CRAIG & RHODES

TAKE THE LEAD

Water Cycle Management Report

PROPOSED SUBDIVISION OF LOT 1 DP 592091

20-22 MACPHERSON STREET, WARRIEWOOD

Prepared for: Green Kingswood Pty Ltd

Date: April 2023

Our Reference: 359-21-WCMR-DA-REV **A**

CRAIG & RHODES

02 9869 1855

Suite 7.01 Level 7, 3 Rider Boulevard

Rhodes NSW 2138

PO Box 3220, Rhodes NSW 2138

ABN 77 050 209 991

www.craigandrhodes.com.au

Contents

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1 Background

Craig & Rhodes has been engaged by Green Kingswood Pty Ltd to prepare for the Development Application (DA) documentation for the civil works as well as the stormwater drainage, stormwater detention and Water Sensitive Urban Design (WSUD) treatment for the proposed residential development of LOT 1 DP 592091, being 20-22 Macpherson Street, Warriewood NSW 2102 (the subject site).

A full set of concept engineering drawings prepared by Craig & Rhodes will accompany this report and DA submission.

The proposed development is located within the Warriewood Valley Land Release. This site is located within the Northern Beaches Local Government Area.

1.1 Site Description

The site is adjoined by Macpherson Street and additional residential development to the north-west and south-east and Narrabeen Creek to northeast.

The subject site is an existing commercial site with at grade carparking.

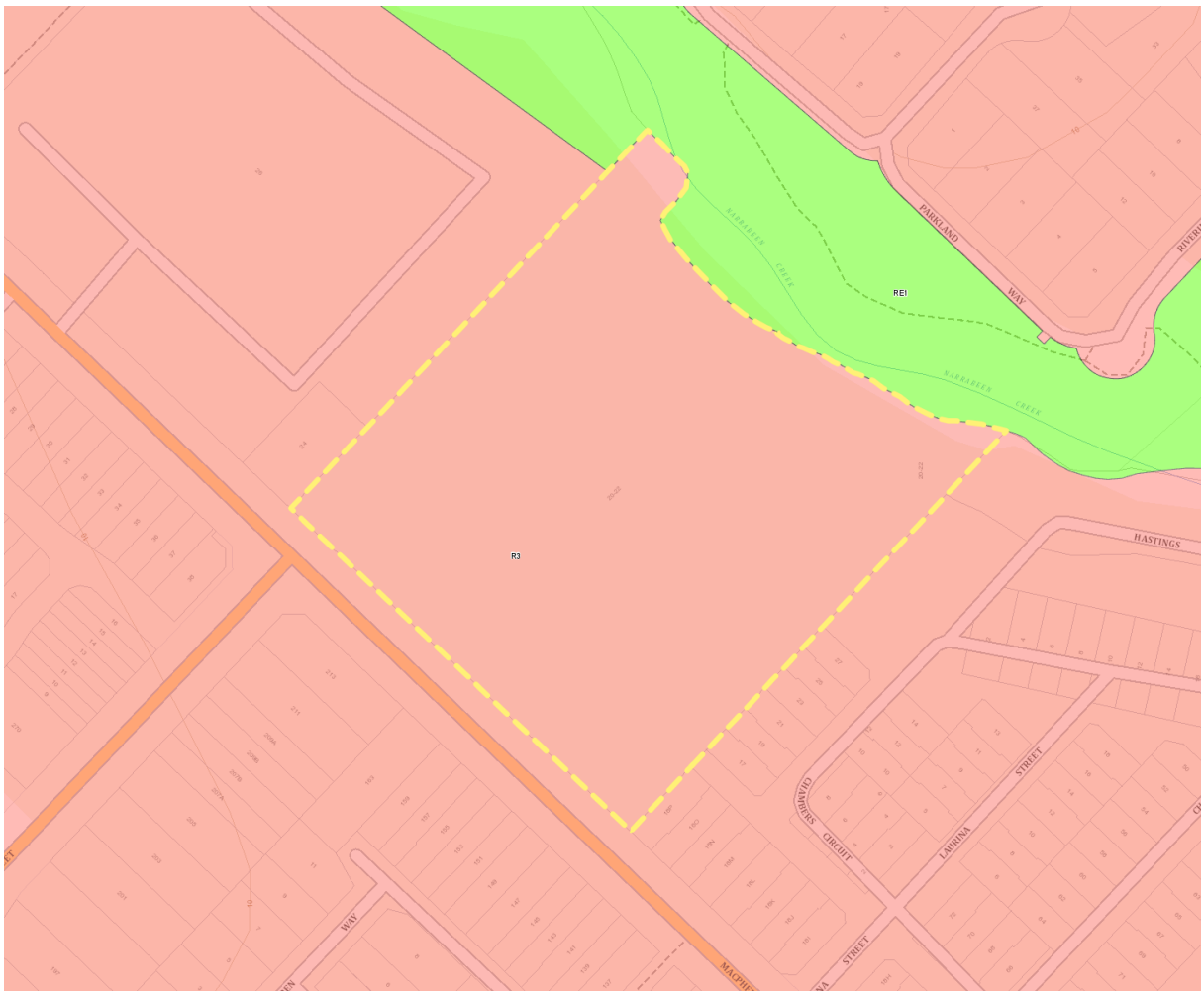

Figure 1 - Northern Beaches Planning Map

The subject site is currently zoned as medium density residential (R3). The site area is approximately 2.05 hectares. The subject site is an existing commercial site with at grade carparking (refer to Figure 1 & 2 below).

Figure 2 - Site Location Ariel Map (Near Maps 2021)

The subject site is irregular in shape and fall generally from north-west to south-east at an average slope of around 2.3%, ranging from 0.4% to 4% sitewide. The site is located within the Northern Beaches Local government Area.

1.2 Proposed Works

The proposed development consists of 53 residential lots and associated infrastructures including roads, stormwater and utility services.

The proposed works for stormwater management includes a construction of a temporary on-site detention tank and a bio-retention basin.

1.3 Reference Policies and Guidelines

The following documents have been referenced in developing the stormwater drainage and water sensitive urban design strategy for the proposed development:

- Pittwater Council, 2021, Pittwater 21 Development Control Plan
- Pittwater Council, 2001, Warriewood Valley Urban Land Release - Water Management Specification
- Engineers Australia, Australian Rainfall & Runoff: A Guide to Flood Estimation
- Commonwealth of Australia, 2019, Australian Rainfall & Runoff: A Guide to Flood Estimation
- NSW Government, 2010, Draft NSW MUSIC Modelling Guidelines

2 Water Cycle Assessment

The Warriewood Valley Water Management Specification requires a water cycle assessment be carried out for the development. This is to ensure that development does not have detrimental impacts on the Warriewood Valley catchment with regards to peak surface water flow rates, and peak flow volumes of surface runoff.

Craig & Rhodes has carried out an assessment for both peak flow rates and volumes of runoff for the development under three conditions, a low rainfall year, and average rainfall year, and the high rainfall year. The average rainfall for the Warriewood Valley was determined from the Bureau of Meteorology Automatic Weather Station (AWS) at Ingleside (Station 066183). This was considered to provide an appropriate representation of rainfall within the Warriewood Valley.

The average rainfall at Northern Beaches Council is 1477 mm per annum. The 10th percentile rainfall is approximately 1118 mm per annum and the 90th percentile is approximately 2002 mm per annum.The rainfall adopted for the Water Cycle Assessment of the proposed development utilised daily rainfall for the following years:

Percentile	Year	Rainfall (mm)
10th	2002	1118
50th	1984	1477
90th	1998	2002

Table 1 - Adopted Rainfall

An additional model was also prepared to look at water balance over a longer period than the individual rainfall years as above. The period covered a 28-year period from 1984 to 2012.

2.1 Treatment Measures

The aim of the water cycle assessment is to determine the changes in surface runoff from the development as result of changing the site conditions. An increase in imperviousness of the catchment increases the peak flow rates and volume of runoff from the catchment. The Warriewood Valley Management Specification requires that the volume of runoff maintain existing conditions where possible.

The primary method for maintaining peak volume of runoff is to detain runoff volumes exceeding the existing volumes via on-site detention.

2.1.1 Rainwater tank

At this stage, as per the preliminary Architectural design prepared by PBD Architects, proposed houses are generally three-bedroom dwellings, and it is appropriate to adopt values that reflect a three-bedroom dwelling as a minimum.

It is assumed that the proposed dwellings will require rainwater tanks for on-lot reuse of stormwater collected from roofs for both internal and external use as per the requirements of BASIX.

At this stage it is assumed that 2,500L rainwater tanks will be provided for each dwelling.

Rainwater tanks will collect runoff from approximately 100% of the roofs of the proposed dwellings. This water will be used to supply the daily demands for the dwellings, which will include laundry, toilet flushing and watering of landscaping.

There are several sources which can be considered when determining water use patterns within residential developments. There are two local government areas within the Sydney Basin that are generally accepted for water reuse values for residential development, these councils are Blacktown City and Ku-ring-gai Council. Alternate policies based on literature is that from the Sydney Catchment Authority (CMA). The CMA adopts the recommendations from Coombes et al (2003). The following table summarised these accepted sources:

Source	Daily Internal Use	Yearly External Use
Blacktown Council Ku-ring-gai Council	0.08kL/day (<320m^2 block) 0.10kL/day (320-520m^2 block)	25kL/yr (<320m^2 block) 50kL/yr (320-520m^2 block)
Coombes et al (2003) (Toilet & Laundry)	0.36kL/day (3 bedroom) 0.47kL/day (4 bedroom)	West Sydney – 55kL/yr Adelaide – 146kL/yr Brisbane – 126kL/yr Melbourne – 81kL/yr (all dwellings)

Table 2 – Rainwater Tank Reuse

As the Warriewood Valley Water Management Specification does not provide reuse values to be assumed for use within the water balance, an assumed value needs to be determined.

As the majority of lots are less than 320m2 in area, the values adopted by Ku-ring-gai Council appear to be appropriate for the site. However, the values provided by Coombes appears to be closer based on dwelling occupants than lot area.

For water reuse drawn from the proposed rainwater tanks, a daily use of 0.36kL per dwelling per day and an annual use of 25kL per dwelling per year has been adopted for the water balance and MUSIC modelling.

Based on the above demands, the daily demand for the development of 53 lots is proposed to be 19.08 KL per day, with an annual demand for the development of 1325 KL per year.

2.1.2 Ground Infiltration

With dwelling footprints and lot layouts limited due to size, it is proposed to assist with water retention by using the infiltration of treated stormwater to groundwater and reduce the volume of surface runoff as required by the Warriewood Valley Water Management Specification.

It is proposed to construct the combined WSUD and Detention basin without an impervious liner. Without an impervious liner, the infiltration of treated stormwater, particularly for frequent rainfall events, will ensure that the ground water can be contributed to due to the reduced infiltration within the catchment as a result of increased imperviousness of the development site.

Soils within the Warriewood Valley are generally deep sandy soils that are highly permeable. The bore logs from the geotechnical report for the project indicate that the soils are generally sandy to a depth of 9 metres below the surface.

The Water Balance model assumes that an infiltration rate of 10 mm/hour has been adopted across the area of the bioretention filtration media. This is lower than the generally accepted infiltration range for sandy soils (Max. 180 mm/hour).

2.2 Water Balance Results

Annual flows from the development have been assessed for a dry, average and wet rainfall years utilising daily rainfall data from 2002, 1984 and 1998 respectively.

The results of the water balance have been summarised in the following table:

Percentile	Pre-Development Annual Surface Runoff (ML/year)	Post-Development Annual Surface Runoff (ML/year)	Reduction (%)
10th	14.3	12.7	6.9
50th	19.5	17.8	5.2
90th	30.0	28.4	3.2
Long Term Average			
1984 – 2012	16.8	15.3	5.4

Table 3 – Water Balance Summary

It can be seen that during a dry year, there is a decrease in the volume of runoff from the catchment by up to 6.9%. The average year indicates that the volume of runoff under post-development conditions is reduced by up to 5.2% compared to pre-development conditions.

Wet years indicate that the volume of runoff under post-development conditions with the introduction of rainwater tanks on each lot and the infiltration of treated stormwater under the bio-retention basin is reduced by up to 3.2%.

Looking at rainfall over a 28-year period, the volume of stormwater runoff from the post-development is reduced by 5.4% from the pre-development scenario. This indicates that the volume of runoff under development conditions is less than existing runoff volumes under pre-development conditions for frequent rainfall events.

Overall, it is expected that there will be a reduction in the volume of runoff in the long-term comparing to which is currently generated by the site, however individual years may vary, and this is to be expected due to seasonal climatic changes.

3 Stormwater Quantity Management

Craig & Rhodes has prepared the sites stormwater strategies based on the natural terrain and has provided catchment plans for both pre-development and post-development conditions.

3.1 Objective

The stormwater management objective for the proposed development is controlled by *Water Management for Development Policy* (WMDP) from Northern Beaches Council. The site region is classified as region 1. Therefore, onsite detention system is required in accordance with section 9.3.1 of WMDP.

OSD basin and OSD tank have been designed to detain stormwater runoff and release it at a flow rate that does not exceed the existing site flow rates from the catchment during storm events of 1% AEP, 5% AEP, and 20%AEP.

According to WMDP section 6.4, drainage must be designed to cater for 5% AEP event (Minor storm) whereas all storm event up to and including major storm (1 in 100-year ARI) shall be conveyed within the road reserve to Council's peak depth, and velocity-depth values when the capacity of the minor system is exceeded.

3.2 Hydrology

An ILSAX model in DRAINS was prepared to design the proposed drainage network for the proposed development. The relevant DRAINS files used for the design and assessment for the stormwater drainage are summarised in Table 1 below:

Table 1 - DRAINS Model Files

Scenario	File Name
1% AEP Pre-development and Post-Development with Climate Change	359-21_DA_001_With Climate Change 1%AEP.drn
5% AEP Pre-development and Post-Development with Climate Change	359-21_DA_001_With Climate Change 5%AEP.drn
Pre-development and Post-Development without Climate Change	359-21_DA_001_Without Climate Change

The first two files take climate change into consideration. The Climate Change Rainfall Multiplier has been adopted as 1.3.

Table 2 is a summary of the input parameters used in the ILSAX model.

Table 2 – DRAINS/ILSAX Model Parameters

Parameter	Value
Paved (Impervious) Area Depression Storage	1.0 mm
Grassed (Pervious) Area Depression Storage	5.0 mm
Soil Type	3
AMC	3
Overland Flow Equation	Kinematic Wave

3.2.1 Rainfall

Rainfall intensities in the model were obtained from the Bureau of Meteorology and Australia Rainfall & Runoff 2019 adopting the latitude and longitude of the site.

3.2.2 Drainage Network

Ultimate drainage network and basins have been modelled in DRAINS software in detail to represent the post-development conditions of the site.

The fraction of imperviousness for internal lot area has been determined by measuring the hard-surface footprint from the architectural plan whereas the 100% imperviousness is adopted for road reserve.

The DRAINS model confirms that both the pipe network and surface overland flows are conform to Council's stormwater drainage requirements.

3.3 Internal Catchment

The existing site, falling from west to east, consists of pervious areas covered by thick native vegetation. The site survey was used to determine the flow direction and approximate slope of the site.

It is considered that the fraction imperviousness for the site is 10% and 90% of the pre-development site catchment is pervious surface.

Topography and existing stormwater drainage of the area indicate that there is no overland flow entering the site from adjoining properties, therefore, no external catchment included in pre-development calculations.

The time of concentration for these catchments has been calculated by DRAINS software using Kinematic Wave equation.

3.4 Post-development Internal Catchment

With respect to the location of the site, there is no upstream overland flow draining to the site and there will not be any future development connecting to the proposed drainage network. Therefore, no external catchment included in ultimate drainage calculations.

An ultimate catchment plan has been prepared to show the sub-catchments draining to the proposed pits and pipes and discharge into proposed OSD tank and OSD basin.

Refer to Figure 3 for Post-Development catchment plan.

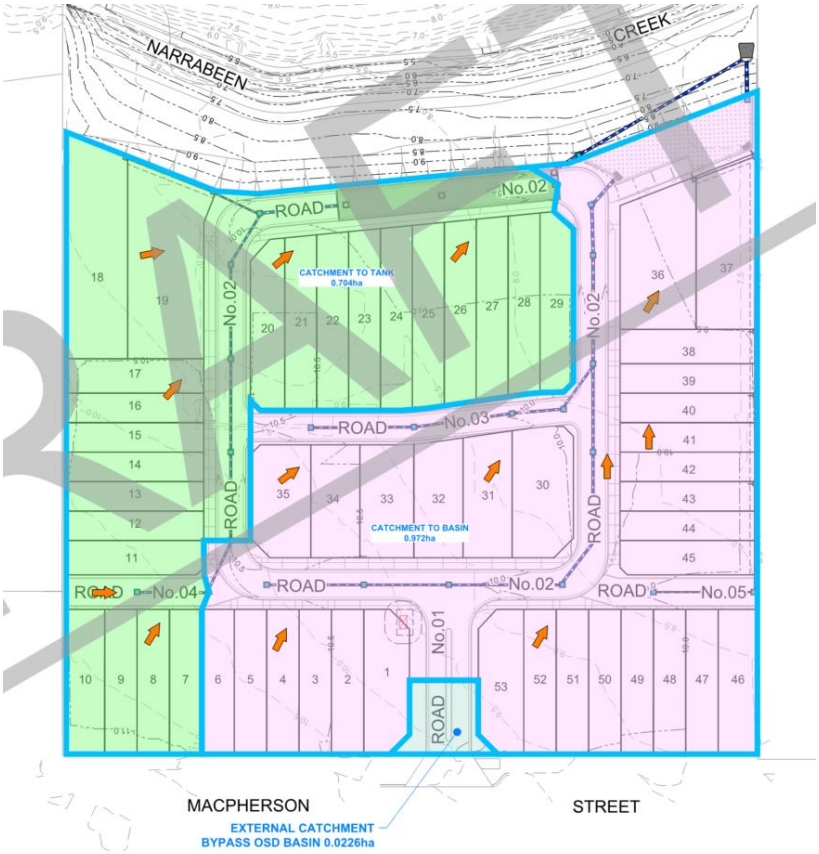

Figure 3 – Post-Development Catchment Plan

3.5 Tailwater conditions

There is no tailwater conditions applied in Drains Model.

3.6 Modelling summary for OSD Basins

The following Table 3 & 4 summarises the performance of the on-site detention tank and on-site detention basin and the comparison between the pre-development flow and post-development flow for both with and without climate change effect. The annual exceedance probability of the storms required are 1%, 5%, and 20% according to Water Management for Development Policy section 9.3.2.6.

Table 3 – On-Site Detention Basin & On-Site Detention Tank Summary Table

ON-SITE DETENTION BASIN				
	Storm Event (AEP)	**1%**	**5%**	**20%**
Without Climate Change	Post-Development Flow Rate (cu.m/s)	0.361	0.201	0.067
	Top Water Level (m)	8.88	8.74	8.51
With Climate Change	Post-Development Flow Rate (cu.m/s)	0.555	0.359	NA
	Top Water Level (m)	9.02	8.88	NA
ON-SITE DETENTION TANK				
	Storm Event (AEP)	**1%**	**5%**	**20%**
Without Climate Change	Post-Development Flow Rate (cu.m/s)	0.148	0.049	0.040
	Top Water Level (m)	9.05	8.73	8.37

With Climate Change	Post-Development Flow Rate (cu.m/s)	0.337	0.18	NA
	Top Water Level (m)	9.17	9.07	NA

Table 4 – Pre-Development and Post-Development Flow

	Storm Event (AEP)	**1%**	**5%**	**20%**
Without Climate Change	Pre-Development Flow Rate (cu.m/s)	0.662	0.408	0.222
	Post-Development Flow Rate (cu.m/s)	0.464	0.250	0.107
With Climate Change	Pre-Development Flow Rate (cu.m/s)	0.896	0.574	0.222
	Post-Development Flow Rate (cu.m/s)	0.892	0.539	NA

4 Stormwater Drainage Concept Plan

The elements of the proposed stormwater drainage concept plan for the subject site are illustrated by the **Craig & Rhodes Drawings 359-21C-DA-0101 & 359-21C-DA-0102 Revision D** and are summarised as follows:

- All roof water is firstly captured by rainwater tanks on each lot and then reused for toilet flushing, garden irrigation, car washing and laundry cold water;
- Impervious surface is restricted to maximize infiltration (limited to 60% impervious for the site area);
- Runoff will be collected by pit and pipe networks and detained by proposed OSD basin and OSD tank;
- A 20% AEP + 30% Climate Change (minor) capacity drainage system will convey all local site flows to the bio–retention/detention basin. Flows in excess of the 20% AEP + 30% Climate Change and up to the 1% AEP + 30% Climate Change (major) shall be conveyed by the road carriageway into the basin and tank. All flows will then discharge to Narrabeen Creek;
- Bio-retention basin and OSD tank will be acting as tertiary treatment.

Stormwater detention measures are proposed, primarily in the form of free storage. These measures ensure flows generated by the site do not exceed those under existing conditions. Runoff water quality is proposed to be managed through a combination of treatment measures. These measures ensure post development stormwater loads generated by the site do not exceed those under existing conditions.

The proposed development generally complies with Council guidelines and achieves best practice standards in sustainability and stormwater management.

5 Water Quality Assessment

5.1 Water Quality Monitoring

Water quality monitoring requirements for the project were established in consultation with Council. Discussions with Council indicated that water quality monitoring data for Narrabeen

Creek is available from various sources and previous DAs undertaken within the nearby vicinity of the site, particularly by Marine Pollution Research (MPR).

MPR has provided a report to meet the conditions of a Northern Beaches Council Request for water quality monitoring data. As MPR combined project work for this section of the creek ceased in June 2019, it was recommended that MPR undertake a full annual survey to bridge the gap between the last sampling and present (*Ref. Warriewood Valley Land Release Narrabeen Creek Below Brands Lane – Pre-Construction Water Quality Monitoring data for 53A Warriewood Road Report dated June 2021, for the period of November 2017 to June 2019 plus May 2021* – Refer Appendix F). Note all available water quality data at Narrabeen Creek over the above period is presented in Appendix B of the MPR report.

In summary, it can be observed that the nutrient concentrations, for total phosphorus (TP) and total nitrogen (TN), are generally within ANZECC (2000) Guidelines levels for lowland rivers. This is notwithstanding the fact that there have been incidences of elevated levels, particularly for TP, in the samples for the 6 February 2018 and 5 June 2019. Likewise, there have been exceedances for TN, but are not considered to be significant.

Dissolved oxygen levels are generally acceptable upstream of the site, but tend to decrease downstream of the site, at NC4 and NC5. The cause of this is not clear but may be due to decomposing algae in the creek at those locations. Suspended solids are generally low, while conductivity, pH and turbidity levels are also considered to be within an acceptable range.

By comparison, faecal coliforms levels are found to be elevated across the 3 sampling locations, and up to 16,000 CFU/100ml (NC4, 11 May 2018). It is not clear if sewer overflows, or animal waste, is a cause of these high levels of bacteria contamination in the creek. These pollution levels suggest that the creek is not suitable for both primary and secondary recreational purposes.

The available data detailed in Appendix F also includes heavy metals, pesticides, PCBs and PAHs. The data indicates that most of these pollutants are at fairly low levels. However, there have also been instances of exceedances, for pesticides.
For the purposes of this project, we have allowed to undertake water quality monitoring within Narrabeen Creek at the following 3 locations:
Just upstream of the proposed development site

- Just upstream of the proposed development site;
- An intermediate location (likely mid-point of the creek alignment through the subject site); and
- Just downstream of the proposed development site.

6 Stormwater Quality Management

Stormwater runoff from the development site undergoes two stages, the construction stage and the post-development stages. These two phases are handled with two different methodologies due to the unique loads each of them generates. These will be handled as required to meet several guidelines from various sources and requirements.

6.1 Construction Stage

During the bulk earthworks and construction phase of the development, sediment and erosion control facilities will be designed and constructed/installed in accordance with Council's specifications and requirements of the NSW DECC publication titled "Managing Urban Stormwater – Soils & Construction" January 2008.
A detailed sediment and erosion control plan will be prepared prior to construction, outlining the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction. Refer **Craig & Rhodes Drawings 359-21C-DA-0901 - 0902 Revision D** for the sediment erosion control plan and details prepared for the project Development Application.
A summary of the principal elements applied to the sediment erosion control plan for the site is summarised below:

- Minimising the extent of disturbed surfaces as any one time through staging of works;
- Stabilising disturbed surfaces immediately following completion of works;
- Protecting stockpiles via silt fencing or diversion bunds;
- Application of silt fencing on the downslopes of disturbed areas;
- Application of silt socks around drainage structures;
- Protection of exposed slopes;
- Restriction of construction vehicles to particular points of entry/exit locations; and
- Application of stabilised site access point sand vehicle wash down bays.

Details for the construction stages of the development have been documented indicatively as part of the DA plans and will be detailed further as part of the Construction Certificate documentation and managed ongoing through the construction process by the selected contractor.

6.2 Post-Development Stage

The proposed water quality treatment for the site consists of the following elements:

- On-lot rainwater tanks (2.5kL per lot) and associated internal & external re-use;
- Onsite detention tank;
- Bio-retention Basin (estimated total surface area 248m_2)

An assessment of the post-development stage of proposed development has been carried out using MUSIC and is detailed in the following sections of the report.

6.3 Objectives and proposed works

The stormwater quality objective for the proposed development is controlled by Warriewood Valley Urban Land Release-Water Management Specification, section 4.3.3. The aim is to not worsen the existing conditions, and to improve the reduce constituent loads if possible.

Existing conditions and proposed conditions are modelled in MUSIC program to determine whether the water treatment design conform to the specification as per council requirements. As required in section 4.3.1, 10^{th} percentile, 50^{th} percentile, and 90^{th} percentile rainfall is modelled in MUSIC programme. Water tank with WSUD chamber and bio retention basin are utilised to achieve the target. Table 5 below shows the water quality results for both pre-development and post-development.

Table 5 - Stormwater Quality Performance Pre-Development and Post-Development

	Pollutant	Pre-Development Average Annual Load	Post-Development Average Annual Load
10th Percentile Rainfall	Total Suspended Solids	3230.00	383.00
	Total Phosphorus	5.18	2.12
	Total Nitrogen	33.30	21.70
	Gross Pollutants	349.00	5.07
50th Percentile Rainfall	Total Suspended Solids	3820.00	403.00
	Total Phosphorus	5.45	3.06
	Total Nitrogen	41.00	28.50
	Gross Pollutants	456.00	6.71
90th Percentile Rainfall	Total Suspended Solids	5550.00	1150.00
	Total Phosphorus	8.37	5.28
	Total Nitrogen	59.20	38.60
	Gross Pollutants	482.00	7.13

6.4 Methodology

The stormwater quality management modelling has been prepared using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Version 6.3.

6.4.1 Data Inputs

Climate Data

As the site is outside of the Sydney drinking water catchment area, the rainfall data has been adopted from Bureau of Meteorology Automatic Weather Station (AWS) at Ingleside (Station 066183).

Data for the 1984 to 2012 period has been adopted for MUSIC modelling. The data for this period has a mean annual rainfall that is representative of the long term mean annual rainfall record at this rainfall station.

Evaporation data for Sydney was sourced from the Bureau of Meteorology. This was combined with the rainfall data in the MUSIC models.

Catchments

The total site area is 2.05 hectares. 1.69 hectares is being developed. The MUSIC modelling will only cater for the area being developed. Each scenario has been separated into land-use catchments representative of the overall site. The summary of the catchment properties is outlined in the following table.

Table 6 - Stormwater Quality Performance Pre-Development and Post-Development

Catchment	**Area (ha)**	**Impervious Fraction (%)**
Pre- Development		
Entire Site	1.690	80
Post- Development		
Roof Area	0.906	100
Landscaped Area	0.489	0
Road Area	0.359	100
Footpath Area	0.135	80

Treatment Train

The proposed stormwater quality treatment for the development includes a bio-retention basin and an on-site detention tank.

It is proposed that bio-retention filter media components to be constructed within the OSD basin.

The proposed filtration area within the bio-retention basin is 248m^2.

As part of the treatment train a minimum 2.5kL of rainwater tank (RWT) is proposed at each residential lot.

An extended detention depth (EDD) of 300mm has been allowed for.

The MUSIC model layout can be seen in figure 4.

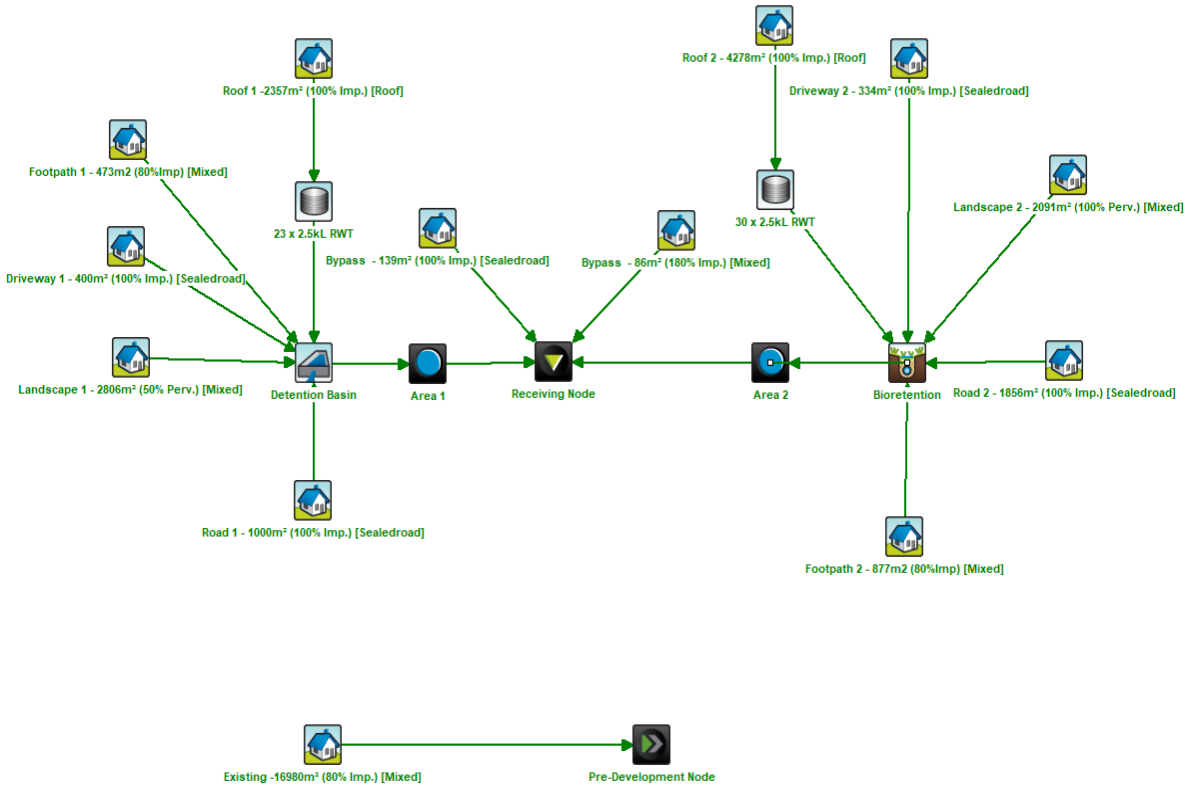

Figure 4 - MUSIC Model Layout

6.5 Overall Treatment Effectiveness

The MUSIC model indicates that the proposed treatment train consisting of on-lot rainwater tanks and bio-retention filtration areas exceeds Council's Stormwater Management Objectives as outlined in Table .

A printout of the results from MUSIC has been provided in table 4.

6.6 Ongoing Requirements

Upon completion of the proposed development, the Water Management Specification (WMS) requires ongoing monitoring and maintenance for the Stormwater Quality Improvement Devices constructed and installed as part of the subdivision.

Monitoring and maintenance of the stormwater treatment train shall include, but not limited to:

- Discrete sampling of stormwater at the inlet & outlet of the proposed bio-retention basin;
- Qualitative assessment of effectiveness of other proposed water quality control measures.

All reporting shall conform to the requirements outlined in the WMS and forwarded to Council as required.

6.7 Mosquito Risk Assessment

The development does not propose to provide permanent waterbodies. As there are no proposed permanent waterbodies, the risk of mosquito activity is low.

There are two areas of potential concern regarding mosquito activity. The stormwater drainage network for the development, and the creek corridor.

The stormwater drainage network consists of a pit and pipe network, with a bio-retention basin. The stormwater network has been designed to drain and not provide areas for stagnant water to collect and allow mosquito and insects to breed. The combined bio-retention and on-site detention basin is not expected to detain stormwater for an extended period greater than a few hours. Provided the basin is designed, constructed and maintained in line with the industry best practices, there is minimal risk that the basin will act as a mosquito habitat.

The lot-based rainwater tanks pose a minimal risk for mosquito breeding and habitat. Rainwater tanks must be adequately maintained with an emphasis on screening the inlets to the rainwater tank to prevents insects and pests from entering the tank.

The proposed creek corridor is being re-graded as part of the development. The proposed typical section for the creek corridor is shown on **Craig & Rhodes Drawings 359-21C-DA-0152 - Revision D** of the Narrabeen Creek Rehabilitation Works set.

The typical section proposed for the development side is to continually fall towards the creek centreline. As the section does not propose permanent pools of water along the creek line, the risk for mosquito forming habitats will be reduced. Natural depressions will form over time which may allow for mosquito habitats to form, however this is not unlike the existing natural site conditions. As a result of the proposed creek rehabilitation works, there will be no increase in mosquito activity from existing site conditions, however as the proposed channel will be formalised, it is expected that mosquito habitats will be reduced.

At this stage it is expected that there is a low risk of forming additional mosquito and insect habitats from what currently exists. It is expected that mosquito habitats will remain static or be reduced due to the proposed works.

A further mosquito risk assessment shall be undertaken as required during the Construction Certificate and Construction stages of the development to ensure that mosquito habitats are not encouraged or formed during the construction process.

6.8 Watercourse and Creekline Corridor Preservation/Restoration

The subject development has a frontage to Narrabeen Creek to the northwest where it is proposed to dedicate a portion of the site to Council as Public Reserve.

The Warriewood Valley Water Management Specification calls for a creek corridor of up to 100m wide. This is comprised of a 50m publicly owned corridor, with a 25m wide buffer held in private ownership outside of the 50m corridor.

The proposed works within the Narrabeen Creek are generally minimal and limited to reshaping of the creek bank as outlined in Section 4.4.4 of the Warriewood Valley Urban Land Release Water Management Specification (Refer to the Narrabeen Creek Rehabilitation Works drawings prepared by C&R, Ref: **359-21C-DA-0152 Revision D).**

7 Maintenance Operations and Checklist

7.1 Maintenance Objectives

The stormwater quality devices constructed and occurring naturally within an urban environment suffer from several constraints placed upon them by disturbance within the upstream contributing catchment. Consequently, these structures will not be able to perform efficiently and continuously without regular maintenance.

Maintenance is required to increase the functionality of each design element and increases the aesthetic amenity and reduces public health and safety risks.

The purpose for this maintenance manual is as follows:

- To set out the procedures of maintenance operations and checklists whereby it can be maintained to a standard that ensure it remains operation in accordance with its original design objectives and intent;
- To provide a systematic monitoring and review procedures for the water quality devices, so that they will remain functionally effective as its original design throughout the design life of the structure.

An overall summary of the maintenance operations related to the stormwater quality improvement devices associated with the development are summarised in the following sections.

7.2 Signage

Signage outlining the nature of hazards and descriptions for the stormwater detention and water quality devices shall be inspected twice yearly for vandalism. Signs should be repaired or replaced as required.

7.3 On-Site Detention Basin

The On-Site Stormwater Detention (OSD) system is designed to temporarily store water during significant rainfall events so that stormwater runoff from the development does not have an impact on flooding downstream of the development. The ponding of water will occur but should not last for more than a few hours in most storms. If ponding persists, it is likely that maintenance is required.

The following schedule (Table 15) provides a guide to the timing of typical maintenance actions for an On-Site Stormwater Detention (OSD) System as well as defining the person responsible and describing the actions required.

Most components of the system should be checked for blockages after each significant storm to ensure that they continue to function effectively. The build-up of sludge and debris depends on the individual site and more frequent maintenance may be required where there are many trees, especially after windy conditions.

Access to the basin will be provided off Lorikeet Grove, with a gate and step irons provided to gain access to the basin. Maintenance for the basin shall be undertaken by a Maintenance Contractor. For major cleans, a small bobcat shall be floated into the basin to move/remove material. Excess material (i.e. large debris) that cannot be manually moved by hand shall be removed by lifting out of the basin via mechanical means.

Table 7 - On-Site Detention Basin Maintenance

Item	Period	Responsibility	Maintenance Procedure
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	Inspect pit and grate conditions
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	Remove debris & accumulated sediment for disposal
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	Inspect berm for erosion
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	Check signage for vandalism and repair as required
Inspection – Major Maintenance	3 months and after major storms	Council / Maintenance Contractor	Inspect pit and grate conditions. Evidence of cracking or spalling of concrete structures.
Inspection – Major Maintenance	3 months and after major storms	Council / Maintenance Contractor	Repair erosion downstream of basin outlet

7.4 Stormwater Pits & Pipes

Stormwater pits and pipes are designed to convey stormwater runoff during significant rainfall events so that surface flows are reduced to reduce inconvenience to users. Pits and pipes should minimise ponding of surface water but if ponding persists after rainfall events, it is likely that maintenance is required.

Pits and pipes should be checked for blockages after each storm event to ensure they continue to function effectively. The build-up of sludge and sediment depends on the upstream catchment and stormwater flows. More frequent maintenance may be required in areas where there is significant bare earth or heavy leaf litter material is conveyed in surface runoff.

In general, land managers could maintain pit and pipe systems where the depth is less than 1.2 metres. For pits deeper than 1.2m, experienced personnel with appropriate experience and qualifications (i.e. confined space training) should maintain the system.

Refer to Appendix B for a draft Maintenance Schedule.

7.5 Water Sensitive Urban Design

There is several WSUD device proposed for this development that operate in a treatment train approach, bio-retention basin planted with grasses and native plants. The recommended maintenance procedures by the manufacturers of these products are summarised in this section. The detailed maintenance procedure is included in the appendices.

Bio-Retention Basin

Following its construction, the bio-retention pond should be inspected every 1 to 3 months (and after each major rainfall event) during the initial vegetation establishment period to determine whether the bio-retention zone requires maintenance, or the media requires replacement. The following critical items should be monitored:

- • Ponding, clogging and blockage of the filter media;
- • Establishment of desired vegetation/plants and density; and
- • Blockage of the outlet from the bio-retention system.

After the initial establishment period (typically 1 to 2 years), inspections may be extended to the frequencies shown in the maintenance frequency table below.

If the bio-retention system is not maintained frequently, the entire filter media may need to be replaced due to clogging of the media material with fine particles. This can result in frequent maintenance being more cost effective in the long-term.

Access to the basin will as per the methods previously mentioned in Section 10.3, via a 5.5m concrete access handle provided off Lorikeet Grove, with a gate and step irons provided to gain access to the basin. Maintenance for the bioretention component shall again undertaken by a Maintenance Contractor. For major cleans and filter media replacement, a small bobcat shall be floated into the basin to move/remove material. Excess material (i.e. large debris) that cannot be manually moved by hand shall be removed by lifting out of the basin via mechanical means.

The following maintenance activities will be required with inspection frequencies shown below.

- Maintenance of flow to and through the system;
- Maintaining the surface vegetation;
- Preventing undesired overgrowth vegetation/weeds from taking over the area;
- Removal of accumulated sediments; and
- Debris removal

The recommended maintenance frequency for the bio-retention pond is provided below.

Table 8 - Bio-retention Basin Maintenance

Item	Period	Responsibility	Maintenance Procedure
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	• Check for sediment deposition, oily or clayey sediment on filtration media • Remove depositions or sediment
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	• Check for erosion and scour of filtration media • Infill holes and repair erosion and scour

Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	• Check for litter • Remove both organic and anthropogenic litter
Inspection – Minor Maintenance	3 months	Council / Maintenance Contractor	• Assess plants for disease and pest infestation • Check plants for signs of stunted growth or die off • Check original plant densities are maintained • Treat and replace plans as necessary
Inspection – Minor Maintenance	3 months	Council / Maintenance Contractor	• Check for presence of weeds • Manually remove weeds where possible or use spot treatment with herbicide appropriate for use near waterways
Inspection – Minor Maintenance	Annually and after major storms	Council / Maintenance Contractor	• Check underdrains are not blocked with sediment or roots • Clear underdrains as required
Inspection – Minor Maintenance	3 months and after major storms	Council / Maintenance Contractor	• Pit and grate conditions. Evidence of cracking or spalling of concrete structures.
Major Maintenance	2 years	Council / Maintenance Contractor	• In situ hydraulic conductivity testing • Replace transition layer and filtration media when hydraulic conductivity falls below Council acceptable limits

7.6 Annual Review

An annual review of all stormwater drainage and water quality infrastructure should be carried out to record changes for the infrastructure over time. This should be in the form of photographs and documentation.

7.6.1 Annual Review

Monitoring should incorporate photography of the infrastructure to record changes. Annual photos should generally be taken at the same time of year from the same location.

7.6.2 Procedures

The monitoring and maintenance program should be reviewed each year to determine if the maintenance objectives are being fulfilled and to ensure that maintenance staff are finding that the maintenance program is adequate for performing maintenance tasks.

The yearly review should include and assessment of the maintenance database to determine the effectiveness of inspections, reporting mechanisms and scheduled maintenance tasks that are effective.

Information in the database should be assessed to determine whether any noticeable changes are evident in vegetation, bird usage of the basin, and operational efficiency of any structure. This will further provide indications as to whether sufficient information is being recorded for management purposes.

8 Conclusions

The stormwater design and details provided for the proposed residential subdivision of Lot 1 D.P.592091 is compliant with Northern Beaches Council's requirements and specifications.

The main conclusions on the design elements are as follows:

Drainage Networks:

- A conventional pit and pipe network within the road reserves to convey minor storm flows.
- The flows from major storms are managed by overland flows within the roads.

Water Quantity Management:

- Permanent aboveground OSD basin and OSD tank have been provided within the development site to detain stormwater runoff and release it at a flow that does not exceed the pre-development site flows from the catchment.

Water Quality Management:

- Permanent bio-retention filter area (rain garden) with 300mm extended detention depth have been provided within the OSD basins.
- Permanent OSD tank has been provided.
- The water quality management for the development site applies minimum 2.5KL Rainwater Tanks for each residential lot in line with WSUD principals.