design Principles (as per Warringah Creek Management Study 2004 – Appendix F s.3) | The existing creeklines are not prone to erosion and the proposed development will not affect the steepness of the channel banks. |
| Channel banks are stable | - Stabilisation of actively eroding banks best practice Natural Channel Design Principles (as per Warringah Creek Management Study 2004 – Appendix F s.3) | The existing channel banks are fixed into sandstone bedrock and will not be affected by the proposed development. |

## Outcome 4: Preserve natural ecological processes

**Table 5. Outcome 4: Preserve natural ecological processes**

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Streamflow and water quality are natural | - No artificial barriers to capture water<br>- No removal of water for consumptive use (except riparian use rights)<br>- Impervious surfaces offset by stormwater management controls so there is no net change in peak loads or pollutant loads in waterways (see On-site Stormwater detention (OSD) technical specification)<br>- Site design adheres to best practice Water Sensitive Urban Design principles AND<br>- On-site uses do not involve specific risks to water quality (e.g. chemicals, organic materials, exposed soil, effluent generation) | - No artificial barriers to capture water are proposed except for OSD and WSUD measures;<br>- No removal of water for consumptive use is proposed;<br>- Alteration in hydrology as a result of increased impervious surfaces will be offset by OSD and WSUD measures;<br>- Site design adheres to best practice WSUD principles;<br>- On-site uses do not involve any specific risks to water quality.<br>See hydrological engineer's report for full details. |
| Aquatic and riparian vegetation are undisturbed and unmodified | - All development is outside riparian zone | All development is outside the riparian zones. Site rehabilitation works including bush regeneration will revegetate the areas around the creeklines with riparian species. See VMP for details. |
| Aquatic and riparian fauna habitat and movement corridors are retained | - Improvement to stream bed or banks | The stream beds and banks of the existing creeklines are confined due to being hewn from sandstone bedrock. Habitat value and movement corridors for mobile fauna will be improved by revegetation works along the creeklines. See VMP for details. |

### Outcome 5: Create opportunities for public access and recreation in waterway corridors

**Table 6. Outcome 5: Create opportunities for public access and recreation in waterway corridors**

| Performance criteria | Acceptable mitigation measures | Proposed mitigation measures |
|---|---|---|
| Provide public access along creek corridors where appropriate | - Set back developments to allow public access within riparian buffers | The existing creeklines do not have any public recreation value. Even so, the proposed development does not prevent access to them. |

## Conclusions and Recommendations

In conclusion, the two artificial creeklines on site are assessed as having low ecological value despite the central creekline being mapped as a Group A headwater of Curl Curl Creek. This is due to the "urban modified" river style of the creeks and the fact that their geomorphic attributes have been altered so much that they do not function as rivers. As such, the proposal is unlikely to negatively impact the existing channel form, erosion rate, or bank stability of the artificial creeklines which have been excavated into sandstone bedrock.

Potential impacts of the proposed development include:

- Increased erosion and sedimentation, especially during the construction phase;
- Increased stormwater runoff during the operational phase due to an increase in impermeable surfaces;
- Modification Loss of habitat and connectivity due to the removal of vegetation;
- Decrease in water quality and increase in nutrient loads;
- Potential contamination of natural areas downstream including Manly Dam Reserve;
- Increase in peak stormwater flows, and;
- Increased stormwater runoff being directed into Council's drainage systems.

These potential impacts may be significantly reduced by the implementation of effective mitigation measures including:

- A CEMP which will require
    - Construction of a temporary stormwater detention basin where silted water can be flocculated and sediment removed prior to release into bushland below;
    - Installation of measures to mitigate potential erosion on site and to stop the flow of silted water off site;
    - The requirement that any erosion and sedimentation is to be managed at the source, and;
    - Compliance of all erosion, sediment and pollution controls with Council's Water Management Policy;

- An Erosion and Sediment Control Plan and Soil and Water Management Plan which will detail types of control, methods of installation, locations, maintenance regimes, responsibilities, stockpile storage, silt fencing, vehicle shake-down, floating silt boom, stabilisation access for machinery, etc. These measures will be installed and maintained until the site is fully established;

- A VMP which will protect and improve the ecological condition of the surrounding bushland by requiring site rehabilitation and bush regeneration of any areas disturbed or otherwise affected by the development;

- Construction of OSD measures including a stormwater detention tank which adequately caters for the volume of water that might be generated in a 1:100 stormwater event;

- Integration of WSUD measures including vegetated swales, sediment basins, etc.;

- Management and minimisation of stormwater overland flow, nuisance flooding and groundwater related damage to properties by channelling stormwater within the existing artificial drainage lines;

- Minimising the quantity of stormwater runoff on Council's drainage system by directing discharge into the existing sediment basin, and;

- Designing, installing, and maintaining the stormwater drainage system in accordance with Council's Water Management Policy, and;
- Situating the development so as to minimise impact on prescribed vegetation including remnant canopy trees, understorey vegetation, and ground cover species;

For development recommendations and construction methodologies see the CEMP, Erosion and Sediment Control Plan, Soil and Water Management Plan, landscape architect's plan, and hydrological engineer's report.

## References

*Biodiversity Conservation Act 2016* (NSW).

Department of Primary Industries (2012) *Guidelines for riparian corridors on waterfront land*. NSW Government Office of Water, DPI, Hurstville.

*Environment Protection and Biodiversity Conservation Act 1999* (Cth).

*National Parks and Wildlife Act 1974* (NSW).

Total Earth Care (2017) *Development Constraints Report: Allambie Heights Village, Allambie Heights*, Sydney.

Total Earth Care (2017) *Vegetation Management Plan: William Charlton Village, Allambie Heights*, Sydney.

Warringah Council (2004) *Warringah Creek Management Study*, Sydney.

Warringah Council, *Protection of Waterways and Riparian Land Policy PL 740*, Sydney, viewed 19 February 2018, https://files.northernbeaches.nsw.gov.au/sites/default/files/documents/policies-register/waterways-and-riparian-land/protection-waterways-and-riparian-land-policy/protectionofwaterwaysandriparianlandpolicy.pdf.

Warringah Council, *Warringah Development Control Plan 2011*, Sydney, viewed 19 February 2018, https://eservices1.warringah.nsw.gov.au/eplanning/live/pages/plan/Book.aspx?exhibit=DCP&hid=81.

Warringah Council, *Waterway Impact Statement Guidelines*, Sydney, viewed 19 February 2018, https://www.northernbeaches.nsw.gov.au/sites/default/files/documents/general-information/environmental-and-community-protections/guidelinesforpreparingawaterwayimpactstatement.pdf.

*Warringah Local Environmental Plan 2011* (NSW), viewed 19 February 2018, https://legislation.nsw.gov.au/#/view/EPI/2011/649/full.

*Water Management Act 2000* (NSW).

## Definitions

***The definitions contained are derived from the documentation identified after each definition. Accordingly, the definition contained within the original documentation supersedes the definition contained within this section.***

**Connectivity** means the interconnection of functionally related ecological elements of a landscape so that species can move amongst them (MWH Australia Pty Ltd 2004, *Warringah Creek Management Study*).

**Creek** means any watercourse, whether ephemeral, intermittent or perennial, whether on its natural course or altered by human interference, whether channelled or not. It also includes any drainage lines able to be identified by a linear vegetation assemblage reflective of regularly moist soil conditions or by a weed plume consistent with regularly moist soil conditions (MWH Australia Pty Ltd 2004, *Warringah Creek Management Study*).

**Development** means:

(a) the use of land, and
(b) the subdivision of land, and
(c) the erection of a building, and
(d) the carrying out of a work, and
(e) the demolition of a building or work, and
(f) any other act, matter or thing referred to in section 26 that is controlled by an environmental planning instrument, but does not include any development of a class or description prescribed by the regulations for the purposes of this definition *(Environmental Planning and Assessment Act, 1979).*

**Riparian** means occurring on the bank of a river (or other waterway, or waterbody). Usually refers to vegetation, "riparian land" (NSW Fisheries 1999, *Policy and Guidelines Aquatic Habitat Management and Fish Conservation).*

**Riparian Buffer** means land which is additional to the riparian zone necessary to protect the values and health of the riparian zone. The primary purpose of the buffer is to protect the integrity of the riparian zone. The combined width of the buffer and riparian zone then constitute a key protective mechanism for the ecological values of waterway systems. The minimum width of a riparian buffer is generally 10 metres, and is dependent on the catchment characteristics, slope and environmental values associated with the riparian corridor. The buffer is primarily designed to:

(a) Prevent water from affecting riparian vegetation (e.g. additional moisture, local erosion, nutrients, toxicants);
(b) Prevent weeds from invading the riparian zone; and
(c) Provide habitat for native fauna (thereby protecting it from external threats such as domestic animals) (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*)

**Riparian Land** is land comprising the riparian zone, riparian buffer and wetland buffer identified by DCP Map Waterways and Riparian Land (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*).

**Riparian Zone** means any land which adjoins, directly influences, or is influenced by a body of water. The width of the zone varies according to extent of riparian vegetation, flood levels, water quality, and channel form. This zone is taken to start at the highest bank of the watercourse (as defined in the *Water Management Act, 2000*). For ephemeral streams without a defined channel, the start of the riparian zone is the creek centre line. The riparian zone provides important habitat, protects the creek from water quality and hydrological impacts. It has other functions, including intrinsic value, as well as providing bed and bank stability, providing woody debris to the waterway and a buffer between development and waterways (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*).

**River** includes:

(a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and
(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and
(c) anything declared by the regulations to be a river, whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river (*Water Management Act 2000).*

**Waterbody (artificial)** or **artificial waterbody** means an artificial body of water, including any constructed waterway, canal, inlet, bay, channel, dam, pond, lake or artificial wetland, but does not include a dry detention basin or other stormwater management construction that is only intended to hold water intermittently. (*Standard Instrument—Principal Local Environmental Plan (*NSW)).

**Waterbody (natural)** or **natural waterbody** means a natural body of water, whether perennial or intermittent, fresh, brackish or saline, the course of which may have been artificially modified or diverted onto a new course, and includes a river, creek,

stream, lake, lagoon, natural wetland, estuary, bay, inlet or tidal waters (including the sea). (*Standard Instrument—Principal Local Environmental Plan (*NSW)).

**Watercourse** means any river, creek, stream or chain of ponds, whether artificially modified or not, in which water usually flows, either continuously or intermittently, in a defined bed or channel, but does not include a waterbody (artificial). (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Waterway** means the whole or any part of a watercourse, wetland, waterbody (artificial) or waterbody (natural). (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Wetland** means:

(a) natural wetland, including marshes, mangroves, backwaters, billabongs, swamps, sedgelands, wet meadows or wet heathlands that form a shallow waterbody (up to 2 metres in depth) when inundated cyclically, intermittently or permanently with fresh, brackish or salt water, and where the inundation determines the type and productivity of the soils and the plant and animal communities, or

(b) artificial wetland, including marshes, swamps, wet meadows, sedgelands or wet heathlands that form a shallow waterbody (up to 2 metres in depth) when inundated cyclically, intermittently or permanently with water, and are constructed and vegetated with wetland plant communities (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Riparian Land** is land comprising the riparian zone, riparian buffer and wetland buffer identified by DCP Map Waterways and Riparian Land (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*).

**Riparian Zone** means any land which adjoins, directly influences, or is influenced by a body of water. The width of the zone varies according to extent of riparian vegetation, flood levels, water quality, and channel form. This zone is taken to start at the highest bank of the watercourse (as defined in the *Water Management Act, 2000*). For ephemeral streams without a defined channel, the start of the riparian zone is the creek centre line. The riparian zone provides important habitat, protects the creek from water quality and hydrological impacts. It has other functions, including intrinsic value, as well as providing bed and bank stability, providing woody debris to the waterway and a buffer between development and waterways (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*).

**River** includes:

(a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and

(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and

(c) anything declared by the regulations to be a river, whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river (*Water Management Act 2000)*.

**Waterbody (artificial)** or **artificial waterbody** means an artificial body of water, including any constructed waterway, canal, inlet, bay, channel, dam, pond, lake or artificial wetland, but does not include a dry detention basin or other stormwater management construction that is only intended to hold water intermittently. (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Waterbody (natural)** or **natural waterbody** means a natural body of water, whether perennial or intermittent, fresh, brackish or saline, the course of which may have been artificially modified or diverted onto a new course, and includes a river, creek, stream, lake, lagoon, natural wetland, estuary, bay, inlet or tidal waters (including the sea). (*Standard Instrument—Principal Local Environmental Plan (*NSW)).

**Watercourse** means any river, creek, stream or chain of ponds, whether artificially modified or not, in which water usually flows, either continuously or intermittently, in a defined bed or channel, but does not include a waterbody (artificial). (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Waterway** means the whole or any part of a watercourse, wetland, waterbody (artificial) or waterbody (natural). (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Wetland** means:

(a) natural wetland, including marshes, mangroves, backwaters, billabongs, swamps, sedgelands, wet meadows or wet heathlands that form a shallow waterbody (up to 2 metres in depth) when inundated cyclically, intermittently or permanently with fresh, brackish or salt water, and where the inundation determines the type and productivity of the soils and the plant and animal communities, or

(b) artificial wetland, including marshes, swamps, wet meadows, sedgelands or wet heathlands that form a shallow waterbody (up to 2 metres in depth) when inundated cyclically, intermittently or permanently with water, and are constructed and vegetated with wetland plant communities (*Standard Instrument—Principal Local Environmental Plan* (NSW)).

**Wetland buffer** means 100m buffer of land, measured from the shoreline, surrounding a wetland which directly influences and protects a wetland (*Warringah Council Protection of Waterway and Riparian Lands Policy PL-740*).

# APPENDICES

## Appendix A. Qualification of Authors

total earth care

# Andrew McGahey

## COMPANY DIRECTOR – TOTAL EARTH CARE

### Industry Experience – Over 30 Years

Andrew is the Director of Total Earth Care, and established the business in Sydney in 1991. Andrew's key roles include business development, client liaison and project direction. Andrew's extensive experience in vegetation management and broad scale ecological restoration project planning and execution spans urban bushland management, ecological consulting, creek-line reconstruction and stabilisation, solutions and techniques in sandstone capping, large-scale soil translocation and reconstruction of native plant communities. As one of the bushland management industry's most experienced professionals, Andrew has pioneered innovative solutions and techniques that are used in a wide spectrum of applications.
Andrew's breadth and volume of practical experience and knowledge in ecological restoration projects is an invaluable resource to the Environmental Consulting Division and our clients.

### Employment History

| | |
|---|---|
| Total Earth Care Pty. Ltd. | 1991 – Present |
| Sydney Bush Regeneration Company Ptd Ltd | 1990 – 1991 |
| Indigenous Regeneration Co Pty Ltd | 1988 – 1990 |
| Self-employed Landscape Gardener | 1986 – 1988 |
| Ku-ring-gai Council | 1985 – 1986 |

### Qualification/Accreditations

| | |
|---|---|
| Bachelor of Science (incomplete) | Macquarie University |
| Associate Diploma of Horticulture | Park Management |
| Certificate 2 in Bushland Regeneration | TAFE NSW |
| White Card, Work safely in the construction industry | WorkCover 2003 |
| Planning for Bush Fire Protection | UTS 2009 |
| Senior First Aid Certificate | TCP Training 2003 |

### Roles and Responsibilities

- Company Director;
- Environmental Impact Assessment;
- Flora and fauna field survey and assessments;
- Project management;
- Bushland management and bush regeneration;
- Quality assurance systems;
- Threatened species identification and assessment;
- Environmental planning & management;
- Application of applicable environmental planning instruments and policy;
- Chief Financial Officer;
- Staff resourcing, business planning and office management.

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# Ram Krishnan

## FIELD ECOLOGIST – ENVIRONMENTAL CONSULTING DIVISION

### Industry Experience – 11 Years

Ram has been with TEC since March 2018 as an Ecologist. Ram has a solid background in ecological restoration and project management. He has over 10 years of bushland restoration experience over a wide range of threatened ecological communities in the greater Sydney Basin bioregion. Throughout his career, he has gained excellent botanical, surveying and report writing skills. Ram has always had a keen interest in the environment and brings sound botanical knowledge as well as project management experience to the role.

### Major Clients & Recent Site Experiences

- **2018 –** Field Ecologist & Botanist for Flora and Fauna Assessments, Vegetation Management Plans, - Monitoring, Terrestrial Biodiversity Reports, Inspections and reviews of Conditions of Consent for residential development in an area regarding threatened species
- **2018 –** Ecologist, Idemitsu Boggabri Coal Mine, Preclearance Surveys for threatened reptile species and other native fauna present on site, Clearing Supervision relocation and monitoring of relocated individuals, habitat assessment, fauna surveys and management, provision of expert advice.
- Supervision of bush regeneration projects for several major clients including OEH, Northern Beaches Council, Sydney Water and Sydney Olympic Park Authority.
- Restoration of several Endangered Ecological Communities in NSW including, but not limited to; – Eastern Suburbs Banksia Scrub, Blue Gum High Forest, Cumberland Plain Woodland, Duffys forest, Freshwater Wetlands on Coastal Flood Plains, Sydney Turpentine Ironbark Forest and Shale Sandstone Transition Forest.
- Regeneration of pre and post burn sites for Ku-ring-gai Council, St Ives Showground, Princes Park and Sheldon Forest.

### Employment History

| | | |
|---|---|---|
| **2018 - Present** | **Ecologist** | Total Earth Care Pty Ltd, WSP |
| **2016 - 2017** | **Supervisor/Seed Collection Supervisor** | Muru Mittigar Pty Ltd |
| **2014 -2015** | **Project Officer** | Toolijooa Environmental Restoration Pty Ltd |
| **2007-2014** | **Bush Regenerator/ Supervisor/Bushcare Supervisor** | Toolijooa Environmental Restoration Pty Ltd |

### Qualification/Accreditations

| | |
|---|---|
| Bachelor of Science, Majors: Biology & Brain, Behaviour and Evolution (2012) | Macquarie University |
| Diploma of Conservation and Land Management (2008) | TAFE NSW |
| Certificate II and III Conservation and Land Management | TAFE NSW |
| Certificate II Animal Studies (2005) | TAFE NSW |
| Chainsaw Operations Level 1 (2016) | TAFE NSW |
| White Card (2010) | WorkCover |

### Conferences/Courses

| | |
|---|---|
| NSW Biodiversity Conservation Reforms (2018) | Environment Institute of Aust. & N. Zealand |
| Introduction to the Cumberland Plain (2018) | Teresa James, Botanist |
| Aboriginal Site Awareness Training (2015) | Aboriginal Heritage Office |
| Level 1 Field Guiding and Naturalist Course (2009) | Eco-Training South Africa |

## Appendix B. Stormwater Management Plan

WOOD & GRIEVE ENGINEERS

# Allambie Heights Village – Project 2

Prepared for:

**Allambie Heights Village Pty Ltd**

**Date:**
18 June 2018

Prepared by:

**Ian Harris**
Project No.38509-CI-RE_001
P:\38509\PROJECT DOCUMENTATION\CIVIL\DOCUMENTS & REPORTS\38509-CI-RE_001.DOCX

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# Revision

| | |
|---|---|
| **Site Address:** | 181 Allambie Road, Allambie Heights, NSW |
| **Real Property Description:** | Lot 2615 DP752038 |
| **Proposed Development:** | Aged Care Development |
| | |
| **Client:** | Allambie Heights Village Pty Ltd |
| **Local Authority** | Northern Beaches Council |
| **Authority Reference #:** | N/A |
| **Wood & Grieve Reference:** | 38509-CI-RE_001 |

**Ian Harris BEng (Hons)**
For and on behalf of
**Wood & Grieve Engineers**

| REVISION | DATE | COMMENT | APPROVED BY |
|---|---|---|---|
| **A** | 01.06.18 | DA Issue | **IH** |
| **B** | 18.06.18 | DA Issue | **IH** |
| | | | |
| | | | |

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# 1. Introduction

Wood & Grieve Engineers have been commissioned by Allambie Heights Village Pty Ltd to prepare this Stormwater Management Plan (SMP) in support of the Development Application for the proposed development at 181 Allambie Road, Allambie Heights, NSW. The sites real address is Lot 2615 DP752038.

This SMP outlines the conceptual DA level stormwater design for the proposed development of an aged care development on the site.

This SMP demonstrates the application of Water Sensitive Urban Design (WSUD) principles and illustrates that the proposed development complies with the Mid-Coast Council Standards and Guidelines for stormwater, Australian Rainfall and Runoff, Australian Standards and best engineering practise.

The purpose of this SMP is to evaluate the quantity and quality of stormwater associated with the proposed development plan so as to demonstrate to Council that an appropriate stormwater management strategy has been adopted.

The SMP specifically addresses the following items for both the construction and operational phases of the development:

- Stormwater runoff volumes and detention (Stormwater Quantity);
- Stormwater quality treatment measures (Stormwater Quality);
- Erosion and Sedimentation Control.

The following will be achieved with the correct application of this SMP report:

- Appropriate standards to be maintained on all aspects of stormwater within the site,
- Pollution control to be maintained,
- Establishment of a unified, clear and concise stormwater management strategy.

# 2. Existing Site Characteristics

## 2.1 Property Detail

| | |
|---|---|
| Address: | 181 Allambie Road, Allambie Heights, NSW |
| Real Property Description: | Lot 2615 DP752038 |
| Total Site Area: | 37,176m² (3.718Ha) |

The proposed development can be seen on the concept design drawings in Appendix A of this report.

The proposed development will consist of an aged care development including residences and a pool building.

As can be seen in the site location aerial photo below, the site is located west of Allambie Road and north of Martin Luther Place.

The area of the site to be developed is currently undeveloped. There are existing aged care buildings to the east of the development area within the extent of the site.


**Figure 1: Site Location Plan (Source: Nearmaps 2018)**

# Existing Site Characteristics

## 2.2 Topography

The area in consideration is currently undeveloped and is currently vegetated over its majority. There is a current bitumen road intersecting the development area. Topographic survey confirms the site falls from the north to south from approximately RL130m AHD to RL120m AHD.


**Figure 2: Site Topography (Source: CMS Surveyors 2017)**

## 2.3 Existing Stormwater Discharge

Visual inspection of the site and the detailed site topographic survey confirm that there is currently no in ground drainage infrastructure on the area of the site being considered for development. Stormwater runoff from this area of the site runs as overland flow towards the northern edge of the bitumen road where it is collected and conveyed towards a headwall and culvert running under the road. This headwall discharges into a vegetated swale which conveys flows towards the southern boundary of the site.

There is an existing waterway running north to south through the site to the west of the proposed development area. This waterway will not be impacted by the proposed development.

There is evidence of in ground drainage for the existing buildings located on the eastern portion of the site. This stormwater network appears to drain towards Allambie Road.

# 3. Local Authority Requirements

Northern Beaches Council set the design requirements for any new stormwater management system associated with new development in their Water Management Policy PL850. A summary of the key requirements for the development of the Stormwater management system for this development are summarized below.

## 3.1 On Site Detention Requirements

Council's policy states:

(a) OSD is required for the following developments:

i. single residential dwellings where the total existing and proposed impervious areas exceed 40% of the total site area (OSD will not be required for alterations and additions or where the total site area is 450m$^2$ or less)

ii. new residential flat buildings/multi-residential unit dwellings

iii. commercial developments

iv. industrial developments

v. subdivisions resulting in the creation of three (3) lots or more

vi. subdivisions resulting in the creation of two (2) lots or more, OSD will be required where the post developed impervious area of the new lots exceed 40% of the site area of the new lots. This requirement also applies to newly created lots with existing dwellings to be retained

vii. Alterations and additions to existing residential flat buildings/multi-residential unit dwellings, commercial developments and industrial developments, OSD is applicable to the extent of the new works only.

(b) Development requiring OSD must comply with Council's Onsite Stormwater Detention Technical Specification.

(c) A positive covenant and Restriction As to User must be registered on the title for the OSD system to ensure regular maintenance and operation.

(d) Council will not permit the use of "Drainage Cell" type products for onsite detention storage as access for maintenance or removal of silt/debris is limited.

(e) Council will allow the volume of rainwater reuse in single residential dwellings to be credited against the calculated OSD storage volume as determined by Council's Onsite Stormwater Detention Technical Specification.

Reference to the Onsite Stormwater Detention Technical Specification states:

**"The general requirement of Council's OSD Specification is to ensure that the site's stormwater runoff after any development does not exceed the runoff prior to the development**"

The specification continues to state:

> The post-development runoff is to be determined based on the post-development impervious area for all storm durations for the 5 year, 20 year, and 100 year ARI storm events. The OSD system(s) must be designed to restrict these flows to the calculated pre-development discharge rates. Hence the 5 year ARI post-development runoff must not exceed the 5 year ARI pre-development discharge, the 20 year ARI post-development runoff must not exceed the 20 year ARI pre-development discharge, and the 100 year ARI post-development runoff must not exceed the 100 year ARI pre-development discharge.

## 3.2 Discharge

For site which cannot directly connect to council drainage infrastructure council set discharge requirements in their Stormwater Drainage From Low Level Properties Technical Specification document.

This document states that direct connection to watercourses should be avoided and On-Site Absorption should be considered. The specification gives the following advice on the design of On-site Absorption.

“The absorption pit is to be designed for an Average Recurrence Interval (ARI) storm of 50 years using DRAINS computer software based on the infiltration rate that can be maintained in the long term. An overflow mechanism in the form of a level spreader must be provided for all storms greater than the 50 year ARI storm, up to and including the 100 year ARI storm. The overflow mechanism is required to minimise overland flow disturbance to the lower property.”

## 3.3 Water Pollutant Reduction Targets

Council's Water Management Policy states "Stormwater treatment measures are required to ensure the development does not impact on the receiving waters."

The policy outlines the following requirements for water quality treatment.

**Table 4 – General Stormwater Quality Requirements**

| Pollutant | Performance Requirements |
|---|---|
| **Total Phosphorous** | 65% reduction in the post development mean annual load[1] |
| **Total Nitrogen** | 45% reduction in the post development mean annual load[1] |
| **Total Suspended Solids** | 85% reduction in the post development mean annual load[1] |
| **Gross Pollutants** | 90% reduction in the post development mean annual load[1] (for pollutants greater than 5mm in diameter) |
| **pH** | 6.5 - 8.5 |
| **Hydrology** | The post-development peak discharge must not exceed the pre-development peak discharge for flows up to the 2 year ARI |

**Note:**

[1]The percentage reduction in the post development mean annual loads are relative to the loads from the proposed development without treatment applied.

# 4. Flood Impact Assessment

When considering a new development it is important to assess the impact of existing flooding on the proposed development and also the impact of the proposed development on existing or potential flooding both upstream and downstream of the development.

## 4.1 Existing Flooding

Referring to Council's online flood mapping indicates that the site is not affected by flooding.

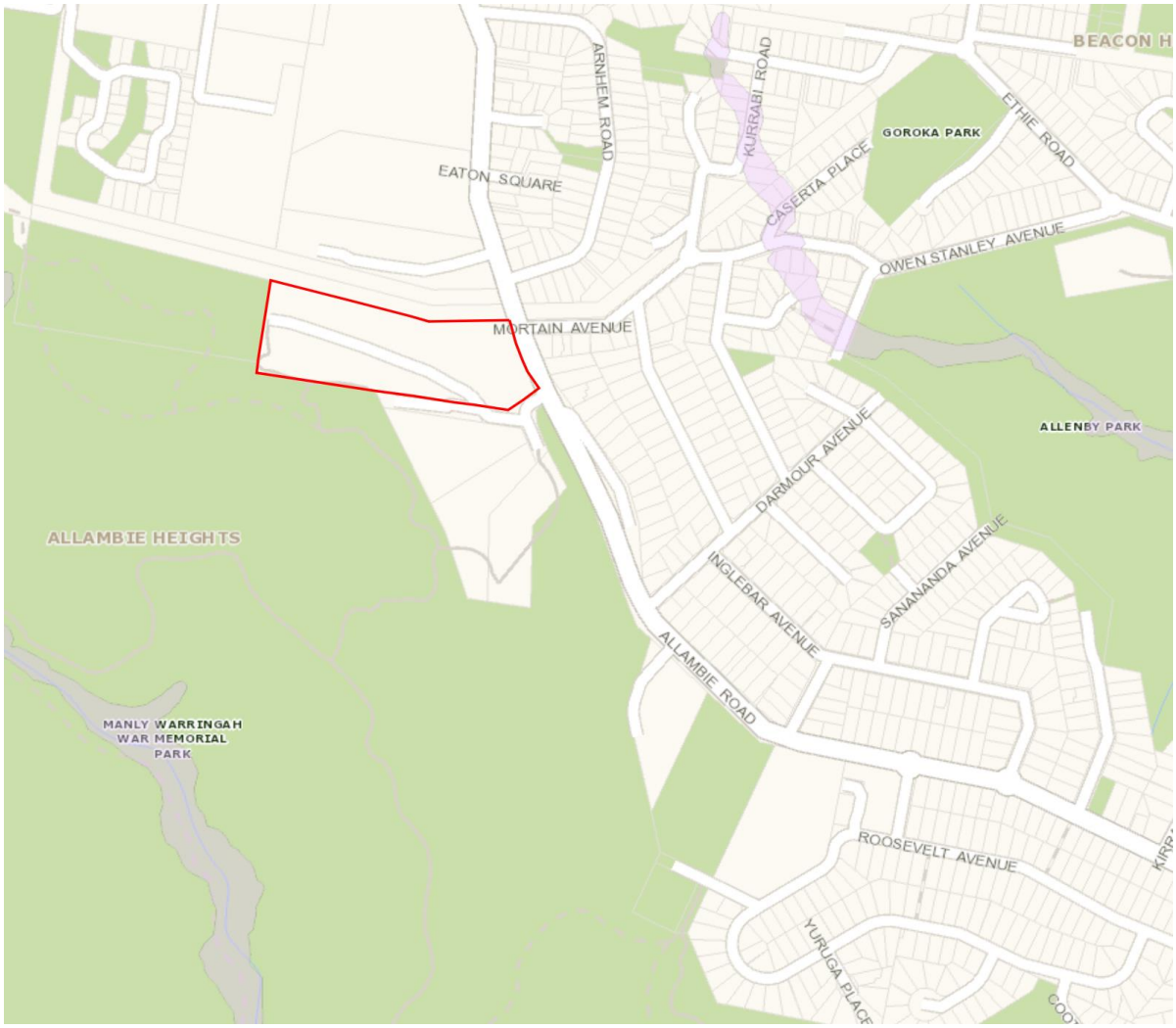



**Figure 3: Low Flood Risk Planning Precinct (Source: Northern Beaches Planning Maps, 2018)**

### 4.1.1 Flood Impacts

As the site is not affected by regional flooding no flood mitigation measures are proposed to deal with regional flooding. Measures will however be incorporated into the design to minimise the risk of local or nuisance flooding to or because of the development. These will include grading external areas to ensure positive stormwater runoff in a controlled manner and the provision of on-site detention to ensure there are no adverse downstream impacts caused by the development.

# 5. Stormwater Conveyance

This section of the report discusses the systems proposed to allow for stormwater to be conveyed across the site to the legal point of discharge.

## 5.1 Roof Drainage

All roof areas will be drained through a conventional downpipe system. The drainage system will be designed in accordance with AS3500.3:2003 to convey the 50 year design storm runoff from the roof to the proposed in ground drainage network. Flows in excess of the design flows will surcharge the roof drainage system and discharge onto the surrounding ground where it will then be conveyed overland in a controlled manner.

## 5.2 Infiltration Discharge

Discharge from the site will be via infiltration into the ground water. The base of the raingardens will allow runoff to discharge into the ground. Geotechnical investigations have been undertaken for the site and confirm that the existing geology on the site would allow for an infiltration rate of 0.01mm/hr, this rate has been used to calculate the area required to allow the runoff to discharge.

The infiltration system has been designed to discharge runoff occurring from a 100 year design storm, a peak discharge flow of 283L/s.

# 6. Stormwater Attenuation

Stormwater detention for the site will be provided to attenuate the post development discharge rates back to the pre-development rates. A DRAINS model has been produced to assess the volume of storage required for the development. This model confirms that 100m³ is required to attenuate the discharge flows.

The stormwater detention will be achieved by providing an underground tank situated below the proposed community building. The location and arrangement of the tank is indicated in the concept drawing in Appendix A of this report.

Discharge rates will be attenuated by providing an orifice plate over the discharge pipe which will restrict the flows discharging to the legal point of discharge. The sizing of this orifice plate has been undertaken using the DRAINS model for the development. The model has confirmed that the orifice plate will have a diameter of 190mm.

The table below summarises the discharge flows from the site.

| Development Scenario | % Impermeable | Discharge Flow Rates (L/s) | | |
|---|---|---|---|---|
| | | 5 Year Design Storm | 20 Year Design Storm | 100 Year Design Storm |
| Pre-Development | 10 | 328 | 463 | 595 |
| Post – Development | 60 | 278 | 359 | 584 |

**Table 1: Site Discharge Flows**

Output from the DRAINS model is included in Appendix B of this report.

# 7. Water Quality Treatment

As discussed in section 3.2 of this report Northern Beaches Council have set targets for the reduction of water borne pollution being conveyed from the site through the stormwater drainage system.

This section of the report demonstrates the Stormwater Quality Improvement Devices (SQID's) to be implemented and the Pollutant Export Modelling undertaken to demonstrate the effectiveness of the treatment system in achieving the reduction targets set by council.

## 7.1 Potential Pollutants

There are a wide range of potential stormwater pollutant sources which occur from urbanised catchments, many which can be managed through appropriate stormwater quality treatment. Typical urban pollutants may include:

- Atmospheric deposition
- Erosion (including that from subdivision and building activities)
- Litter and debris
- Traffic emissions and vehicle wear
- Animal droppings
- Pesticides and fertilisers
- Application, storage and wash-off of car oil, detergents and other household and commercial solvents and chemicals
- Solids accumulation and growth in stormwater systems
- Weathering of buildings

These pollutants in urban stormwater can be placed into various categories as follows. The pollutants underlined below are able to be readily modelled:

- Suspended Solids
- Litter
- Nutrients such as Nitrogen and Phosphorous
- Biological oxygen demand (BOD) and chemical oxygen demand (COD) materials
- Micro-organisms
- Toxic organics
- Trace metals
- Oils and surfactants

While only the key pollutants underlined above will be examined within the modelling, the stormwater Quality Improvement Devices implemented are expected to assist in reducing a wide range of pollutants. For example, heavy metals are commonly associated with, and bound to fine sediments. Thus reducing the discharge of fine sediment during the construction and operational phases will also reduce the discharge of heavy metals to existing stormwater systems.

## 7.2 Pollutant Reduction System

In order to achieve the pollutant reduction targets specified in section 3.3 of this report a series of treatment devices are proposed with together form a treatment train. The diagram below shows the proposed treatment train for this development.

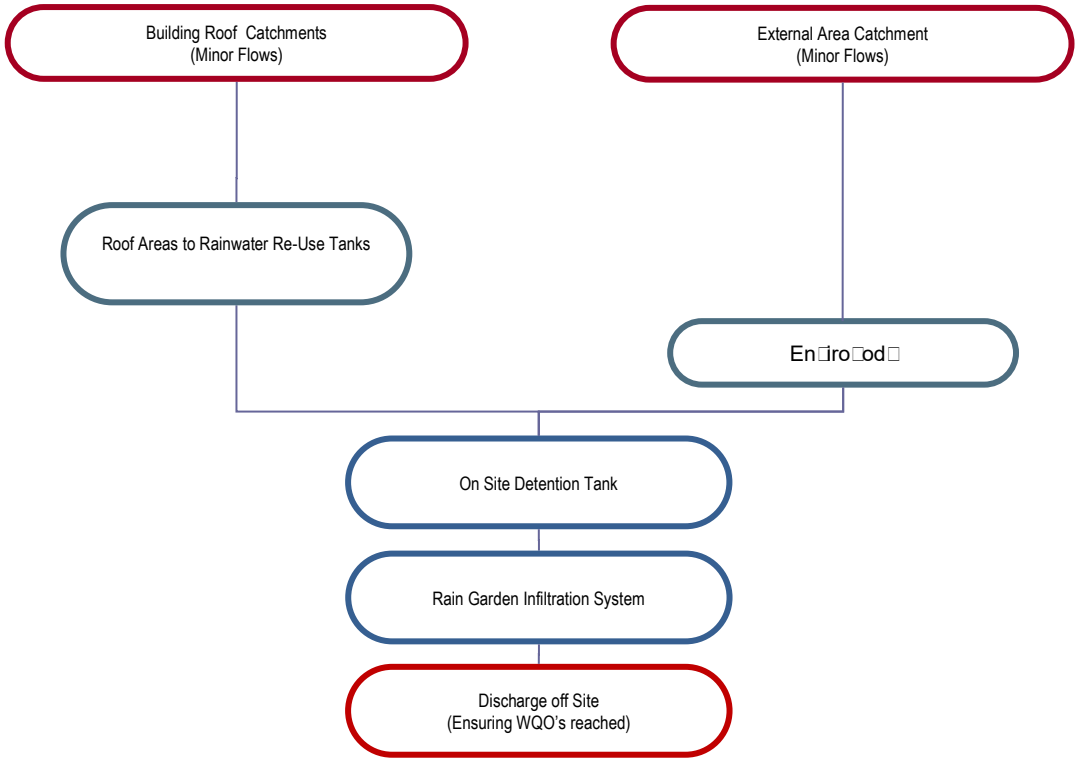



**Figure 4: Proposed Water Quality Treatment Train**

Further discussion on each element of this treatment train is provided below.

### 7.2.1 Rainwater Tanks

As shown in the proposed treatment train, the roof water from the building will drain to rainwater tanks and will be used for irrigation. The use of rainwater tanks will allow for a reduction of TSS by the settling of particles over time and through the screening of water before it enters the tank.

A 130Kl tank is proposed for the development.

### 7.2.2 EnviroPod Pit Inlet Trap (or approved equivalent)

EnviroPod's (or other similar approved equivalents) provide effective removal of TSS and gross pollutants. EnviroPod's are a filter cage system which are inserted into roadway gully pits to filter and remove pollutants before the water enters the piped drainage system. It is proposed to placed EnviroPod filters within every pit in the roadway.

The MUSIC modelling parameters for this device are set by the manufacturer, Stormwater 360.


| Parameters | TSS | TP | TN | GP |
|---|---|---|---|---|
| Input (mg/L) | 100 | 10 | 50 | 14.8 |
| Output (mg/L) | 53 | 10 | 50 | 0 |
| Reduction (%) | 47 | 0 | 0 | 100 |

**Figure 5: EnviroPod Pit Inlet Trap (Source: Stormwater 360)**

### 7.2.3 Rain Garden

Bio-retention systems are vegetated areas where stormwater is passed through densely planted filter media (loamy sand) allowing the plants to absorb the collected and stored nutrients. Bio-retention basins utilise temporary ponding above the vegetated surface to increase the volume of stored water for treatment. Bio-retention systems can take a number of forms but all have common features including the extended detention depth above the media surface, the filter media and a low level drainage media and subsoil system. These are shown in the figure below.

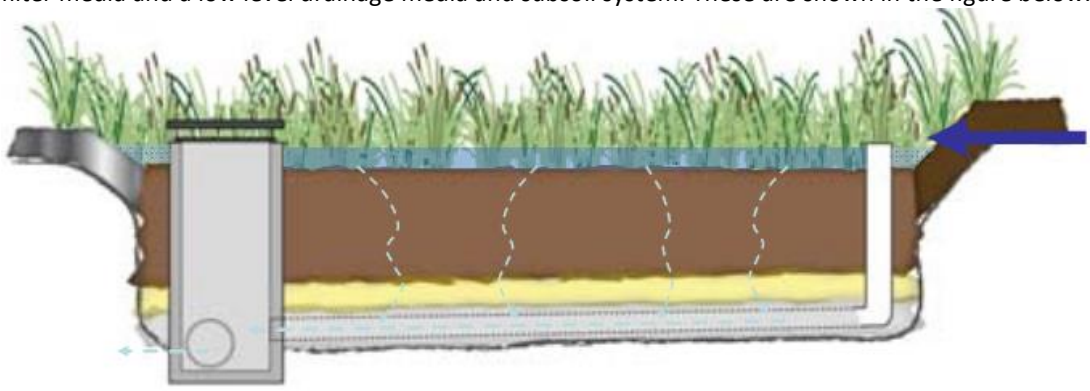


**Figure 6: Typical Section of a generic Bio-retention system (Source: Water by Design)**

## 7.3 Pollutant Reduction Modelling

In order to demonstrate that the proposed treatment train meets the required reduction targets, pollutant reduction modelling is proposed using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Software program Version 5.0 by eWater CRC. Pollutant export rates are currently only available for Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorous (TP) and Gross Pollutants (GP). Therefore only quantitative modelling for TSS, TN, TP & GP has been undertaken using MUSIC.

Modelling has only been undertaken on the post-development proposal with SQID's installed so as to demonstrate the percentage reduction for each pollutant type.

### 7.3.1 MUSIC Program Setup

This section explains the setup of the MUSIC model with the detailed pollutant reduction calculations being included in the MUSIC results in Appendix C.

For Music Modelling (using MUSIC 6.2.1) the following parameters have been used:

**Table 2: MUSIC modelling parameters**

| **Model Parameters** | |
|---|---|
| Meteorological Data: | Sydney |
| Evaporation Data: | Period: 1959 |
| Time Step: | 6 minute |

**Table 3: Catchment modelling parameters**

| **Node Description** | **Area (Ha)** | **Percentage Impervious (%) / Area Impervious (Ha)** | | **Land Use Rainfall and Pollutant Parameters** |
|---|---|---|---|---|
| Building Roof Catchment | 0.364 | 100 | 0.364 | Urban Residential |
| External Areas | 0.160 | 100 | 0.160 | Urban Residential |
| Bypass Area | 0.243 | 0 | 0 | Revegitated |
| | Total: 0.767Ha | Effective FI 68% | | |

### 7.3.2 MUSIC Results & Parameters

**MUSIC Model**

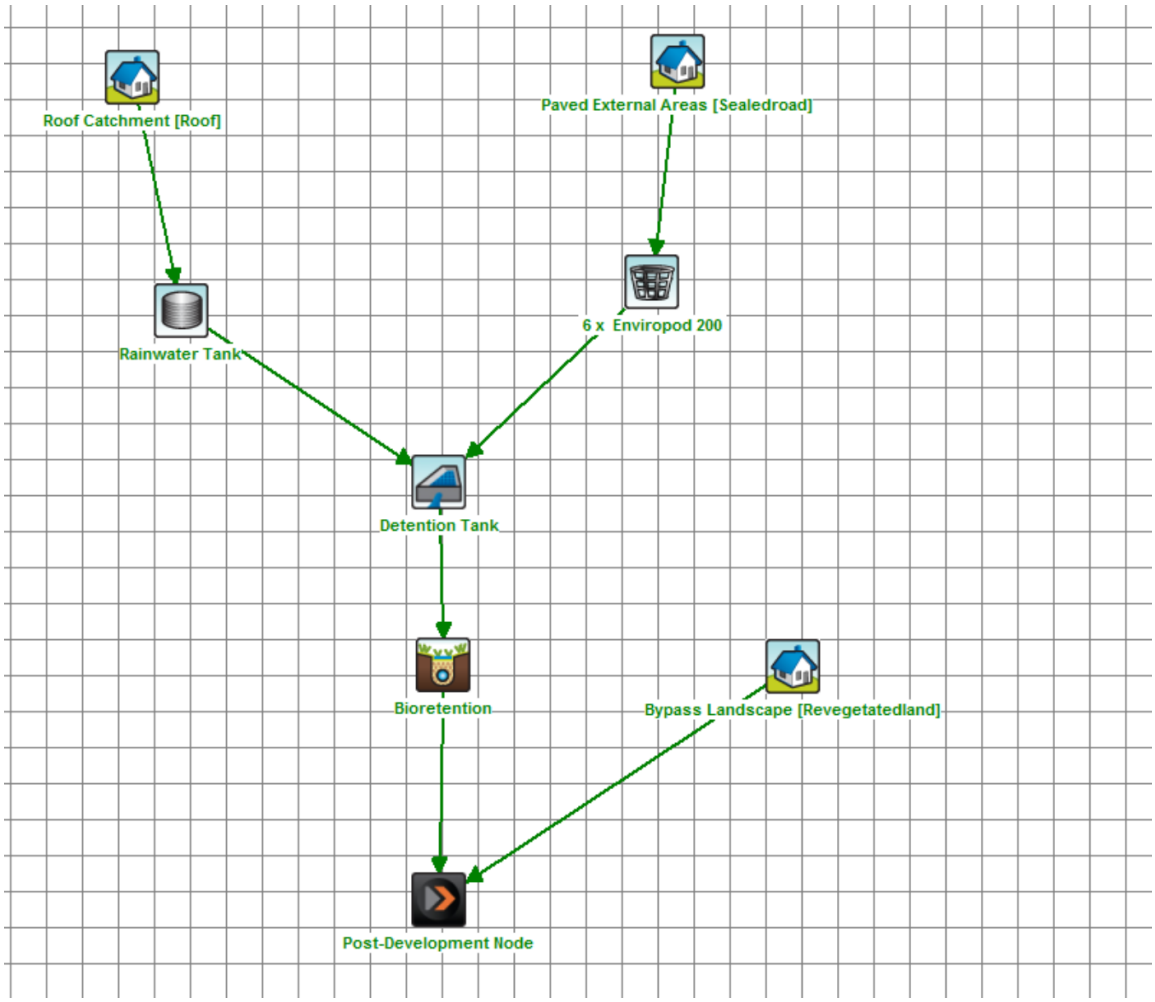



**Figure 7 MUSIC Model**

**MUSIC Output**

| | Sources | Residual Load | % Reduction |
|---|---|---|---|
| Flow (ML/yr) | 8.18 | 5.54 | 32.4 |
| Total Suspended Solids (kg/yr) | 956 | 120 | 87.5 |
| Total Phosphorus (kg/yr) | 2.13 | 0.452 | 78.8 |
| Total Nitrogen (kg/yr) | 17.6 | 6.27 | 64.4 |
| Gross Pollutants (kg/yr) | 171 | 0 | 100 |

**Figure 8 MUSIC Results**

### MUSIC Runoff Generation Parameters

The following properties have been used in the MUSIC Modelling based on the Land Use Rainfall and Pollutant Parameters.

**Table 4: Recommended MUSIC Runoff Generation Parameters**

| Parameter | Urban Residential |
|---|---|
| Rainfall Threshold (mm) | 1.0 |
| Soil Capacity (mm) | 120 |
| Initial Storage (%) | 25 |
| Field Capacity | 80 |
| Infiltration Capacity Coefficient a | 200 |
| Infiltration Capacity Coefficient b | 1.00 |
| Initial Depth (mm) | 10 |
| Daily Recharge Rate (%) | 25 |
| Daily Drainage Rate (%) | 5 |
| Daily Deep Seepage Rate (%) | 0 |

### MUSIC Concentration Parameters

**Table 5: MUSIC Concentration Parameters for Parramatta Catchments**

| Land-use Type | Parameters | TSS Log10 mg/L | | TP Log10 mg/L | | TN Log10 mg/L | |
|---|---|---|---|---|---|---|---|
| | | Base Flow | Storm Flow | Base Flow | Storm Flow | Base Flow | Storm Flow |
| Roof Catchment | Mean | 1.1 | 1.3 | -0.82 | -0.89 | 0.32 | 0.30 |
| | STD Dev | 0.17 | 0.32 | 0.19 | 0.25 | 0.12 | 0.19 |
| External Areas | Mean | 1.2 | 2.43 | -0.85 | -0.3 | 0.11 | 0.34 |
| | STD Dev | 0.17 | 0.32 | 0.19 | 0.25 | 0.12 | 0.19 |
| Vegetated Bypass | Mean | 1.15 | 1.95 | -1.22 | -0.66 | -0.05 | 0.30 |
| | STD Dev | 0.17 | 0.32 | 0.19 | 0.25 | 0.12 | 0.19 |

### 7.3.3 Pollutant Reduction Results

A number of management measures have been considered with a focus on reducing polluted runoff volumes from the site. The WSUD principals proposed for stormwater treatment includes the following SQID's:

- Rainwater Tank
- Detention Tank
- Gross Pollutant Traps
- Raingarden

The effectiveness of the treatment devices proposed in the above section has been modelled using MUSIC with the overall treatment train efficiency results shown in Table 6 below.

**Table 6: Treatment Train Efficiencies**

| Indicator | Total Site Reduction | Site Targets | Target Achieved |
|---|---|---|---|
| Gross Pollutants | 100% | 90% | Yes |
| Total Suspended Solids (TSS) | 87.5% | 85% | Yes |
| Total Phosphorus (TP) | 78.8% | 60% | Yes |
| Total Nitrogen (TN) | 64.4% | 45% | Yes |

From the results presented above it can be seen that the proposed SQID's mean that the stormwater quality treatment meets with the reduction targets set for the development.

# 8. Erosion & Sedimentation Control

Landcom have published a design guide entitled "Managing Urban Stormwater - Soils and Construction" which is regarded as the standard to which erosion and sedimentation control should be designed to within NSW. Northern Beaches Council specifies compliance with the Landcom design guide in there Design Guidelines Subdivision/Developments.

The control of erosion and sedimentation describes the measures incorporated during and following construction of a new development to prevent the pollution and degradation of the downstream watercourse.

A Soil and Water Management Plan has prepared as part of the development application documentation and is included in Appendix A of this report.

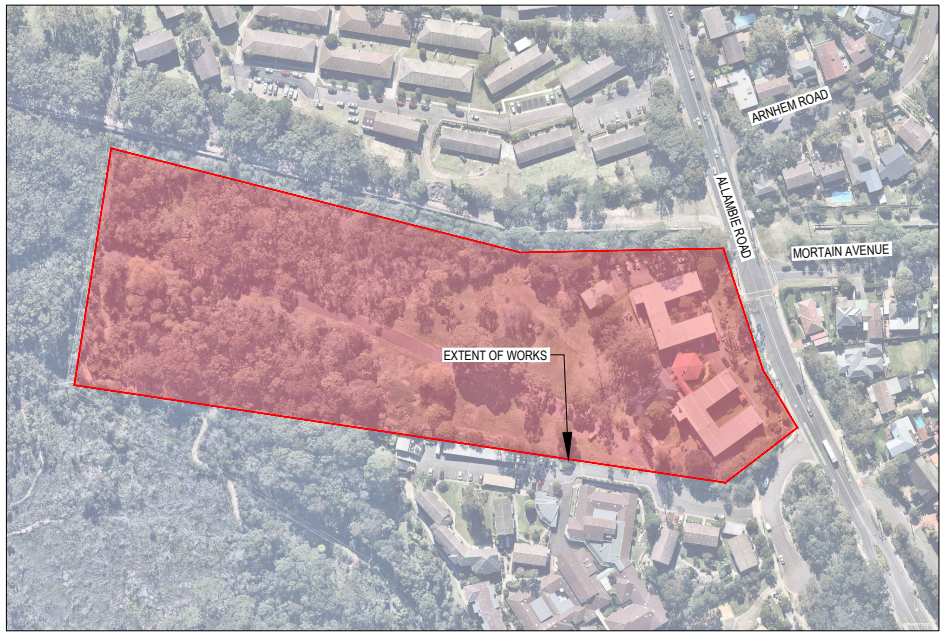
Common control measures adopted are:

- Sedimentation fences;
- Sedimentation basins;
- Stormwater drainage inlet protection;
- Overland flow diversion swales;
- Shaker Grids and wash downs for vehicles leaving the construction site;
- Dust control measures.

The maintenance of these control measures throughout their intended lifespan will ensure that the risk of erosion and sedimentation pollution of the downstream watercourse will be minimized.

# Appendix A – Civil Drawings

# CIVIL ENGINEERING WORKS




| Sheet List Table | |
|---|---|
| Sheet Number | Sheet Title |
| CI-000-01 | COVER SHEET |
| CI-070-01 | SEDIMENTATION & EROSION CONTROL PLAN |
| CI-070-02 | SEDIMENTATION & EROSION CONTROL DETAILS |
| CI-100-01 | BULK EARTHWORKS PLAN |
| CI-520-01 | STORMWATER MANAGEMENT PLAN |
| CI-526-01 | STORMWATER MANAGEMENT DETAILS |

JACKSON TEECE
Architecture

| JACKSON TEECE | 181 ALLAMBIE ROAD, ALAMBIE HEIGHTS | WOOD & GRIEVE ENGINEERS | 38509 | CI-000-01 | A |
|---|---|---|---|---|---|
| CLIENT | PROJECT | | PROJECT No | DRAWING No | REV |


NOTE:
REFER DRAWING CI-076-01 FOR EROSION AND SEDIMENT CONTROL DETAILS

| REV | DESCRIPTION | DRAWN | APPD | DATE |
|---|---|---|---|---|
| A | ISSUED FOR DA APPROVAL | CPO | IAH | 01.06.18 |

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| DRAWN: | CPO |
| DESIGNED: | IAH |
| VERIFIED: | IAH 01.06.18 |
| APPROVED FOR TENDER: | ... JJJ.. |
| APPROVED FOR CONSTRUCTION: | ... JJJ.. |

JACKSON TEECE
Architecture
ARCHITECT/CLIENT

181 ALLAMBIE ROAD
ALLAMBIE HEIGHTS
NSW
PROJECT

SEDIMENTATION & EROSION CONTROL PLAN
TITLE

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WOOD & GRIEVE ENGINEERS

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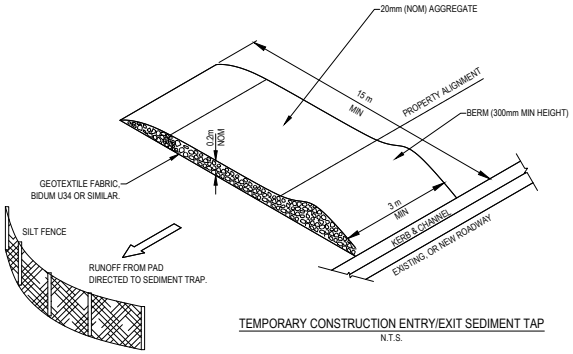
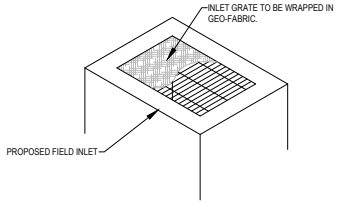



TEMPORARY CONSTRUCTION ENTRY/EXIT SEDIMENT TAP
N.T.S.




FIELD INLET SEDIMENT CONTROL
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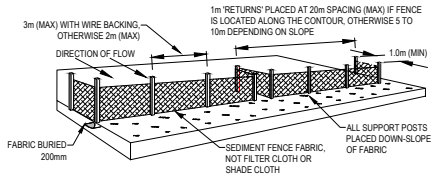
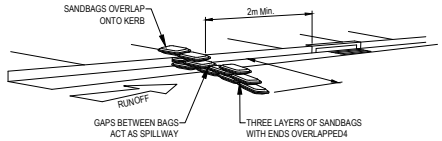



INSTALLATION OF SEDIMENT FENCE
N.T.S




SANDBAG KERB INLET SEDIMENT TRAP
N.T.S.

| REV | DESCRIPTION | DRAWN | APP'D | DATE |
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| A | ISSUED FOR DA APPROVAL | CPO | IAH | 01.06.18 |

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| DRAWN: | CPO |
| DESIGNED: | IAH |
| VERIFIED: | IAH 01.06.18 |
| APPROVED FOR TENDER: | ... J.J. |
| APPROVED FOR CONSTRUCTION: | ... J.J. |

JACKSON TEECE
Architecture

ARCHITECT/CLIENT

181 ALLAMBIE ROAD
ALLAMBIE HEIGHTS
NSW

PROJECT

SEDIMENTATION & EROSION
CONTROL DETAILS

TITLE

38509-CI-070-02.dwg

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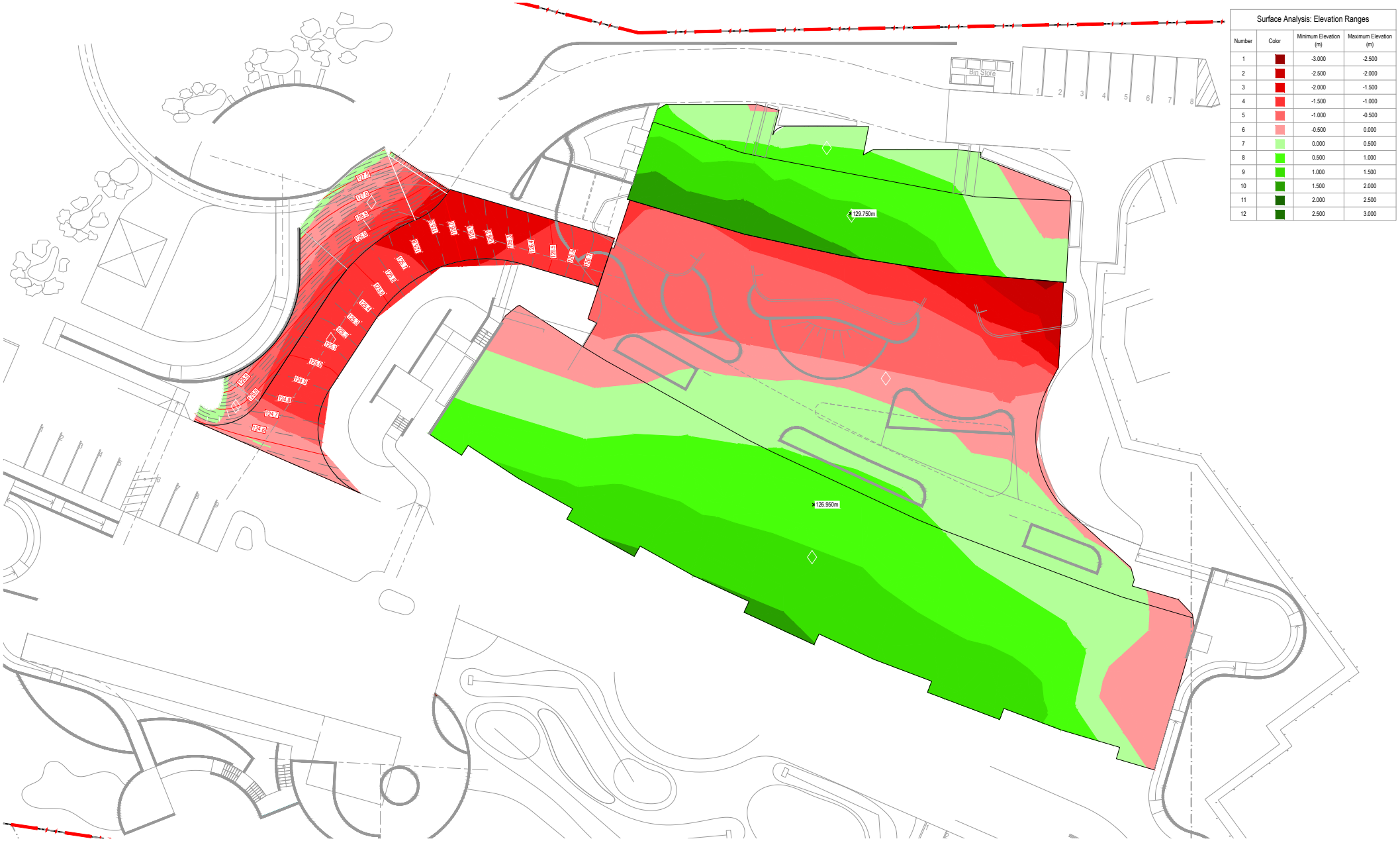
WOOD & GRIEVE ENGINEERS

FOR APPROVAL
NOT FOR CONSTRUCTION

| AS SHOWN | 38509 | CI-070-02 | A |
|---|---|---|---|
| SCALE @ A1 | PROJECT No | DRAWING No | REV |




Surface Analysis: Elevation Ranges

| Number | Color | Minimum Elevation (m) | Maximum Elevation (m) |
|---|---|---|---|
| 1 | | -3.000 | -2.500 |
| 2 | | -2.500 | -2.000 |
| 3 | | -2.000 | -1.500 |
| 4 | | -1.500 | -1.000 |
| 5 | | -1.000 | -0.500 |
| 6 | | -0.500 | 0.000 |
| 7 | | 0.000 | 0.500 |
| 8 | | 0.500 | 1.000 |
| 9 | | 1.000 | 1.500 |
| 10 | | 1.500 | 2.000 |
| 11 | | 2.000 | 2.500 |
| 12 | | 2.500 | 3.000 |

**Cut/Fill Summary**

| Name | Cut Factor | Fill Factor | 2d Area | Cut | Fill | Net |
|---|---|---|---|---|---|---|
| BE Volumes | 1.000 | 1.000 | 4068.214sq.m | 1332.485 Cu. M. | 1673.776 Cu. M. | 341.291 Cu. M.<Fill> |
| Totals | | | 4068.214sq.m | 1332.485 Cu. M. | 1673.776 Cu. M. | 341.291 Cu. M.<Fill> |

1:200 2 0 2 4 6 8 10 A1
1:400 A3

| | | | |
|---|---|---|---|
| A | ISSUED FOR DA APPROVAL | CPO | IAH | 01.06.18 |

JACKSON TEECE
Architecture

181 ALLAMBIE ROAD
ALLAMBIE HEIGHTS
NSW

BULK EARTHWORKS PLAN

WOOD & GRIEVE ENGINEERS

FOR APPROVAL
NOT FOR CONSTRUCTION

AS SHOWN | 38509 | CI-100-01 | A

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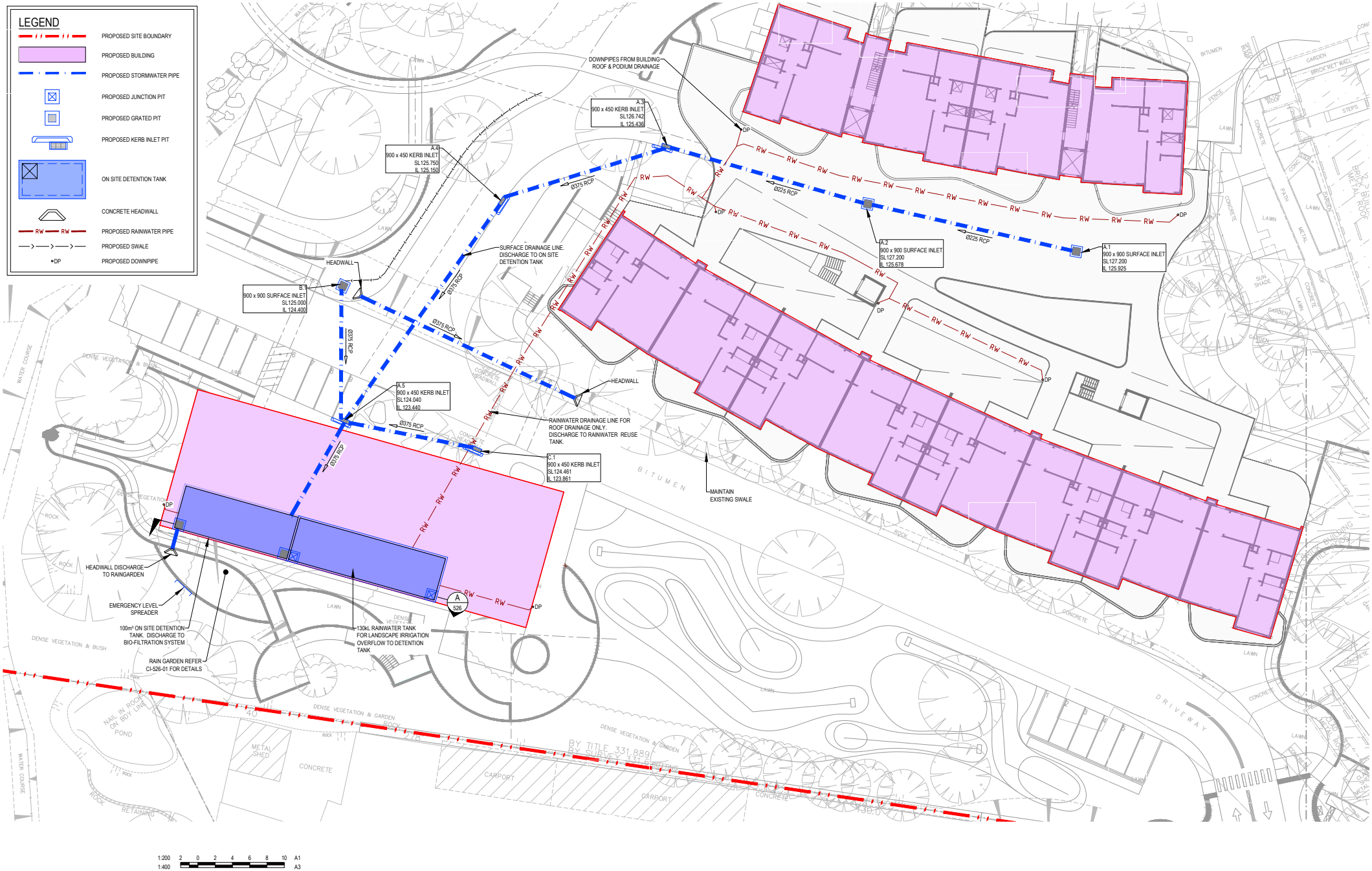


| REV | DESCRIPTION | DRAWN | APPD | DATE |
|---|---|---|---|---|
| A | ISSUED FOR DA APPROVAL | CPO | IAH | 01.06.18 |

| | |
|---|---|
| DRAWN: | CPO |
| DESIGNED: | IAH |
| VERIFIED: | IAH 01.06.18 |
| APPROVED FOR TENDER: | ... JJJ.. |
| APPROVED FOR CONSTRUCTION: | ... JJJ.. |

JACKSON TEECE
Architecture

ARCHITECT/CLIENT

181 ALLAMBIE ROAD
ALLAMBIE HEIGHTS
NSW

PROJECT

STORMWATER MANAGEMENT PLAN

TITLE

38509-CI-520-01.dwg

WOOD & GRIEVE ENGINEERS

FOR APPROVAL
NOT FOR CONSTRUCTION

| AS SHOWN | 38509 | CI-520-01 | A |
|---|---|---|---|
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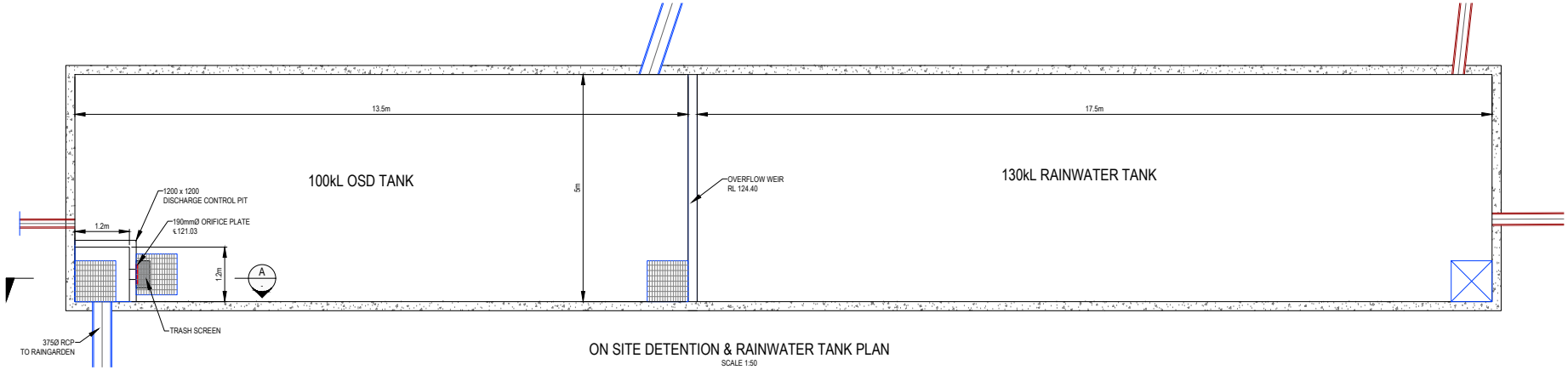
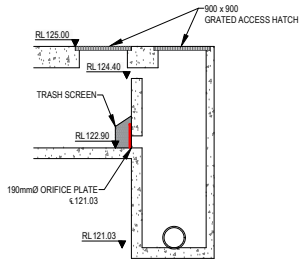
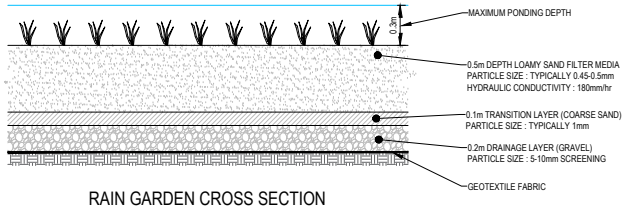


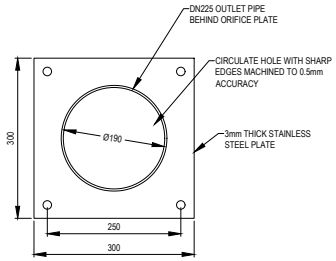

ON SITE DETENTION & RAINWATER TANK PLAN
SCALE 1:50



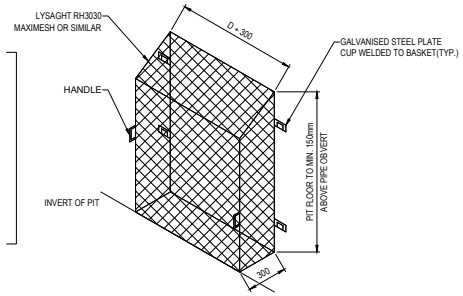

ON SITE DETENTION DISCHARGE CONTROL PIT SECTION
SCALE 1:50




RAIN GARDEN CROSS SECTION
SCALE 1:20




ORIFICE PLATE DETAIL
SCALE 1:5




SCREEN MESH DETAIL
N.T.S.

1:5 0.1 0 0.1 0.2 A1
1:10 A3

1:50 1 0.5 0 1 2 A1
1:100 A3

1:100 1 0 1 2 3 4 5 A1
1:200 A3

| REV | DESCRIPTION | DRAWN | APP'D | DATE |
|---|---|---|---|---|
| A | ISSUED FOR DA APPROVAL | CPO | IAH | 01.06.18 |

| | |
|---|---|
| DRAWN: | CPO |
| DESIGNED: | IAH |
| VERIFIED: | IAH 01.06.18 |
| APPROVED FOR TENDER: | ... JJJ.. |
| APPROVED FOR CONSTRUCTION: | ... JJJ.. |

JACKSON TEECE
Architecture
ARCHITECT/CLIENT

181 ALLAMBIE ROAD
ALLAMBIE HEIGHTS
NSW
PROJECT

STORMWATER MANAGEMENT
DETAILS
TITLE

38509-CI-526-01.dwg

WOOD & GRIEVE ENGINEERS

FOR APPROVAL
NOT FOR CONSTRUCTION

| AS SHOWN | 38509 | CI-526-01 | A |
|---|---|---|---|
| SCALE @ A1 | PROJECT No | DRAWING No | REV |

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# Appendix B – DRAINS Output

# Appendix B – DRAINS Output

**5 Year Model Output**

DRAINS results prepared from Version 2018.01

PIT / NODE DETAILS Version 8

| Name | Max HGL | HGL | Max Pond Flow Arriving (cu.m/s) | (cu.m) | Max Surface Volume (m) | Max Pond Freeboard | Min (cu.m/s) | Overflow | Constraint |
|---|---|---|---|---|---|---|---|---|---|
| A.1 | 125.99 | 127.22 | 0.004 | 0.1 | 1.21 | 0.000 | Inlet Capacity | | |
| A.2 | 125.73 | 127.22 | 0.004 | 0.1 | 1.47 | 0.000 | Inlet Capacity | | |
| A.3 | 125.52 | | 0.002 | | 1.32 | 0.000 | None | | |
| A.4 | 124.64 | | 0.004 | | 1.19 | 0.000 | None | | |
| A.5 | 124.13 | | 0.004 | | 1.17 | 0.000 | None | | |
| A.6 | 123.46 | 124.56 | 0.004 | 0.2 | 1.08 | 0.000 | Inlet Capacity | | |
| Roof | 124.86 | | 0.163 | | | | | | |
| RWT | 124.57 | | 0.000 | | | | | | |
| B.1 | 124.16 | 125.04 | 0.032 | 0.5 | 0.84 | 0.000 | Inlet Capacity | | |

SUB-CATCHMENT DETAILS

| Name | Max Flow Q (cu.m/s) | Paved Max Q (cu.m/s) | Grassed Max Q (cu.m/s) | Paved Tc (min) | Grassed Tc (min) | Supp. Tc (min) | Due to Storm | |
|---|---|---|---|---|---|---|---|---|
| PreDev Catchment | 0.328 | 0.045 | 0.292 | 5.00 | 8.00 | 8.00 | AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 | |
| A.1 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| A.2 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| A.3 Catch | 0.002 | 0.002 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| A.4 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| A.5 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| A.6 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| Roof Catch | 0.163 | 0.163 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | |
| Bypass Catch | 0.168 | 0.045 | 0.131 | 5.00 | 8.00 | 8.00 | AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 | |
| B.1 Catch | 0.032 | 0.000 | 0.032 | 5.00 | 8.00 | 8.00 | AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 | |

Outflow Volumes for Total Catchment (0.63 impervious + 1.48 pervious = 2.11 total ha)

| Storm | Total Rainfall cu.m | Total Runoff cu.m (Runoff %) | Impervious Runoff cu.m (Runoff %) | Pervious Runoff cu.m (Runoff %) |
|---|---|---|---|---|
| AR&R 5 year, 5 minutes storm, average 162 mm/h, Zone 1 | 285.12 | 116.50 (40.9%) | 78.88 (92.6%) | 37.62 (18.8%) |
| AR&R 5 year, 10 minutes storm, average 126 mm/h, Zone 1 | 443.52 | 230.73 (52.0%) | 126.20 (95.2%) | 104.53 (33.6%) |
| AR&R 5 year, 15 minutes storm, average 107 mm/h, Zone 1 | 564.96 | 317.95 (56.3%) | 162.48 (96.3%) | 155.47 (39.2%) |

# Appendix B – DRAINS Output

| | | | | |
|---|---|---|---|---|
| AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 | 661.76 | 386.06 (58.3%) | 191.40 (96.8%) | 194.65 (41.9%) |
| AR&R 5 year, 30 minutes storm, average 77.0 mm/h, Zone 1 | 813.12 | 469.34 (57.7%) | 236.63 (97.4%) | 232.72 (40.8%) |
| AR&R 5 year, 45 minutes storm, average 62.0 mm/h, Zone 1 | 982.08 | 573.00 (58.3%) | 287.11 (97.8%) | 285.90 (41.5%) |
| AR&R 5 year, 1 hour storm, average 54.0 mm/h, Zone 1 | 1140.48 | 672.96 (59.0%) | 334.43 (98.1%) | 338.53 (42.3%) |
| AR&R 5 year, 1.5 hours storm, average 42.2 mm/h, Zone 1 | 1336.90 | 772.76 (57.8%) | 393.11 (98.4%) | 379.64 (40.5%) |
| AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 | 1499.52 | 861.59 (57.5%) | 441.70 (98.6%) | 419.89 (39.9%) |

PIPE DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Max U/S HGL (m) | Max D/S HGL (m) | Due to Storm |
|---|---|---|---|---|---|
| 1.000 | 0.004 | 0.71 | 125.972 | 125.729 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 1.001 | 0.009 | 1.42 | 125.702 | 125.515 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 1.002 | 0.011 | 1.51 | 125.482 | 124.640 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 1.003 | 0.015 | 1.72 | 124.600 | 124.127 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 1.004 | 0.019 | 1.78 | 124.082 | 123.459 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 1.005 | 0.055 | 0.96 | 123.439 | 123.443 | AR&R 5 year, 1.5 hours storm, average 42.2 mm/h, Zone 1 |
| 1.006 | 0.110 | 2.76 | 121.387 | 121.205 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 2.000 | 0.164 | 2.32 | 124.864 | 124.573 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 2.001 | 0.164 | 2.36 | 124.573 | 124.286 | AR&R 5 year, 20 minutes storm, average 94.0 mm/h, Zone 1 |
| 3.000 | 0.032 | 2.33 | 124.093 | 123.459 | AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 |

CHANNEL DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Due to Storm |
|---|---|---|---|

OVERFLOW ROUTE DETAILS

| Name | Max Q U/S | | Max Q D/S | | Safe Q | Max D | Max DxV | Max Width | Max V | Due to Storm |
|---|---|---|---|---|---|---|---|---|---|---|
| OF2 | 0 | 0 | -999.000 | 0 | 0 | 0 | 0 | | | |
| OF5 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF10 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF21 | 0 | 0 | -0.000 | 0 | 0 | 0 | 0 | | | |
| OF27 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF32 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF36 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF35 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF39 | 0.168 | 0.168 | 0.000 | 0.095 | 0.09 | 5.03 | 0.92 | AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1 | | |
| OF41 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |

DETENTION BASIN DETAILS

| Name | Max WL | MaxVol | Max Q Total | Max Q Low Level | Max Q High Level |
|---|---|---|---|---|---|
| OSD Tank | | 123.44 | 38.7 | 0.110 | 0.110 | 0.000 |
| Bio | 120.98 | 0.0 | 0.000 | 0.000 | 0.000 | |

CONTINUITY CHECK for AR&R 5 year, 2 hours storm, average 35.5 mm/h, Zone 1

| Node | Inflow | Outflow | Storage Change | Difference |
|---|---|---|---|---|

# Appendix B – DRAINS Output

| | (cu.m) | (cu.m) | (cu.m) | % | |
|---|---|---|---|---|---|
| DS.1 | 343.38 | 343.38 | 0.00 | 0.0 | |
| A.1 | 7.00 | 7.02 | 0.00 | -0.3 | |
| A.2 | 14.02 | 14.12 | 0.00 | -0.7 | |
| A.3 | 17.62 | 17.57 | 0.00 | 0.3 | |
| A.4 | 24.57 | 24.59 | 0.00 | -0.1 | |
| A.5 | 31.59 | 31.61 | 0.00 | -0.1 | |
| A.6 | 68.48 | 68.40 | 0.00 | 0.1 | |
| OSD Tank | | 323.34 | 323.34 | 0.00 | -0.0 |
| Bio | 323.34 | 323.34 | 0.00 | 0.0 | |
| Roof | 254.80 | 254.92 | 0.00 | -0.0 | |
| RWT | 254.92 | 254.94 | 0.00 | -0.0 | |
| N42 | 195.15 | 195.15 | 0.00 | 0.0 | |
| Bypass | 195.15 | 195.15 | 0.00 | 0.0 | |
| B.1 | 29.77 | 29.87 | 0.00 | -0.3 | |

Run Log for 38509 run at 16:34:05 on 30/5/2018
No water upwelling from any pit. Freeboard was adequate at all pits.
The maximum flow in these overflow routes is unsafe: OF39

**20 Year Design Output**
DRAINS results prepared from Version 2018.01

PIT / NODE DETAILS Version 8

| Name | Max HGL | HGL | Max Pond Flow Arriving (cu.m/s) | Max Pond Volume (cu.m) | Max Surface (m) | Freeboard | Max Pond (cu.m/s) | Min | Overflow | Constraint |
|---|---|---|---|---|---|---|---|---|---|---|
| A.1 | 126.00 | 127.22 | 0.006 | 0.1 | 1.20 | 0.000 | Inlet Capacity | | | |
| A.2 | 125.74 | 127.22 | 0.006 | 0.1 | 1.46 | 0.000 | Inlet Capacity | | | |
| A.3 | 125.53 | | 0.003 | | 1.31 | 0.000 | None | | | |
| A.4 | 124.65 | | 0.006 | | 1.17 | 0.000 | None | | | |
| A.5 | 124.14 | | 0.006 | | 1.16 | 0.000 | None | | | |
| A.6 | 124.07 | 124.56 | 0.006 | 0.3 | 0.47 | 0.000 | Inlet Capacity | | | |
| Roof | 125.27 | | 0.214 | | | | | | | |
| RWT | 124.78 | | 0.000 | | | | | | | |
| B.1 | 124.19 | 125.05 | 0.046 | 0.6 | 0.81 | 0.000 | Inlet Capacity | | | |

SUB-CATCHMENT DETAILS

| Name | Max Flow Q (cu.m/s) | Paved Max Q (cu.m/s) | Grassed Max Q (cu.m/s) | Paved Tc (min) | Grassed Tc (min) | Supp. Tc (min) | Due to Storm | | |
|---|---|---|---|---|---|---|---|---|---|
| PreDev Catchment | | | 0.463 | 0.060 | 0.414 | 5.00 | 8.00 | 8.00 | AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 |
| A.1 Catch | | 0.006 | 0.006 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | |
| A.2 Catch | | 0.006 | 0.006 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | |
| A.3 Catch | | 0.003 | 0.003 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | |
| A.4 Catch | | 0.006 | 0.006 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | |
| A.5 Catch | | 0.006 | 0.006 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | |

# Appendix B – DRAINS Output

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A.6 Catch | 0.006 | 0.006 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| Roof Catch | 0.214 | 0.214 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| Bypass Catch | 0.235 | 0.061 | 0.186 | 5.00 | 8.00 | 8.00 | AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 |
| B.1 Catch | 0.046 | 0.000 | 0.046 | 5.00 | 8.00 | 8.00 | AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 |

Outflow Volumes for Total Catchment (0.63 impervious + 1.48 pervious = 2.11 total ha)

| Storm | Total Rainfall cu.m | Total Runoff cu.m (Runoff %) | Impervious Runoff cu.m (Runoff %) | Pervious Runoff cu.m (Runoff %) |
|---|---|---|---|---|
| AR&R 20 year, 5 minutes storm, average 208 mm/h, Zone 1 | 366.08 | 195.13 (53.3%) | 103.06 (94.2%) | 92.07 (35.9%) |
| AR&R 20 year, 10 minutes storm, average 164 mm/h, Zone 1 | 577.28 | 361.57 (62.6%) | 166.16 (96.3%) | 195.41 (48.3%) |
| AR&R 20 year, 15 minutes storm, average 139 mm/h, Zone 1 | 733.92 | 482.26 (65.7%) | 212.96 (97.1%) | 269.30 (52.3%) |
| AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 | 865.92 | 585.53 (67.6%) | 252.40 (97.6%) | 333.13 (54.9%) |
| AR&R 20 year, 30 minutes storm, average 102 mm/h, Zone 1 | 1077.12 | 728.70 (67.7%) | 315.50 (98.0%) | 413.20 (54.7%) |
| AR&R 20 year, 45 minutes storm, average 83.0 mm/h, Zone 1 | 1314.72 | 896.76 (68.2%) | 386.49 (98.4%) | 510.27 (55.3%) |
| AR&R 20 year, 1 hour storm, average 72.0 mm/h, Zone 1 | 1520.64 | 1044.01 (68.7%) | 448.01 (98.6%) | 596.00 (55.9%) |
| AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 | 1774.06 | 1200.35 (67.7%) | 523.73 (98.8%) | 676.63 (54.4%) |
| AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 | 2002.21 | 1349.32 (67.4%) | 591.89 (98.9%) | 757.43 (53.9%) |

PIPE DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Max U/S HGL (m) | Max D/S HGL (m) | Due to Storm |
|---|---|---|---|---|---|
| 1.000 | 0.006 | 0.77 | 125.979 | 125.741 | AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 |
| 1.001 | 0.012 | 1.52 | 125.709 | 125.526 | AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 |
| 1.002 | 0.014 | 1.63 | 125.488 | 124.654 | AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 |
| 1.003 | 0.019 | 1.87 | 124.607 | 124.143 | AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 |
| 1.004 | 0.025 | 1.92 | 124.091 | 124.066 | AR&R 20 year, 20 minutes storm, average 123 mm/h, Zone 1 |
| 1.005 | 0.068 | 0.43 | 124.060 | 124.057 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| 1.006 | 0.124 | 3.11 | 121.447 | 121.205 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| 2.000 | 0.215 | 3.03 | 125.274 | 124.780 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| 2.001 | 0.215 | 3.04 | 124.780 | 124.300 | AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1 |
| 3.000 | 0.046 | 2.58 | 124.106 | 124.066 | AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 |

CHANNEL DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Due to Storm |
|---|---|---|---|

OVERFLOW ROUTE DETAILS

| Name | Max Q U/S | Max Q D/S | Safe Q | Max D | Max DxV | Max Width | Max V | Due to Storm |
|---|---|---|---|---|---|---|---|---|
| OF2 | 0 | -999.0000 | 0 | 0 | 0 | | | |
| OF5 | 0 | 0.000 0 | 0 | 0 | 0 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| OF10 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |
| OF21 | 0 | 0 | -0.000 | 0 | 0 | 0 | 0 | |
| OF27 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |
| OF32 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |
| OF36 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |
| OF35 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |
| OF39 | 0.235 | 0.235 | 0.000 | 0.105 | 0.10 | 5.80 | 0.99 | AR&R 20 year, 2 hours storm, average 47.4 mm/h, Zone 1 |
| OF41 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | |

DETENTION BASIN DETAILS

| Name | Max WL | MaxVol | Max Q Total | Max Q Low Level | Max Q | High Level |
|---|---|---|---|---|---|---|
| OSD Tank | | 124.06 | 80.2 | 0.124 | 0.124 | 0.000 |
| Bio | 120.98 | 0.0 | 0.000 | 0.000 | 0.000 | |

CONTINUITY CHECK for AR&R 20 year, 1.5 hours storm, average 56.0 mm/h, Zone 1

| Node | Inflow (cu.m) | Outflow (cu.m) | Storage Change (cu.m) | % | Difference |
|---|---|---|---|---|---|
| DS.1 | 521.86 | 521.86 | 0.00 | 0.0 | |
| A.1 | 8.30 | 8.32 | 0.00 | -0.2 | |
| A.2 | 16.62 | 16.64 | 0.00 | -0.2 | |
| A.3 | 20.79 | 20.82 | 0.00 | -0.2 | |
| A.4 | 29.12 | 29.15 | 0.00 | -0.1 | |
| A.5 | 37.45 | 37.40 | 0.00 | 0.1 | |
| A.6 | 93.72 | 94.39 | 0.00 | -0.7 | |
| OSD Tank | | 396.63 | 396.62 | 0.00 | -0.0 |
| Bio | 396.62 | 396.62 | 0.00 | 0.0 | |
| Roof | 302.12 | 302.21 | 0.00 | -0.0 | |
| RWT | 302.21 | 302.24 | 0.00 | -0.0 | |
| N42 | 282.76 | 282.76 | 0.00 | 0.0 | |
| Bypass | 282.76 | 282.76 | 0.00 | 0.0 | |
| B.1 | 47.97 | 48.03 | 0.00 | -0.1 | |

Run Log for 38509 run at 16:35:07 on 30/5/2018
No water upwelling from any pit. Freeboard was adequate at all pits.
The maximum flow in these overflow routes is unsafe: OF39

**100 Year Design Output**
DRAINS results prepared from Version 2018.01

PIT / NODE DETAILS Version 8

| Name | Max HGL | HGL | Max Pond Flow Arriving (cu.m/s) | Max Pond Volume (cu.m) | Max Surface Freeboard (m) | Max Pond (cu.m/s) | Min | Overflow | Constraint |
|---|---|---|---|---|---|---|---|---|---|
| A.1 | 126.01 | 127.22 | 0.007 | 0.1 | 1.19 | 0.000 | Inlet Capacity | | |
| A.2 | 125.75 | 127.22 | 0.007 | 0.1 | 1.45 | 0.000 | Inlet Capacity | | |
| A.3 | 125.54 | | 0.004 | | 1.30 | 0.000 | None | | |
| A.4 | 124.74 | | 0.007 | | 1.09 | 0.000 | None | | |
| A.5 | 124.80 | | 0.007 | | 0.50 | 0.000 | None | | |
| A.6 | 124.69 | 124.69 | 0.007 | 4.1 | 0.00 | 0.000 | Outlet System | | |
| Roof | 126.21 | | 0.266 | | | | | | |
| RWT | 125.48 | | 0.000 | | | | | | |

# Appendix B – DRAINS Output

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B.1 | 124.75 | 125.06 | 0.059 | 0.7 | 0.25 | 0.000 | Inlet Capacity |

SUB-CATCHMENT DETAILS

| Name | Max Flow Q (cu.m/s) | Paved Max Q (cu.m/s) | Grassed Max Q (cu.m/s) | Paved Tc (min) | Grassed Tc (min) | Supp. Tc (min) | Due to Storm |
|---|---|---|---|---|---|---|---|
| PreDev Catchment | | 0.595 | 0.074 | 0.534 | 5.00 | 8.00 | 8.00 AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 |
| A.1 Catch | 0.007 | 0.007 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| A.2 Catch | 0.007 | 0.007 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| A.3 Catch | 0.004 | 0.004 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| A.4 Catch | 0.007 | 0.007 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| A.5 Catch | 0.007 | 0.007 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| A.6 Catch | 0.007 | 0.007 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| Roof Catch | 0.266 | 0.266 | 0.000 | 5.00 | 6.00 | 6.00 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| Bypass Catch | 0.301 | 0.075 | 0.239 | 5.00 | 8.00 | 8.00 | AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 |
| B.1 Catch | 0.059 | 0.000 | 0.059 | 5.00 | 8.00 | 8.00 | AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 |

Outflow Volumes for Total Catchment (0.63 impervious + 1.48 pervious = 2.11 total ha)

| Storm | Total Rainfall cu.m | Total Runoff cu.m (Runoff %) | Impervious Runoff cu.m (Runoff %) | Pervious Runoff cu.m (Runoff %) |
|---|---|---|---|---|
| AR&R 100 year, 5 minutes storm, average 269 mm/h, Zone 1 | 473.44 | 300.67 (63.5%) | 135.14 (95.5%) | 165.53 (49.9%) |
| AR&R 100 year, 10 minutes storm, average 213 mm/h, Zone 1 | 749.76 | 531.43 (70.9%) | 217.69 (97.2%) | 313.73 (59.7%) |
| AR&R 100 year, 15 minutes storm, average 182 mm/h, Zone 1 | 960.96 | 704.71 (73.3%) | 280.80 (97.8%) | 423.92 (62.9%) |
| AR&R 100 year, 20 minutes storm, average 161 mm/h, Zone 1 | 1133.44 | 844.50 (74.5%) | 332.33 (98.1%) | 512.18 (64.4%) |
| AR&R 100 year, 30 minutes storm, average 134 mm/h, Zone 1 | 1415.04 | 1059.69 (74.9%) | 416.46 (98.5%) | 643.23 (64.8%) |
| AR&R 100 year, 45 minutes storm, average 111 mm/h, Zone 1 | 1758.22 | 1329.37 (75.6%) | 518.99 (98.8%) | 810.38 (65.7%) |
| AR&R 100 year, 1 hour storm, average 96.0 mm/h, Zone 1 | 2027.52 | 1540.20 (76.0%) | 599.45 (99.0%) | 940.75 (66.2%) |
| AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 | 2376.00 | 1794.24 (75.5%) | 703.57 (99.1%) | 1090.67 (65.5%) |
| AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 | 2661.16 | 2002.06 (75.2%) | 788.76 (99.2%) | 1213.30 (65.0%) |

PIPE DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Max U/S HGL (m) | Max D/S HGL (m) | Due to Storm |
|---|---|---|---|---|---|
| 1.000 | 0.007 | 0.83 | 125.985 | 125.751 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |

# Appendix B – DRAINS Output

| | | | | | |
|---|---|---|---|---|---|
| 1.001 | 0.015 | 1.68 | 125.713 | 125.537 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 1.002 | 0.017 | 1.75 | 125.494 | 124.736 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 1.003 | 0.031 | 0.63 | 124.721 | 124.798 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 1.004 | 0.037 | 0.34 | 124.796 | 124.690 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 1.005 | 0.090 | 0.57 | 125.095 | 125.149 | AR&R 100 year, 20 minutes storm, average 161 mm/h, Zone 1 |
| 1.006 | 0.136 | 3.42 | 121.541 | 121.205 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 2.000 | 0.265 | 3.75 | 126.213 | 125.477 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 2.001 | 0.264 | 3.74 | 125.476 | 125.149 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 |
| 3.000 | 0.063 | 0.57 | 124.726 | 124.690 | AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 |

CHANNEL DETAILS

| Name | Max Q (cu.m/s) | Max V (m/s) | Due to Storm |
|---|---|---|---|

OVERFLOW ROUTE DETAILS

| Name | Max Q U/S | | Max Q D/S | | Safe Q | Max D | Max DxV | Max Width | Max V | Due to Storm |
|---|---|---|---|---|---|---|---|---|---|---|
| OF2 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF5 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF10 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF21 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF27 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF32 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF36 | 0.147 | 0.147 | 0.000 | 0.060 | 0.05 | 4.00 | 0.82 | AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1 | | |
| OF35 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |
| OF39 | 0.301 | 0.301 | 0.000 | 0.114 | 0.12 | 6.44 | 1.04 | AR&R 100 year, 2 hours storm, average 63.0 mm/h, Zone 1 | | |
| OF41 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | | | |

DETENTION BASIN DETAILS

| Name | Max WL | MaxVol | Max Q Total | Max Q Low Level | Max Q High Level |
|---|---|---|---|---|---|
| OSD Tank | | 125.15 | 104.4 | 0.283 | 0.136 | 0.147 |
| Bio | 120.98 | 0.0 | 0.000 | 0.000 | 0.000 | |

CONTINUITY CHECK for AR&R 100 year, 1.5 hours storm, average 75.0 mm/h, Zone 1

| Node | Inflow (cu.m) | Outflow (cu.m) | Storage Change (cu.m) | Difference % |
|---|---|---|---|---|
| DS.1 | 817.66 | 817.66 | 0.00 | 0.0 |
| A.1 | 11.15 | 11.14 | 0.00 | 0.1 |
| A.2 | 22.29 | 22.28 | 0.00 | 0.0 |
| A.3 | 27.85 | 27.82 | 0.00 | 0.1 |
| A.4 | 38.97 | 38.90 | 0.00 | 0.2 |
| A.5 | 50.05 | 50.35 | 0.00 | -0.6 |
| A.6 | 139.05 | 135.35 | 0.00 | 2.7 |
| OSD Tank | | 542.15 | 542.14 | 0.00 | -0.0 |
| Bio | 542.14 | 542.14 | 0.00 | 0.0 |
| Roof | 405.86 | 406.28 | 0.00 | -0.1 |
| RWT | 406.28 | 406.80 | 0.00 | -0.1 |
| N42 | 432.07 | 432.07 | 0.00 | 0.0 |
| Bypass | 432.07 | 432.07 | 0.00 | 0.0 |
| B.1 | 77.33 | 77.56 | 0.00 | -0.3 |

# Appendix B – DRAINS Output

Run Log for 38509 run at 16:35:49 on 30/5/2018

The maximum water level in these storages exceeds the maximum elevation you specified:  OSD Tank.
DRAINS has extrapolated the Elevation vs Storage table to a higher Elevation.  Please provide accurate values for higher elevations.
No water upwelling from any pit.
Freeboard was less than 0.15m at A.6
Flows were safe in all overflow routes.

# Appendix C – MUSIC Model Results

# Appendix C – MUSIC Model Results

Source nodes
Location,Roof Catchment,Paved External Areas,Bypass Landscape
ID,1,5,8
Node Type,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode
Zoning Surface Type,Roof,Sealedroad,Revegetatedland
Total Area (ha),0.364,0.16,0.243
Area Impervious (ha),0.364,0.159397014925373,0
Area Pervious (ha),0,0.000602985074626861,0.243
Field Capacity (mm),80,80,80
Pervious Area Infiltration Capacity coefficient - a,200,200,200
Pervious Area Infiltration Capacity exponent - b,1,1,1
Impervious Area Rainfall Threshold (mm/day),1,1,1
Pervious Area Soil Storage Capacity (mm),120,120,120
Pervious Area Soil Initial Storage (% of Capacity),25,25,25
Groundwater Initial Depth (mm),10,10,10
Groundwater Daily Recharge Rate (%),25,25,25
Groundwater Daily Baseflow Rate (%),5,5,5
Groundwater Daily Deep Seepage Rate (%),0,0,0
Stormflow Total Suspended Solids Mean (log mg/L),1.3,2.43,1.95
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.32,0.32,0.32
Stormflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0,0
Stormflow Total Phosphorus Mean (log mg/L),-0.89,-0.3,-0.66
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.25,0.25,0.25
Stormflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0,0
Stormflow Total Nitrogen Mean (log mg/L),0.3,0.34,0.3
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.19,0.19,0.19
Stormflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0,0
Baseflow Total Suspended Solids Mean (log mg/L),1.1,1.2,1.15
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.17,0.17,0.17
Baseflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0,0
Baseflow Total Phosphorus Mean (log mg/L),-0.82,-0.85,-1.22
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.19,0.19,0.19
Baseflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0,0
Baseflow Total Nitrogen Mean (log mg/L),0.32,0.11,-0.05
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.12,0.12,0.12
Baseflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0,0
Flow based constituent generation - enabled,Off,Off,Off
Flow based constituent generation - flow file, , ,
Flow based constituent generation - base flow column, , ,
Flow based constituent generation - pervious flow column, , ,
Flow based constituent generation - impervious flow column, , ,
Flow based constituent generation - unit, , ,
OUT - Mean Annual Flow (ML/yr),4.91,2.16,1.12
OUT - TSS Mean Annual Load (kg/yr),128,755,66.8
OUT - TP Mean Annual Load (kg/yr),0.750,1.24,0.164
OUT - TN Mean Annual Load (kg/yr),10.6,5.23,1.80
OUT - Gross Pollutant Mean Annual Load (kg/yr),119,52.2,0.00
Rain In (ML/yr),5.42212,2.38335,3.61971

# Appendix C – MUSIC Model Results

ET Loss (ML/yr),0.514048,0.225955,2.50116
Deep Seepage Loss (ML/yr),0,0,0
Baseflow Out (ML/yr),0,0,0.591647
Imp. Stormflow Out (ML/yr),4.90808,2.1574,0
Perv. Stormflow Out (ML/yr),0,0,0.526913
Total Stormflow Out (ML/yr),4.90808,2.1574,0.526913
Total Outflow (ML/yr),4.90808,2.1574,1.11856
Change in Soil Storage (ML/yr),0,0,-7E-6
TSS Baseflow Out (kg/yr),0,0,9.05422
TSS Total Stormflow Out (kg/yr),127.962,755.393,57.7569
TSS Total Outflow (kg/yr),127.962,755.393,66.8111
TP Baseflow Out (kg/yr),0,0,0.039014
TP Total Stormflow Out (kg/yr),0.750111,1.24375,0.124487
TP Total Outflow (kg/yr),0.750111,1.24375,0.163501
TN Baseflow Out (kg/yr),0,0,0.54805
TN Total Stormflow Out (kg/yr),10.6426,5.23226,1.24862
TN Total Outflow (kg/yr),10.6426,5.23226,1.79667
GP Total Outflow (kg/yr),118.765,52.2044,0

No Imported Data Source nodes

USTM treatment nodes
Location,Rainwater Tank,Bioretention,Detention Tank
ID,2,4,6
Node Type,RainWaterTankNode,BioRetentionNodeV4,DetentionBasinNode
Lo-flow bypass rate (cum/sec),0,0,0
Hi-flow bypass rate (cum/sec),100,100,100
Inlet pond volume,0, ,0
Area (sqm),87.5,100,67.5
Initial Volume (m^3),0, ,
Extended detention depth (m),0.2,0.2,1.5
Number of Rainwater tanks,1, ,
Permanent Pool Volume (cubic metres),130, ,2
Proportion vegetated,0, ,0
Equivalent Pipe Diameter (mm),100, ,1
Overflow weir width (m),10,2,0.3
Notional Detention Time (hrs),0.467, ,9.86E3
Orifice Discharge Coefficient,0.6, ,0.6
Weir Coefficient,1.7,1.7,1.7
Number of CSTR Cells,2,3,1
Total Suspended Solids - k (m/yr),400,8000,8000
Total Suspended Solids - C* (mg/L),12,20,20
Total Suspended Solids - C** (mg/L),12, ,20
Total Phosphorus - k (m/yr),300,6000,6000
Total Phosphorus - C* (mg/L),0.13,0.13,0.13
Total Phosphorus - C** (mg/L),0.13, ,0.13
Total Nitrogen - k (m/yr),40,500,500
Total Nitrogen - C* (mg/L),1.4,1.4,1.4
Total Nitrogen - C** (mg/L),1.4, ,1.4
Threshold Hydraulic Loading for C** (m/yr),3500, ,3500
Horizontal Flow Coefficient, ,3,
Reuse Enabled,On,Off,Off
Max drawdown height (m),1.48571428571429, ,
Annual Demand Enabled,Off,Off,Off

# Appendix C – MUSIC Model Results

Annual Demand Value (ML/year), , ,
Annual Demand Distribution, , ,
Annual Demand Monthly Distribution: Jan, , ,
Annual Demand Monthly Distribution: Feb, , ,
Annual Demand Monthly Distribution: Mar, , ,
Annual Demand Monthly Distribution: Apr, , ,
Annual Demand Monthly Distribution: May, , ,
Annual Demand Monthly Distribution: Jun, , ,
Annual Demand Monthly Distribution: Jul, , ,
Annual Demand Monthly Distribution: Aug, , ,
Annual Demand Monthly Distribution: Sep, , ,
Annual Demand Monthly Distribution: Oct, , ,
Annual Demand Monthly Distribution: Nov, , ,
Annual Demand Monthly Distribution: Dec, , ,
Daily Demand Enabled,On,Off,Off
Daily Demand Value (ML/day),0.0063, ,
Custom Demand Enabled,Off,Off,Off
Custom Demand Time Series File, , ,
Custom Demand Time Series Units, , ,
Filter area (sqm), ,100,
Filter perimeter (m), ,14,
Filter depth (m), ,0.5,
Filter Median Particle Diameter (mm), , ,
Saturated Hydraulic Conductivity (mm/hr), ,100,
Infiltration Media Porosity, ,0.35,
Length (m), , ,
Bed slope, , ,
Base Width (m), , ,
Top width (m), , ,
Vegetation height (m), , ,
Vegetation Type, ,Vegetated with Effective Nutrient Removal Plants,
Total Nitrogen Content in Filter (mg/kg), ,600,
Orthophosphate Content in Filter (mg/kg), ,30,
Is Base Lined?, ,No,
Is Underdrain Present?, ,Yes,
Is Submerged Zone Present?, ,No,
Submerged Zone Depth (m), , ,
B for Media Soil Texture,-9999,13,-9999
Proportion of upstream impervious area treated, , ,
Exfiltration Rate (mm/hr),0,0,0
Evaporative Loss as % of PET,0,100,100
Depth in metres below the drain pipe, , ,
TSS A Coefficient, , ,
TSS B Coefficient, , ,
TP A Coefficient, , ,
TP B Coefficient, , ,
TN A Coefficient, , ,
TN B Coefficient, , ,
Sfc, ,0.61,
S*, ,0.37,
Sw, ,0.11,
Sh, ,0.05,
Emax (m/day), ,0.008,
Ew (m/day), ,0.001,

# Appendix C – MUSIC Model Results

IN - Mean Annual Flow (ML/yr),4.91,4.64,4.82
IN - TSS Mean Annual Load (kg/yr),128,157,399
IN - TP Mean Annual Load (kg/yr),0.750,0.748,1.25
IN - TN Mean Annual Load (kg/yr),10.6,8.25,10.0
IN - Gross Pollutant Mean Annual Load (kg/yr),119,0.00,0.00
OUT - Mean Annual Flow (ML/yr),2.67,4.42,4.64
OUT - TSS Mean Annual Load (kg/yr),51.7,50.5,157
OUT - TP Mean Annual Load (kg/yr),0.378,0.298,0.748
OUT - TN Mean Annual Load (kg/yr),5.50,4.69,8.25
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00,0.00
Flow In (ML/yr),4.90804,4.64089,4.82458
ET Loss (ML/yr),0,0.221265,0.0850746
Infiltration Loss (ML/yr),0,0,0
Low Flow Bypass Out (ML/yr),0,0,0
High Flow Bypass Out (ML/yr),0,0,0
Orifice / Filter Out (ML/yr),2.13987,2.86636,0.0786461
Weir Out (ML/yr),0.527306,1.55131,4.55943
Transfer Function Out (ML/yr),0,0,0
Reuse Supplied (ML/yr),2.23943,0,0
Reuse Requested (ML/yr),2.29794,0,0
% Reuse Demand Met,97.4538,0,0
% Load Reduction,45.657,4.80989,3.8657
TSS Flow In (kg/yr),127.962,156.689,399.228
TSS ET Loss (kg/yr),0,0,0
TSS Infiltration Loss (kg/yr),0,0,0
TSS Low Flow Bypass Out (kg/yr),0,0,0
TSS High Flow Bypass Out (kg/yr),0,0,0
TSS Orifice / Filter Out (kg/yr),41.1785,7.39103,1.60655
TSS Weir Out (kg/yr),10.5687,43.125,155.164
TSS Transfer Function Out (kg/yr),0,0,0
TSS Reuse Supplied (kg/yr),28.9992,0,0
TSS Reuse Requested (kg/yr),0,0,0
TSS % Reuse Demand Met,0,0,0
TSS % Load Reduction,59.5605,67.7603,60.7316
TP Flow In (kg/yr),0.750111,0.748307,1.24828
TP ET Loss (kg/yr),0,0,0
TP Infiltration Loss (kg/yr),0,0,0
TP Low Flow Bypass Out (kg/yr),0,0,0
TP High Flow Bypass Out (kg/yr),0,0,0
TP Orifice / Filter Out (kg/yr),0.306375,0.067488,0.0103158
TP Weir Out (kg/yr),0.0712789,0.23063,0.737966
TP Transfer Function Out (kg/yr),0,0,0
TP Reuse Supplied (kg/yr),0.295559,0,0
TP Reuse Requested (kg/yr),0,0,0
TP % Reuse Demand Met,0,0,0
TP % Load Reduction,49.6536,60.161,40.055
TN Flow In (kg/yr),10.6426,8.2494,10.0477
TN ET Loss (kg/yr),0,0,0
TN Infiltration Loss (kg/yr),0,0,0
TN Low Flow Bypass Out (kg/yr),0,0,0
TN High Flow Bypass Out (kg/yr),0,0,0
TN Orifice / Filter Out (kg/yr),4.38103,1.84889,0.113912
TN Weir Out (kg/yr),1.11458,2.84082,8.13815
TN Transfer Function Out (kg/yr),0,0,0

# Appendix C – MUSIC Model Results

TN Reuse Supplied (kg/yr),3.872,0,0
TN Reuse Requested (kg/yr),0,0,0
TN % Reuse Demand Met,0,0,0
TN % Load Reduction,48.3621,43.1509,17.8711
GP Flow In (kg/yr),118.765,0,0
GP ET Loss (kg/yr),0,0,0
GP Infiltration Loss (kg/yr),0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0
GP High Flow Bypass Out (kg/yr),0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0
GP Weir Out (kg/yr),0,0,0
GP Transfer Function Out (kg/yr),0,0,0
GP Reuse Supplied (kg/yr),0,0,0
GP Reuse Requested (kg/yr),0,0,0
GP % Reuse Demand Met,0,0,0
GP % Load Reduction,100,100,100
PET Scaling Factor, ,2.1,

Generic treatment nodes
Location, 6 x  Enviropod 200
ID,7
Node Type,GPTNode
Lo-flow bypass rate (cum/sec),0
Hi-flow bypass rate (cum/sec),0.12
Flow Transfer Function
Input (cum/sec),0
Output (cum/sec),0
Input (cum/sec),10
Output (cum/sec),10
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Input (cum/sec),
Output (cum/sec),
Gross Pollutant Transfer Function
Enabled,True
Input (kg/ML),0
Output (kg/ML),0
Input (kg/ML),14.780776740251
Output (kg/ML),0
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),

Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Input (kg/ML),
Output (kg/ML),
Total Nitrogen Transfer Function
Enabled,True
Input (mg/L),0
Output (mg/L),0
Input (mg/L),10
Output (mg/L),8.7
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Total Phosphorus Transfer Function
Enabled,True
Input (mg/L),0
Output (mg/L),0
Input (mg/L),10
Output (mg/L),7
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),

Output (mg/L),
Input (mg/L),
Output (mg/L),
Total Suspended Solids Transfer Function
Enabled,True
Input (mg/L),0
Output (mg/L),0
Input (mg/L),100
Output (mg/L),46
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
Input (mg/L),
Output (mg/L),
TSS Flow based Efficiency Enabled,Off
TSS Flow based Efficiency,
TP Flow based Efficiency Enabled,Off
TP Flow based Efficiency,
TN Flow based Efficiency Enabled,Off
TN Flow based Efficiency,
GP Flow based Efficiency Enabled,Off
GP Flow based Efficiency,
IN - Mean Annual Flow (ML/yr),2.16
IN - TSS Mean Annual Load (kg/yr),755
IN - TP Mean Annual Load (kg/yr),1.24
IN - TN Mean Annual Load (kg/yr),5.23
IN - Gross Pollutant Mean Annual Load (kg/yr),52.2
OUT - Mean Annual Flow (ML/yr),2.16
OUT - TSS Mean Annual Load (kg/yr),347
OUT - TP Mean Annual Load (kg/yr),0.871
OUT - TN Mean Annual Load (kg/yr),4.55
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00
Flow In (ML/yr),2.15738
ET Loss (ML/yr),0
Infiltration Loss (ML/yr),0
Low Flow Bypass Out (ML/yr),0
High Flow Bypass Out (ML/yr),0
Orifice / Filter Out (ML/yr),0
Weir Out (ML/yr),0
Transfer Function Out (ML/yr),2.15738
Reuse Supplied (ML/yr),0
Reuse Requested (ML/yr),0
% Reuse Demand Met,0

# Appendix C – MUSIC Model Results

% Load Reduction,0
TSS Flow In (kg/yr),755.392
TSS ET Loss (kg/yr),0
TSS Infiltration Loss (kg/yr),0
TSS Low Flow Bypass Out (kg/yr),0
TSS High Flow Bypass Out (kg/yr),0
TSS Orifice / Filter Out (kg/yr),0
TSS Weir Out (kg/yr),0
TSS Transfer Function Out (kg/yr),347.48
TSS Reuse Supplied (kg/yr),0
TSS Reuse Requested (kg/yr),0
TSS % Reuse Demand Met,0
TSS % Load Reduction,54
TP Flow In (kg/yr),1.24375
TP ET Loss (kg/yr),0
TP Infiltration Loss (kg/yr),0
TP Low Flow Bypass Out (kg/yr),0
TP High Flow Bypass Out (kg/yr),0
TP Orifice / Filter Out (kg/yr),0
TP Weir Out (kg/yr),0
TP Transfer Function Out (kg/yr),0.870622
TP Reuse Supplied (kg/yr),0
TP Reuse Requested (kg/yr),0
TP % Reuse Demand Met,0
TP % Load Reduction,30
TN Flow In (kg/yr),5.23226
TN ET Loss (kg/yr),0
TN Infiltration Loss (kg/yr),0
TN Low Flow Bypass Out (kg/yr),0
TN High Flow Bypass Out (kg/yr),0
TN Orifice / Filter Out (kg/yr),0
TN Weir Out (kg/yr),0
TN Transfer Function Out (kg/yr),4.55207
TN Reuse Supplied (kg/yr),0
TN Reuse Requested (kg/yr),0
TN % Reuse Demand Met,0
TN % Load Reduction,13
GP Flow In (kg/yr),52.2045
GP ET Loss (kg/yr),0
GP Infiltration Loss (kg/yr),0
GP Low Flow Bypass Out (kg/yr),0
GP High Flow Bypass Out (kg/yr),0
GP Orifice / Filter Out (kg/yr),0
GP Weir Out (kg/yr),0
GP Transfer Function Out (kg/yr),0
GP Reuse Supplied (kg/yr),0
GP Reuse Requested (kg/yr),0
GP % Reuse Demand Met,0
GP % Load Reduction,100

Other nodes
Location,Post-Development Node
ID,3
Node Type,PostDevelopmentNode

# Appendix C – MUSIC Model Results

IN - Mean Annual Flow (ML/yr),5.54
IN - TSS Mean Annual Load (kg/yr),117
IN - TP Mean Annual Load (kg/yr),0.462
IN - TN Mean Annual Load (kg/yr),6.49
IN - Gross Pollutant Mean Annual Load (kg/yr),0.00
OUT - Mean Annual Flow (ML/yr),5.54
OUT - TSS Mean Annual Load (kg/yr),117
OUT - TP Mean Annual Load (kg/yr),0.462
OUT - TN Mean Annual Load (kg/yr),6.49
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00
% Load Reduction,32.4
TSS % Load Reduction,87.7
TN % Load Reduction,63.3
TP % Load Reduction,78.6
GP % Load Reduction,100

Links
Location,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link
Source node ID,1,4,2,6,5,7,8
Target node ID,2,3,6,4,7,6,3
Muskingum-Cunge Routing,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed
Muskingum K, , , , , , ,
Muskingum theta, , , , , , ,
IN - Mean Annual Flow (ML/yr),4.91,4.42,2.67,4.64,2.16,2.16,1.12
IN - TSS Mean Annual Load (kg/yr),128,50.5,51.7,157,755,347,66.8
IN - TP Mean Annual Load (kg/yr),0.750,0.298,0.378,0.748,1.24,0.871,0.164
IN - TN Mean Annual Load (kg/yr),10.6,4.69,5.50,8.25,5.23,4.55,1.80
IN - Gross Pollutant Mean Annual Load (kg/yr),119,0.00,0.00,0.00,52.2,0.00,0.00
OUT - Mean Annual Flow (ML/yr),4.91,4.42,2.67,4.64,2.16,2.16,1.12
OUT - TSS Mean Annual Load (kg/yr),128,50.5,51.7,157,755,347,66.8
OUT - TP Mean Annual Load (kg/yr),0.750,0.298,0.378,0.748,1.24,0.871,0.164
OUT - TN Mean Annual Load (kg/yr),10.6,4.69,5.50,8.25,5.23,4.55,1.80
OUT - Gross Pollutant Mean Annual Load (kg/yr),119,0.00,0.00,0.00,52.2,0.00,0.00

Catchment Details
Catchment Name,38509 - ALLAMBIE HEIGHTS MUSIC
Timestep,6 Minutes
Start Date,1/01/1959
End Date,31/12/1959 11:54:00 PM
Rainfall Station, 66062 SYDNEY
ET Station,Monthly User Defined
Mean Annual Rainfall (mm), 1490
Mean Annual ET (mm), 1260

ERROR: syntaxerror
OFFENDING COMMAND: --nostringval--

STACK:

437
9116
5