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Stormwater Management Plan

4 Forest Road, Warriewood

Prepared for: BMN Properties Pty Ltd

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Issue: B

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REVISIONS

Revision	Date	Purpose	Prepared By	Approved By
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Review Panel	
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Table of Contents

1 Introduction 5

1.1 Purpose and Scope of Report 5

1.2 Project Description 5

2 Site 5

2.1 Property Description 5

2.2 Proposed Works 6

2.3 Upstream Catchment 6

3 Stormwater Quantity 7

3.1 Standards and References 7

3.2 Minor Pipework 7

3.3 Major Flow Paths 7

3.4 Legal Point of Discharge 7

3.5 Detention Strategy 7

3.6 DRAINS Modelling 8

4 Stormwater Quality 12

4.1 Standards and References 12

4.2 Methodology and Modelling 12

4.3 Model Results 14

5 Conclusion 15

List of Figures

Figure 1: Site Location (Nearmaps) 6

Figure 2: Comparison of On-lot Detention Modelling Approaches....................9

Figure 3: OSD Configuration in DRAINS 10

List of Tables

Table 1: Calculated Lot PSD Rates (m3/s/ha) 8
Table 2: Peak flowrates for each lot during different storm events (m3/s) 8
Table 3: OSD Results 11
Table 4: MUSIC Source Node Soil Properties 13
Table 5: Bio-retention Basin Parameters 14
Table 6: Subdivision MUSIC Model Results 14

1 Introduction

1.1 Purpose and Scope of Report

ACOR Consultants P/L has been engaged by BMN Properties Pty Ltd to undertake the DA design of the stormwater drainage system to service the proposed subdivision of 4 Forest Road, Warriewood. This stormwater management report supports the DA submissions for 4 Forest Road, providing an assessment of the proposed development with respect to stormwater drainage, quantity, and quality management.

This report documents the methodology involved in determining the design of the proposed stormwater drainage system and is to be read in conjunction with drawings by ACOR, NSW210416-SHT-DA-C1.001-C8.101.

1.2 Project Description

In accordance with the Northern Beaches Council Water Management for Development Policy and Australian Rainfall & Runoff 2019, the proposed stormwater management system will, in principle, consist of a major and minor stormwater runoff conveyance system, incorporating surface collection pits and underground pipes for minor flow. Major flows in excess of the capacity of the pipe system will be safely conveyed overland within the roadways.

The design proposes a stormwater detention strategy to ensure that the post-development peak discharges from storm events including the 20%, 5%, and 1% AEP storms do not exceed the pre-development site discharge.

2 Site

2.1 Property Description

The 9681 m^2 site, located at 4 Forest Road is characterised by undeveloped grassy slopes, currently containing a single residential dwelling and a number of sheds. The site is currently zoned as R3 medium density residential. It is situated on a natural slope falling to the north-east at grades varying between 10-40%. These steep grades naturally drain the site towards the nearby Narrabeen creek, however the natural surface flow to the creek has been interrupted by development in the adjacent properties to the north and the east. A connection point to a piped drainage system supported by an easement to drain water under Bert Close has been provided by the development to the north.

To the west the site is bordered by 8 Forest Road which features mixed zoning. The natural bush land occupying the majority of the boundary is protected by RU2 rural landscape zoning, with the portion of the site to the north being zoned as R3 medium density residential. Development of this portion of 8 Forest Road is currently underway. Along the southern boundary is a 20m wide strip of public land which contains the driveway entry to the adjacent Mater Maria Catholic College further south.

Figure 1: Site Location (Nearmaps)

2.2 Proposed Works

The proposed development consists of the subdivision of the site into 13 residential lots in line with the planning controls. Refer to plan C3.001 for the general layout of the subdivision.

There are two roads being proposed for access to the subdivided lots. This includes the continuation of Forest Road from the existing cul-de-sac towards the west through the public land. Off this road there are two proposed entrances to the site, forming roads referred to in the civil plans as MC01 – Forest Road and MC02. These roads converge in the north-west, forming another point of access towards the west via the subdivision currently under construction in 8 Forest Road.

The geotechnical report undertaken by Alliance Geotechnical in August 2016 identified relatively shallow Class V sandstone across the site, with depths to the rock varying between 0.6-1.9m. These favourable subsurface conditions are anticipated to simplify the design and construction of any retaining structures. In addition, the sandstone itself was identified as having a maximum cut batter of 1:2 (H:V), allowing the opportunity for stabilised cut rock solutions in some locations proposed in the civil design.

2.3 Upstream Catchment

There is a significant upstream catchment of 4781 m^2 that drains onto the site from the bushland to the south-west. Refer to NSW210416-SHT-DA-C7.101 for the definition of this catchment, which has been established based on a combination of the site survey and LiDAR data. In order to maintain the existing flow regime, it is proposed that this catchment is captured on site and directed in-ground to the downstream legal point of discharge.

3 Stormwater Quantity

3.1 Standards and References

The stormwater quantity measures implemented in this design have been designed in accordance with the following documents:

- Australian Rainfall and Runoff 2019
- Northern Beaches Council Water Management for Development Policy – Version 2, 26 February 2021

3.2 Minor Pipework

The minor system for stormwater conveyance consists of a traditional pit and pipe network catering for 5% AEP flows.

Refer to Stormwater Drainage Plan NSW211540-SHT-DA-C7.001 for minor system layout.

3.3 Major Flow Paths

The major system for stormwater conveyance consists of roadways and overland flow paths catering for 1% AEP flows, resulting in safe VxD (velocity and depth) products no more than 0.4 m^2/s.

An emergency overland flow path has been provided for the lowest sag point in the road system located at pit 03\7 in order to avoid the flooding of downhill properties in the event of a total blockage of the piped system. Operating under normal conditions with the blockage factors required, the 1% AEP is still contained within the pipe network. The overland flow path is provided as an emergency provision.

3.4 Legal Point of Discharge

The legal point of discharge for the site the existing pit adjacent to the northern boundary in Bert Close. This pit connects to an existing pit and pipe network in Bert Close that lies within an easement to drain water from 4 Forest Road. It appears the pipe network has been sized to accommodate flows from 4 Forest Road, given the upstream pipe (identified on council's stormwater infrastructure map) is sized as a 600mm diameter RCP. An emergency overland flow path from the proposed On-site detention has been provided to 2 Forest Road.

3.5 Detention Strategy

The strategy for the provision of on-site detention for this development is summarised as follows:

- Detention of lot runoff will be handled on each individual lot
- Detention of road runoff and other catchments not associated with lots will be provided in an OSD tank located at the low point of the site, adjacent to the legal point of discharge

Each lot will be responsible for the provision and maintenance of detention on the lots, in line with the recommendations made in this report. An individually community Lot is proposed to be burdened with on-site detention (OSD) to serve the road catchment and ongoing maintenance of the water quality treatments is the shared responsibility of Lots 1-10. The maintenance requirements for these structures have been included in 5Appendix B - of this report.

3.6 DRAINS Modelling

There are 3 models' setup to analyse the sites drainage and overall detention, with an additional model setup to estimate the discharge response of the individual lot OSD systems. These models are as follows:

- NSW210416_DRAINS_DA_20%AEP_V12
- NSW210416_DRAINS_DA_5%AEP_V12
- NSW210416_DRAINS_DA_1%AEP_V12
- NSW210416_DRAINS_Lot OSD Estimate_A

3.6.1 Detention Modelling

3.6.1.1 On Lot Detention

In order to design this system, the overall detention required for the entire site was estimated, based on which, permissible site discharges (PSD) have been calculated for the individual lots. The detention required to meet the PSD rates will be provided at a later stage when the individual lots are developed. As such, the on-lot detention systems have not been designed as a part of this submission. For modelling purpose only, an example of an on-lot OSD system has been modelled to demonstrate the feasibility of the prescribed PSD rate for a Lot area of 450 m^2, and this analysis is in the *Lot OSD Estimate* model. Taking typical values for tank dimensions, this model allows us to estimate the volume that will be required on each site in order to meet the prescribed PSD rates, as specified below. This site storage rate (SSR) is estimated to be roughly 240 m^3/ha, equating to the requirement for 10.8m^3 of storage on a 450 m^2 lot and actual required on-site detention storage will vary based on the lot sizes shown on NSW211540-SHT-DA-C3.001. refer to table 2 for peak discharge flows for each lot during different storm events;

Table 1: Calculated Lot PSD Rates (m3/s/ha)

20% AEP	5% AEP	1% AEP
0.1	0.2	0.36

Table 2: Peak flowrates for each lot during different storm events (m3/s)

	20% AEP	5% AEP	1% AEP
Lot 1	0.00413	0.00826	0.0149
Lot 2	0.00386	0.00772	0.0139
Lot 3	0.00385	0.0077	0.0139
Lot 4	0.00385	0.0077	0.0138
Lot 5	0.00383	0.00766	0.0148
Lot 6	0.00511	0.01022	0.0184

Lot 7	0.00411	0.00822	0.0148
Lot 8	0.00432	0.00864	0.01555
Lot 9	0.00414	0.00828	0.01490
Lot 10	0.0047	0.0094	0.0169
Lot 11	0.0074	0.0148	0.0266
Lot 12	0.00722	0.01444	0.02599
Lot 13	0.00544	0.01088	0.01958

The post development time of concentration from the lots given the installation of detention structures can also be estimated with the *Lot OSD Estimate* model. This data has been used in the DA drains models in developing inflow hydrographs for the interallotment drainage pits that will be receiving flows from the detention structures on each lot. The shape of the discharge hydrograph from the modelled lot based OSD tank has been adopted for every lot, adjusting the peak flows for the 20%, 5%, and 1% AEP events based on each lot's area and the PSD rates. The adopted hydrographs are shown in Appendix A -, showing the peak flow based on the modelled 450m^2 lot.

Adopting inflow hydrographs is significantly more accurate than the alternative approach of adopting baseflows that are equivalent to the PSD. This is due to the fact that baseflows do not vary with time, resulting in an unrealistic constant flow through the stormwater network. This difference is illustrated in the figure below, comparing the total volumes of different modelling assumptions for a typical 450m^2 lot.

The difference in total volume over the duration of a storm event is very significant. As can be seen in Figure 2 below, modelling the lot OSD discharge as a baseflow would result in a total volume of 29.7m^3 over a 55 minute monitoring window. This is almost twice the volume of 16.9m^3 that is produced by the adopted hydrograph, which has been based on the results of the sample OSD model.

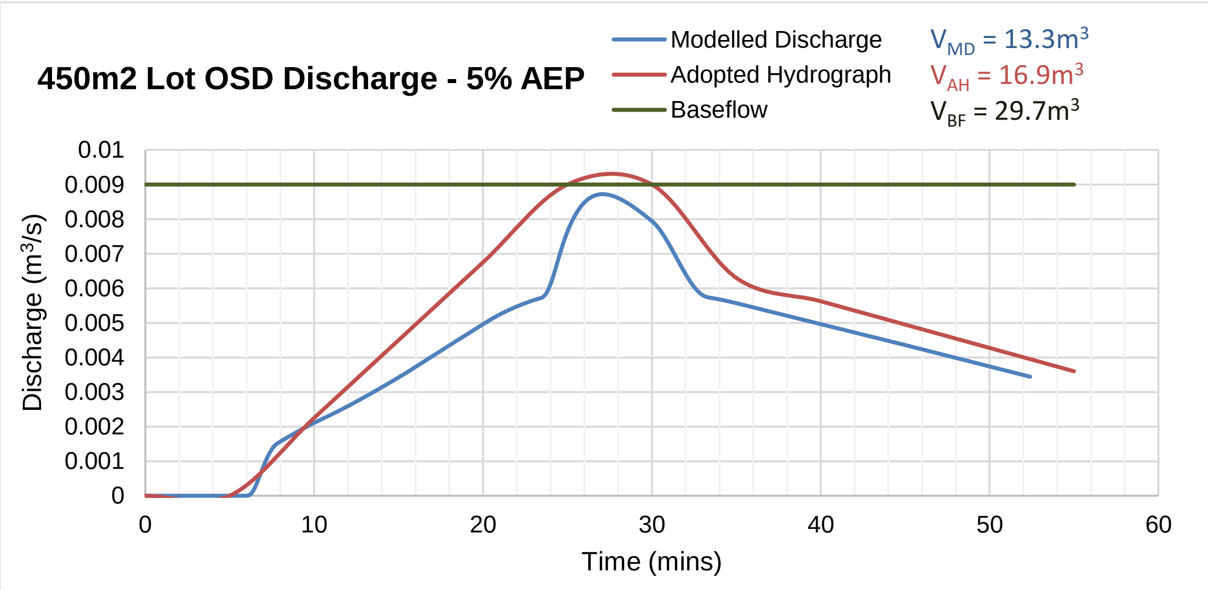


Figure 2: Comparison of On-lot Detention Modelling Approaches

3.6.1.2 Overall Site Detention

Given the structure of the OSD tank and overlying bio-retention basin, there have been two detention nodes modelled in DRAINS to simplify the interaction between these two storage zones. The entire site is directed, as per the design, into the bio-retention basin to begin with. In the DRAINS models the detention basin node called “Bio-retention” is modelled to account for the storage provided by the bioretention basin above the extended detention depth (EDD). It is assumed that at the beginning of each storm the EDD zone is full, and so the storage in this node begins at RL. 22.20 (the top of the EDD zone). The volume available for storage has been modelled as 10% more for bio-retention shown in plan to allow for vegetation.

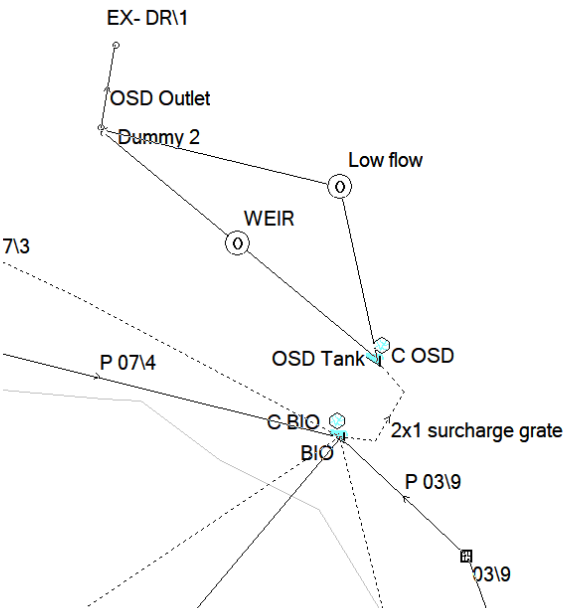


Figure 3: OSD Configuration in DRAINS

The inlet structure into the OSD tank from the bio-retention area has been modelled as an overflow route by using weir data equation to represent the OSD tank inlet structure (2m x 1m raised grate inlet). Some extra volume has been provided for the OSD tank volume to allow for construction tolerance. The outlet structures have been modelled with individual orifice and weir reaches which connect to a dummy node, simulating the point immediately downstream of the discharge control structure which then drains via a short outlet pipe into the existing 600mm pipe downstream.

3.6.2 Tailwater

Given that the site is not flood effected, and that the point of connection into the existing system is upstream of any other points of connection, there has been no tailwater assumed. The calculations assume that the outlet is free draining.

3.6.3 Catchment Modelling

The predevelopment catchment has been modelled to include the site area as well as the area of the upstream catchments, as this will drain through the detention tank. The catchment is taken as 100% pervious, with time of concentration of 16, 13 and 14 minutes for upstream sub-catchment 1, 2 and 3 respectively.

The upstream catchment has been modelled as 100% pervious in the post development model, adopting the same method used for the pre-development catchment to determine the concentration times of each sub catchment. The road catchments have been modelled as 90% impervious, with a TC's of 5 and 10 minutes for impervious and pervious areas respectively.

As discussed in Section 3.6.1, the pre-development runoff from the lots has been modelled with inflow hydrographs rather than sub catchments in order to mimic the discharge behaviour of the future on-site detention structures.

In order to account for the flows from the site that are bypassing the detention structures and discharging overland, a bypass catchment has been added into the models. This catchment includes the areas of road reserve that are bypassing the drainage system. It has been estimated as 90% pervious with a TC of 10 minutes for pervious areas and 5 minutes for impervious areas. In order to determine the post development discharge, flow from this catchment has been added to the flows from the other points of discharge.

3.6.4 Results

Tabulated below are the pre and post development discharges from the site with the implementation of the detention structures and the discharge controls that have been documented.

Table 3: OSD Results

	Pre-development Discharge (m^3/s)	Post-Development Discharge (m^3/s)
20% AEP	0.136	0.052
5% AEP	0.315	0.153
1% AEP	0.546	0.389

4 Stormwater Quality

4.1 Standards and References

The stormwater quality measures implemented in this design have been designed in accordance with the following documents:

- Northern Beaches Council Water Management for Development Policy – Version 02, 26 February 2021
- Northern Beaches Council WSUD & MUSIC Modelling Guidelines – Version 03, June 2016
- NSW MUSIC Modelling Guidelines (BTM WBM Pty Ltd, August 2015)

The overall water quality performance objectives are as follows

- 90% reduction in total gross pollutants (GP)
- 85% reduction in total suspended solids (TSS)
- 65% reduction in total phosphorus (TP)
- 45% reduction in total nitrogen (TN)

4.2 Methodology and Modelling

4.2.1 Overview

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is used to assess the pollutant generation from the site in post-development conditions and to evaluate the proposed treatment train effectiveness.

Modelling has been undertaken in accordance with BMT WBM (2015) guidelines with the developed site based on conceptual lot layout with water quality treatment devices included to achieve councils' objectives. The model referred to in this report is NSW210416_MUSIC_DA_V8.

The treatment train adopted across the site consists of the following elements:

- 10kL rainwater tanks for each residential lot - Reuse demand for toilets flushing and washing is 0.176 kL/day/dwelling. For irrigation of landscaped areas purposes is 55 kL/year/dwelling as PET – Rain
- OceanProtect Ocean Save GPT
- Bio-retention basin

4.2.2 Catchment Areas

The sites catchment has been divided into road reserve area, and lot area. Within the lots, 60% of the area has been assumed to be roof catchment, 75% of which is treated by the rainwater tanks, with the remaining area runs directly into the interallotment drainage network and it treated by the bio-retention basin downstream. The entirety of the road reserve catchment is treated by the GPT before draining to the bio-retention basin. There are two additional catchments to account for the road area bypassing the bio-retention basin, and the area of the basin itself

Upstream catchments have been excluded from the model as they are not required to be treated on site.

The land uses adopted in the model are based on the proposed site layout design. Refer to ACOR drawing NSW210416-SHT-DA-C3.001 for the proposed general siteworks plan.

4.2.3 Climate Data

As per table 2 of the NBC WSUD & MUSIC Modelling Guidelines, the pluviograph rainfall data was sourced from rainfall station No. 066062 Sydney Observatory. The data was run on a 6-minute timestep from 1/01/1981 to 31/08/1985.

4.2.4 Model Parameters

Soil and groundwater parameters were adopted from tables 4 & 5 of the NBC WSUD & MUSIC Modelling Guidelines. The pervious area parameters for sandy clay loam soils have been adopted based on geotechnical investigations identifying silty and sandy clay soils. Refer to Preliminary Geotechnical Report number 2406-GR-1-1 undertaken by Alliance Geotechnical, 3rd of August 2016.

Parameters for the bio-retention basin and rainwater tanks have been adopted from table 6 of the NBC guidelines. Rainwater re-use rates are adopted from the NSW MUSIC Modelling Guidelines, assuming re-use for toilets and washing machines internally, and external irrigation.

Table 4: MUSIC Source Node Soil Properties

Soil Parameter	Value
Rainfall Threshold (mm/day)	0.3 (for Roof) & 1.50 (for Roads/Paths)
Soil Storage Capacity (mm)	108
Initial Storage (% of Capacity)	30
Field Capacity	73
Infiltration Capacity Coefficient – a	250
Infiltration Capacity Coefficient – b	1.3
Groundwater Initial Depth (mm)	10
Groundwater Daily Recharge Rate (%)	60
Groundwater Daily Base Flow (%)	45
Groundwater Daily Deep Seepage Rate (%)	0

Table 5: Bio-retention Basin Parameters

Basin Parameter	Value
Extended Detention Depth (m)	0.3
Unlined Filter Media Perimeter (m)	0.01
Saturated Hydraulic Conductivity (mm/hr)	100
Filter Depth (m)	0.4
TN Content of Filter Media (mg/kg)	400
Orthophosphate of Filter Material (mg/kg)	40
Exfiltration Rate (mm/hr)	0
Base Lined	Yes
Vegetation Removing Plants	Effective Nutrient Removal Plants
Under Drain Present	Yes

4.3 Model Results

The results of the assessment of the proposed site development are provided below in Table 4.

Table 6: Subdivision MUSIC Model Results

	Source Load	Residual Load	% Achieved Reduction	% Required Reduction	Complies (Y/N)
TSS (kg/yr)	1470	212	85.6%	85%	Y
TP (kg/yr)	2.88	0.882	69.4%	65%	Y
TN (kg/yr)	19.4	8.5	56.2%	45%	Y
Gross Pollutants (kg/yr)	213	10.4	95.1%	90%	Y

MUSIC results show that the required reduction criteria can be achieved for the site with the implementation of the proposed treatment train.

5 Conclusion

As outlined in this report, the stormwater management strategy for the proposed development of 4 Forest Road addresses both stormwater quality and quantity. With the implementation of on-site detention structures, flows can be reduced to less than pre-development levels for the design events analysed. This detention system in conjunction with the stormwater treatment train detailed in this report also reduces post-development pollutant loading to the specified levels.

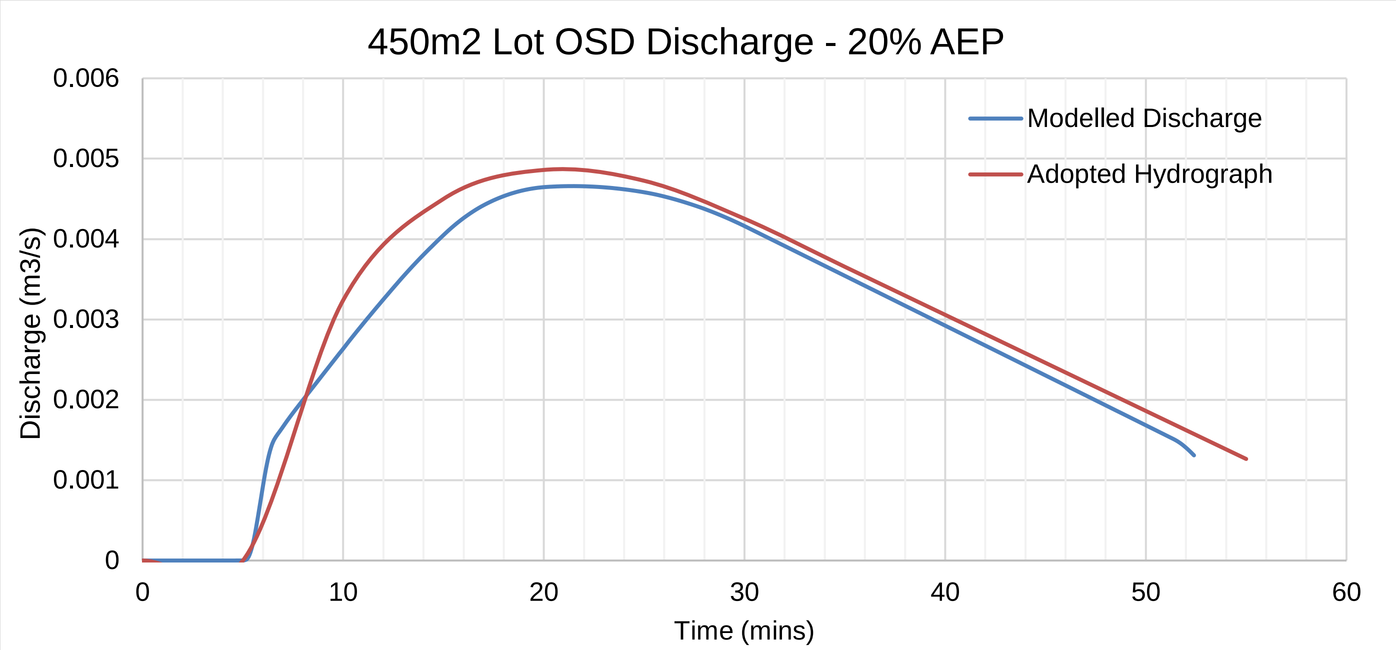
The proposed development therefore complies with current requirements of The Northern Beaches Council for both stormwater quality and quantity controls.

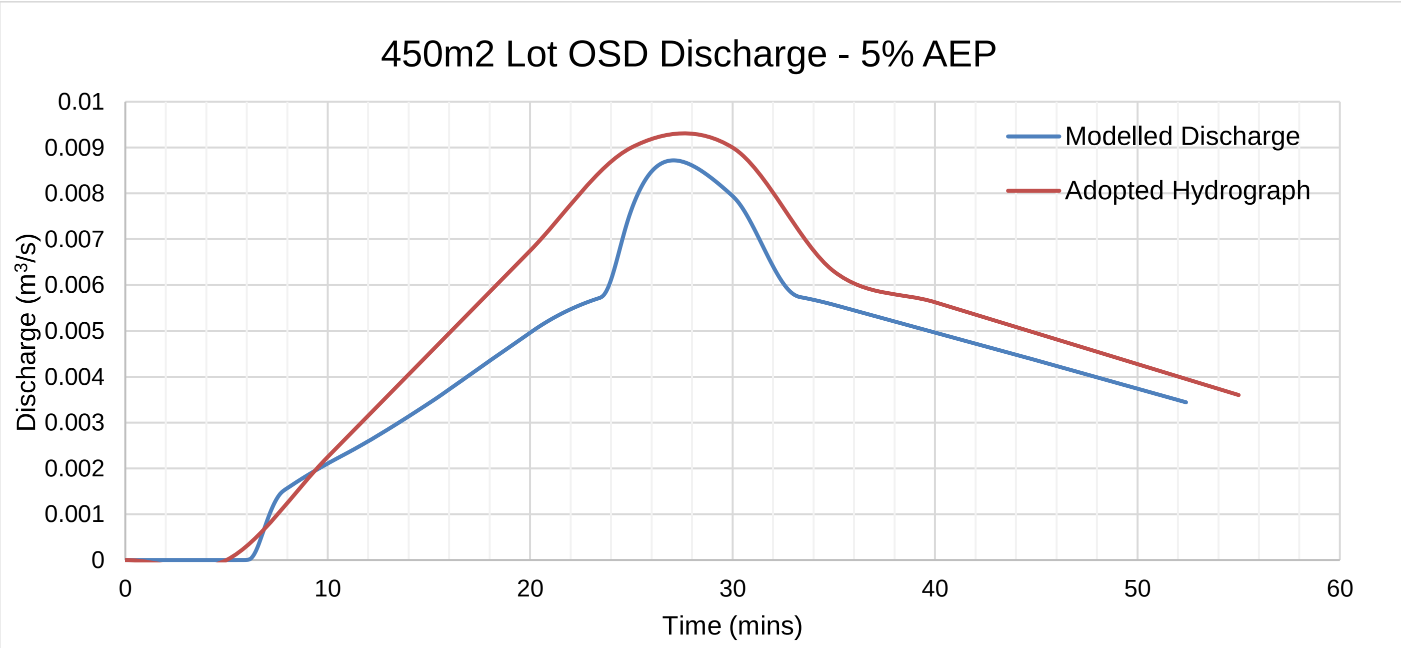
Yours faithfully,

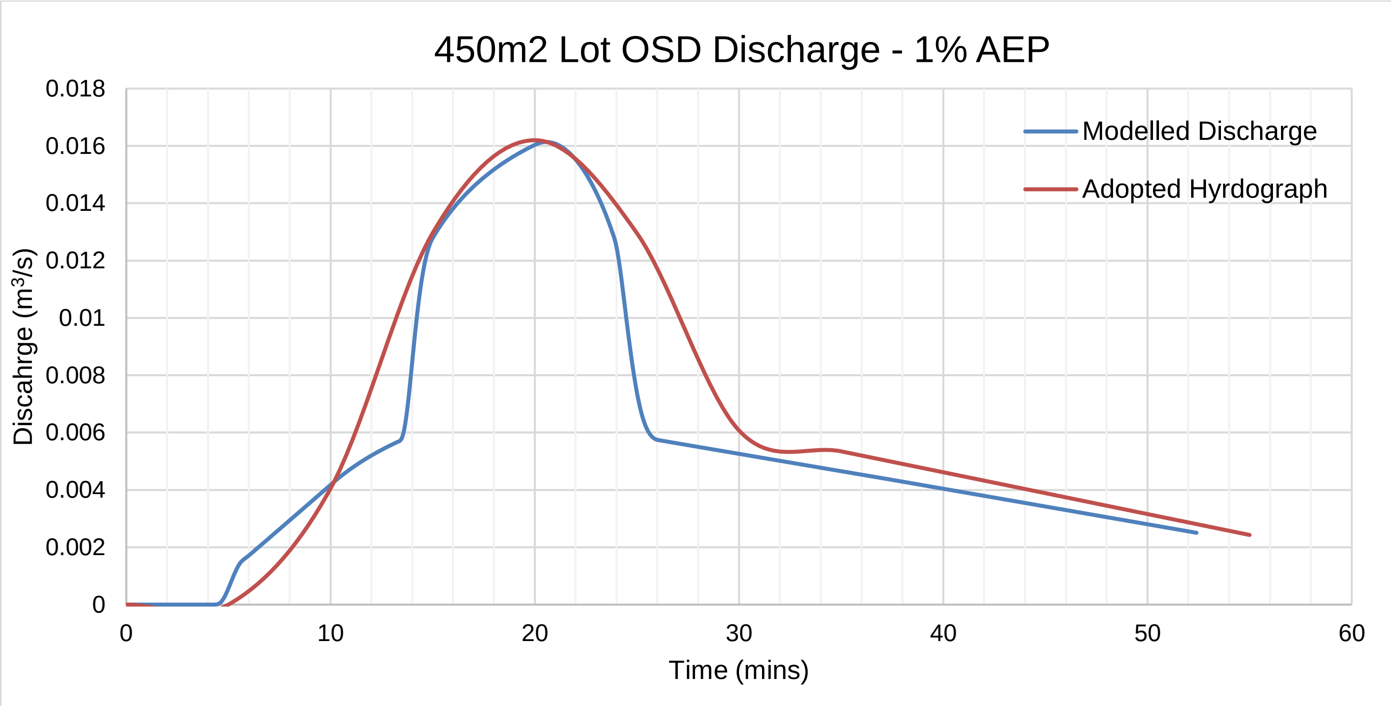
Stella Hong

Senior Civil Engineer
ACOR Consultants Pty Ltd

Appendix A - Inflow Hydrographs for Lot Discharge






450m2 Lot OSD Discharge - 1% AEP
Modelled Discharge
Adopted Hyrdograph
Discahrge (m³/s)
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
10
20
30
40
50
60
Time (mins)

Appendix B - Maintenance Schedules

B.1 OSD Tank Maintenance Schedule

Maintenance Action	Frequency	Procedure
Outlet		
Inspect and remove any blockage of orifice in tank	Six months	Open control pit and remove screen to inspect orifice.
Check attachment of orifice plate to wall of basin	Annually	Remove access grate to control pit and remove screen. Ensure plate is mounted securely, tighten four dynabolts if required. Seal gaps as required.
Check orifice diameter is correct and retain sharp edge.	Five yearly	Compare diameter to design and ensure edge is not pitted or damaged.
Inspect screen and clean	Six months	Remove access grate to control pit and remove screen to clean it.
Check attachment of trash screen to wall of basin.	Annually	Remove access grate to control pit and remove screen. Ensure screen fixings are secure. Repair if required.
Check screen for corrosion	Annually	Remove access grate to control pit and examine screen for rust and corrosion, especially at corners or welds.
Inspect walls for cracks and spalling	Annually	Remove access grates to pits to inspect the walls. Repair as required.
Inspect outlet sump and remove any sediment/sludge	Six months	Remove access grate to control pit. Remove sediment/sludge build-up and check orifice is clear.
Inspect pits grate for damage or blockage	Six months	Check both sides of a grate for corrosion, (especially corners and welds) damage or blockage
Inspect outlet pipe and remove any blockages	Six months	Remove control pit access grate and screen. Check for sludge/debris on upstream side of outlet pipe and remove as necessary.
Check step irons for corrosion	Annually	Remove access grate to control pit. Examine step irons and repair any corrosion or damage.
Check fixing of step irons is secure	Six months	Remove access grate to control pit and ensure fixings are secure prior to placing weight on step iron.
OSD Storage		
Inspect storage and remove any sedimentation/sludge	Six months	Check for sedimentation/sludge inside tank structure and remove as necessary.
Inspect and remove any debris/litter/mulch etc blocking access grates	Six months	Remove blockages for grates.

B.2 Bioretention Basin Maintenance Schedule

Maintenance Action	Frequency	Procedure
Check for unevenness at surface of bio-retention	Six months	If erosion is minor, re-profile using hand tools or light machinery to limit damage to adjacent vegetation. Re-plant using replacements from other parts of the asset of bring in new stock. If erosion is major (i.e. poses a risk to public safety), undertake repairs immediately.
Inspect inlets and outlets for blockage	Six months	Check to see if water is flowing freely at the inlet and outlet. If not, remove debris by hand or with hand tools, such as shovels, forks and tongs. Special opening tools (e.g. grate/gatic openers) are required for some outlets.
Inspect subsoil drainage lines	Six months	Check to see if water is flowing freely through subsoil drainage lines and clear blockages where required. In the event that blockages cannot be cleared, subsoil drainage lines are to be replaced.
Check for excessive sediment build up	Six months	When the sediment build-up in the basin exceeds 100mm in depth the filtration media must be removed and replaced in accordance with the designed filtration media specifications. Established vegetation to be maintained of possible during media replacement works to be re-established in new media. When established media cannot be maintained, new tube stock is to be planted as per design specifications. Do not undertake works during periods of rain or when rainfall is likely.
Inspect for excessive litter and debris	Six months	Check for litter which can enter downstream (potentially causing environmental harm). Remove litter and excessive debris, by hand or with hand tools such as shovels, forks and tongs.
Inspect for dense, even distribution of vegetation across all planted areas.	Six months	If it is found that uneven vegetation persists in the bio-retention basin, re-establish vegetation using new stock. Use plant species that are growing well in other parts of the asset. Plant at a density of between Six-10 plants per square metre and use a minimum of two species.
Controlling weeds	Six months	Remove or control all weed species as part of a regular maintenance program. This can be done through: hand pulling, hand raking, grubbing, mechanical removal, slashing, biological means (i.e. insects and disease to control spreading of a particular weed species) and herbicides.
Managing algal or moss growth	Six months	Inspect for grown or algae or moss. Algae can be identified as a green/brown coating on the surface of the filter media. Moss looks like green carpet. Allow the bio-retention system to dry out, remove algae by hand, and replant the asset as required. Observe the asset over the next 12 months to ensure the problem is resolved.

B.3 OceanSave GPT Maintenance Manual

OceanSave

Operations & Maintenance Manual

Table of Contents

Introduction 2
Why do I need to perform maintenance? 2
Health and Safety 3
Personnel health and safety 3
How does it Work? 4
Maintenance Procedures 5
Primary Types of Maintenance 5
Minor Service 5
Major Service 5
Additional Types of Maintenance 6
Hazardous Material Spill 6
Blockages 6
Major Storms and Flooding 7
Disposal of Waste Materials 7
Maintenance Services 7

Rev: *1* ***Last Updated:*** *Aug 2020*

Introduction

The primary purpose of stormwater treatment devices is to capture and prevent pollutants from entering waterways, maintenance is a critical component of ensuring the ongoing effectiveness of this process. The specific requirements and frequency for maintenance depends on the treatment device and pollutant load characteristics of each site. This manual has been designed to provide details on the cleaning and maintenance processes as recommended by the manufacturer.

The OceanSave is a vortex type engineered stormwater management device designed to remove litter, gross pollutants, sediment and associated pollutants from stormwater runoff. It removes all particles 5 mm and greater from stormwater flows, including neutrally buoyant material. It also removes some suspended solids and free-floating oil and grease via the internal baffle.

The OceanSave is a system that effectively captures and retains a broad range of pollutants.

Why do I need to perform maintenance?

Adhering to the maintenance schedule of each stormwater treatment device is essential to ensuring that it works properly throughout its design life.

During each inspection and clean, details of the mass, volume and type of material that has been collected by the device should be recorded. This data will assist with the revision of future management plans and help determine maintenance interval frequency. It is also essential that qualified and experienced personnel carry out all maintenance (including inspections, recording and reporting) in a systematic manner.

Maintenance of your stormwater management system is essential to ensuring ongoing at-source control of stormwater pollution. Maintenance also helps prevent structural failures (e.g. prevents blocked outlets) and aesthetic failures (e.g. debris build up).

Health and Safety

Access to an OceanSave unit requires removing heavy access covers/grates, additionally it might become necessary to enter into a confined space. Pollutants collected by the OceanSave will vary depending on the nature of your site. There is potential for these materials to be harmful. For example, sediments may contain heavy metals, carcinogenic substances or objects such as broken glass and syringes. For these reasons, all aspects of maintaining and cleaning your OceanSave require careful adherence to Occupational Health and Safety (OH&S) guidelines.

It is important to note that the same level of care needs to be taken to ensure the safety of non-work personnel, as a result it may be necessary to employ traffic/pedestrian control measures when the device is situated in, or near areas with high vehicular/pedestrian activity.

Personnel health and safety

Whilst performing maintenance on the OceanSave, precautions should be taken in order to minimise (or when possible prevent) contact with sediment and other captured pollutants by maintenance personnel. In order to achieve this the following personal protective equipment (PPE) is recommended:

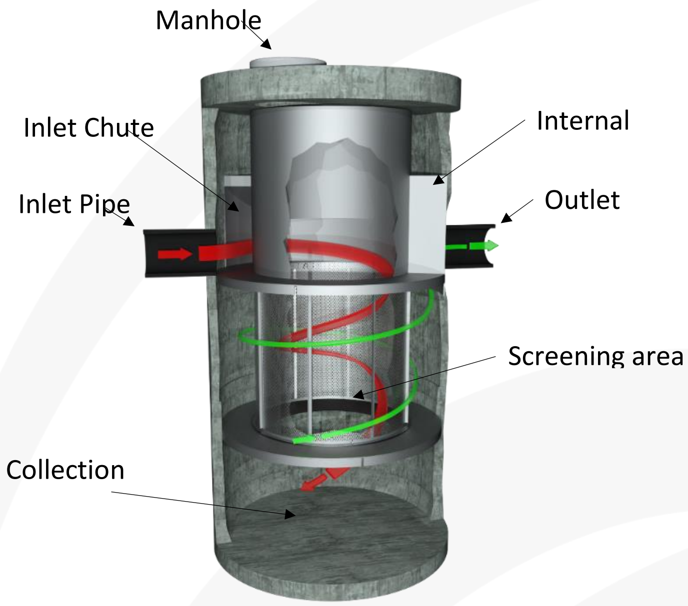
- Puncture resistant gloves
- Steel capped safety boots,
- Long sleeve clothing, overalls or similar skin protection
- Eye protection
- High visibility clothing or vest

During maintenance activities it may be necessary to implement traffic control measures. Ocean Protect recommend that a separate site specific traffic control plan is implemented as required to meet the relevant governing authority guidelines.

Whilst the minor maintenance for the OceanSave can be performed from surface level, there will be a need to enter the pit (confined space) during major services. It is recommended that all maintenance personnel evaluate their own needs for confined space entry and compliance with relevant industry regulations and guidelines. Ocean Protect maintenance personnel are fully trained and carry certification in confined space entry requirements.

How does it Work?

The OceanSave employs a unique screen design that maximizes hydraulic capacity and pollutant removal whilst simultaneously cleaning the screen surface. During operation, a tangential inlet causes stormwater to swirl in the circular treatment chamber. Buoyant materials migrate to the centre of the treatment chamber and rise above the screen while non-floating pollutants are trapped in the storage sump below.



During a storm, pipe flow enters the inlet structure where it is directed tangentially to the circular screen. The system builds driving head and forces water down into the screening area. This creates a vortex action with high tangential velocities across the face of the screen relative to the normal velocities through the screen. This indirect screening feature simultaneously cleans the screen surface whilst removing debris from stormwater. Floatable material is captured in the screening zone. There is also a baffle wall outside the screening zone that allows for the storage of hydrocarbons. Sediment and settable material fall into the sump below the screening area with treated stormwater exiting through the screen to the outlet pipe.

At higher flow rates, a portion of the runoff spills over the weirs located on either side of the inlet structure without affecting the treatable flow rate of the OceanSave. At the end of the storm water drains down to the pipe inverts further promoting the settling of fine suspended debris into the storage sump.

Given the unique component design the device can have multiple inlet/outlet pipes coming at a range of angles generally up to 270 degrees between inlet and outlet. Furthermore, any debris that accumulates behind the screen can be cleaned at time of routine maintenance without dismantling of the screen itself. The refined design of the OceanSave technology utilises the proven performance of the indirect vortex style gross pollutant traps whilst improving characteristics such as configuring and associated installation and maintenance.

Maintenance Procedures

To ensure optimal performance, it is advisable that regular maintenance is performed. Typically, the OceanSave requires a minor service every 6 months and a major service every 12 to 24 months.

Primary Types of Maintenance

The table below outlines the primary types of maintenance activities that typically take place as part of an ongoing maintenance schedule for the OceanSave.

	Description of Typical Activities	Frequency
Minor Service	Visual inspection of inlet aperture Removal of large floatable pollutants Measuring of sediment depth	At 6 Months
Major Service	Removal of accumulated sediment and gross pollutants. Inspection of screening element and cleaning every 2 years	At 12 Months

Maintenance requirements and frequencies are dependent on the pollutant load characteristics of each site. The frequencies provided in this document represent what the manufacturer considers to be best practice to ensure the continuing operation of the device is in line with the original design specification.

Minor Service

This service is designed to assess the condition of the device and record necessary information that will inform the activities to be undertaken during a major service.

1. Establish a safe working area around the access point
2. Remove access cover
3. Visually inspect the inlet aperture
4. Remove large floatable pollutants with a net
5. Measure and record sediment depth
6. Replace access cover

Major Service

This service is designed to return the OceanSave device back to optimal operating performance.

1. Establish a safe working area around the access point
2. Remove access cover
3. Using a vacuum unit remove any floatable pollutants
4. Decant water until water level reaches accumulated sediment
5. Remove accumulated sediment and gross pollutants with vacuum unit (if required)
6. Enter the device to inspect the screening element (every 2 years on larger units)
7. Use high pressure water to clean screen and sump area (if required)
8. Replace access cover

When determining the need to remove accumulated sediment from the OceanSave unit, the specific sediment storage capacity for the size of unit should be considered (see table below).

OceanSave Model	Unit Diameter (m)	Total Capacity (m^3)	Sump Storage Capacity (m^3)
OS-0606	1.2	1.5	0.8
OS-0809	1.5	2.8	0.8
OS-1112	2.2	8.0	2.5
OS-1612	2.2	11.0	4.4
OS-2318	3.2	28.0	11.9
OS-2324	3.2	33.0	9.5

Additional Types of Maintenance

The standard maintenance approach is designed to work towards keeping the OceanSave system operational during normal conditions. From time to time events on site can make it necessary to perform additional maintenance to ensure the continuing performance of the device.

Hazardous Material Spill

If there is a spill event on site, the OceanSave unit that potentially received flow should be inspected and cleaned. Specifically all captured pollutants from within the unit should be removed and disposed in accordance with any additional requirements that may relate to the type of spill event.

Blockages

The OceanSave internal high flow bypass functionality is designed to minimise the potential of blockages/flooding. In the unlikely event that flooding occurs around or upstream of the device location the following steps should be undertaken to assist in diagnosing the issue and determining the appropriate response.

1. Inspect the inlet aperture, ensuring that it is free of debris and pollutants
2. Decant water from OceanSave unit in preparation for confined space entry
3. Inspect the screen and flume as well as both inlet and outlet pipes for obstructions, if present remove any built up pollutants or blockages.

Major Storms and Flooding

In addition to the scheduled activities, it is important to inspect the condition of the OceanSave after a significant major storm event. The focus is to inspect for higher than normal sediment accumulation that may result from localised erosion, where necessary accumulated pollutants should be removed and disposed.

Disposal of Waste Materials

The accumulated pollutants found in the OceanSave must be handled and disposed of in a manner that is in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. If the system has been exposed to any hazardous or unusual substance, there may be additional special handling and disposal methods required to comply with relevant government/authority/industry regulations.

Maintenance Services

With over a decade and a half of maintenance experience Ocean Protect has developed a systematic approach to inspecting, cleaning and maintaining a wide variety of stormwater treatment devices. Our fully trained and professional staff are familiar with the characteristics of each type of system, and the processes required to ensure its optimal performance.

Ocean Protect has several stormwater maintenance service options available to help ensure that your stormwater device functions properly throughout its design life. In the case of our OceanSave system we offer long term pay-as-you-go contracts and pre-paid once off servicing.

For more information please visit www.OceanProtect.com.au