# SQIDEP independent evaluators report:

# Filterra biofiltration system

Final Report

7 October 2024

**AECOM and Sustainability Workshop**

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# 1 INTRODUCTION

This report summarises the assessment undertaken by the independent evaluators of Stormwater Australia for an application by Ocean Protect for performance verification of the Filterra biofiltration system.

This independent evaluation is undertaken using field and analytical data provided by Ocean Protect and follows the requirements of the 'Body of Evidence (BOE)' pathway set out by SQIDEP V1.3 (Stormwater Australia, 2019).

## 1.1 Evaluators Declaration of Independence

It is declared that the evaluators, Ricky Kwan and Mark Liebman, are completely independent and have no conflict of interest with respect to this engagement. They have not, nor have ever been employed or commissioned by the Applicant, Ocean Protect.

They have not been involved in the design or development or monitoring of the Filterra biofiltration system and have undertaken this assessment in good faith and without prejudice.

| | | |
|---|---|---|
| Signed by | Mark Liebman | Ricky Kwan |
| Signature: |  |  |
| Date | 24/10/24 | Date 24/10/24 |

# 2 BACKGROUND

## 2.1 Available Data

Data provided and relevant for the Filterra biofiltration system included the following set of documents:

- Detailed performance report for SQIDEP review – Filterra biofiltration (Ocean Protect, March 2024, Final Revision August 2024);
- WSU (Western Sydney University) Filterra data & analysis spreadsheet (March 2024, Final Revision August 2024);
- WSU additional information (antecedent rainfall analysis. drawings, equipment calibration and maintenance, maintenance photos, MUSIC analyses, individual storm reports and analysis, site photos, Sample Receipt Notifications (ALS);
- Statutory Declarations (Ocean Protect);
- Design and Maintenance Guidance (Ocean Protect); and
- Coatesville Filterra Infiltration Trial (Report by Pattle Delamore Partners Ltd, Auckland July 2023).

The information package submitted also included the data monitoring equipment, data collection process, data analysis, chain of custody, certificates of analysis and quality control reports. It is noted that the statutory declarations are declarations provided by Ocean Protect staff.

## 2.2 Filterra biofiltration system

The Filterra biofiltration system works in a similar manner to conventional biofiltration systems. The primary difference, however, is that it uses a filter media that has a relatively high infiltration rate and therefore can treat flows at a significantly higher flowrate than typical biofiltration systems.

Filterra biofiltration systems are available in a wide range of configurations. This includes "tree pit" as well as "bioscape configurations, as shown in Figure 1 and Figure 2.


*Figure 1: Ocean Protect Filterra biofiltration 'tree pit' system*

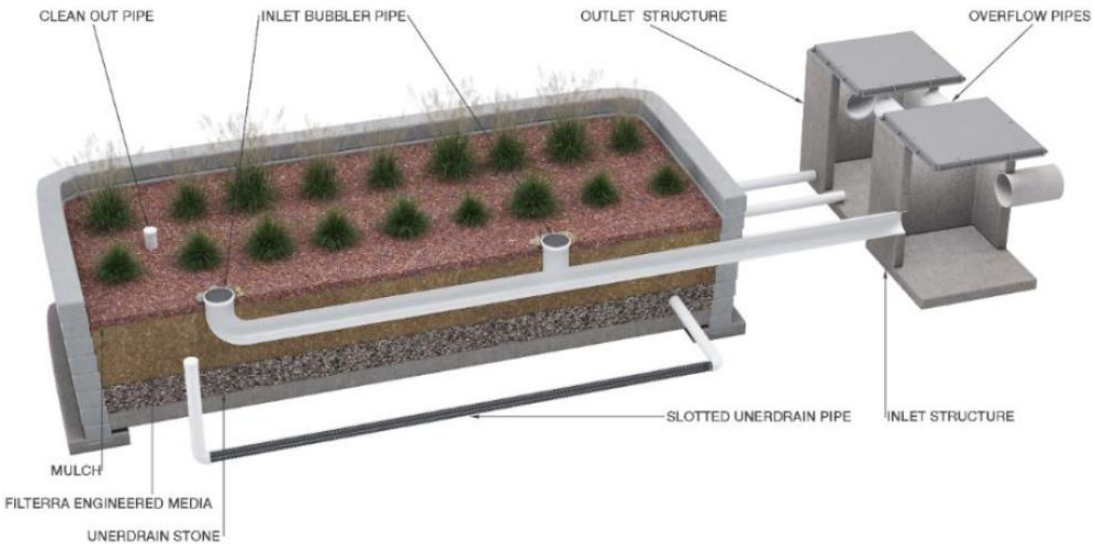

*Figure 2: Ocean Protect Filterra biofiltration 'bioscape' system*

### 2.3 Filterra monitoring site at Kingswood Campus Carpark, Western Sydney University

- The Filterra biofiltration monitoring site is located at the Kingswood Campus of Western Sydney University (WSU), NSW. The site has a catchment area of about 420 $m^2$ and is 100% impervious, as determined by land survey and site inspections (Figure 3). The system was installed in approximately April 2018 and had been well established prior to monitoring.

The treatment system design has the following components:

- An underground Filterra biofiltration precast pit (1200mm x 1200mm);
- A Filterra filter area of 1.44m2 and depth of 0.53m, with a design infiltration rate of 5,000 mm/hr (2 L/s) (see Figure 1);
- Mulch (hardwood) depth of 75mm placed on top of the filter media; this mulch is replaced every 12 to 18 months;
- A Bush Christmas Lilly Pilly grown in the biofiltration pit;
- Bypass flows are designed to back up in the inlet area and overflow into the adjacent bypass pit (Figures 3 to 6); and
- Treated stormwater is discharged via filter outlet pipes to the sampling equipment container and then released to the street drainage network.


*Figure 3: Kingswood Campus Carpark Monitoring Site, Western Sydney University*

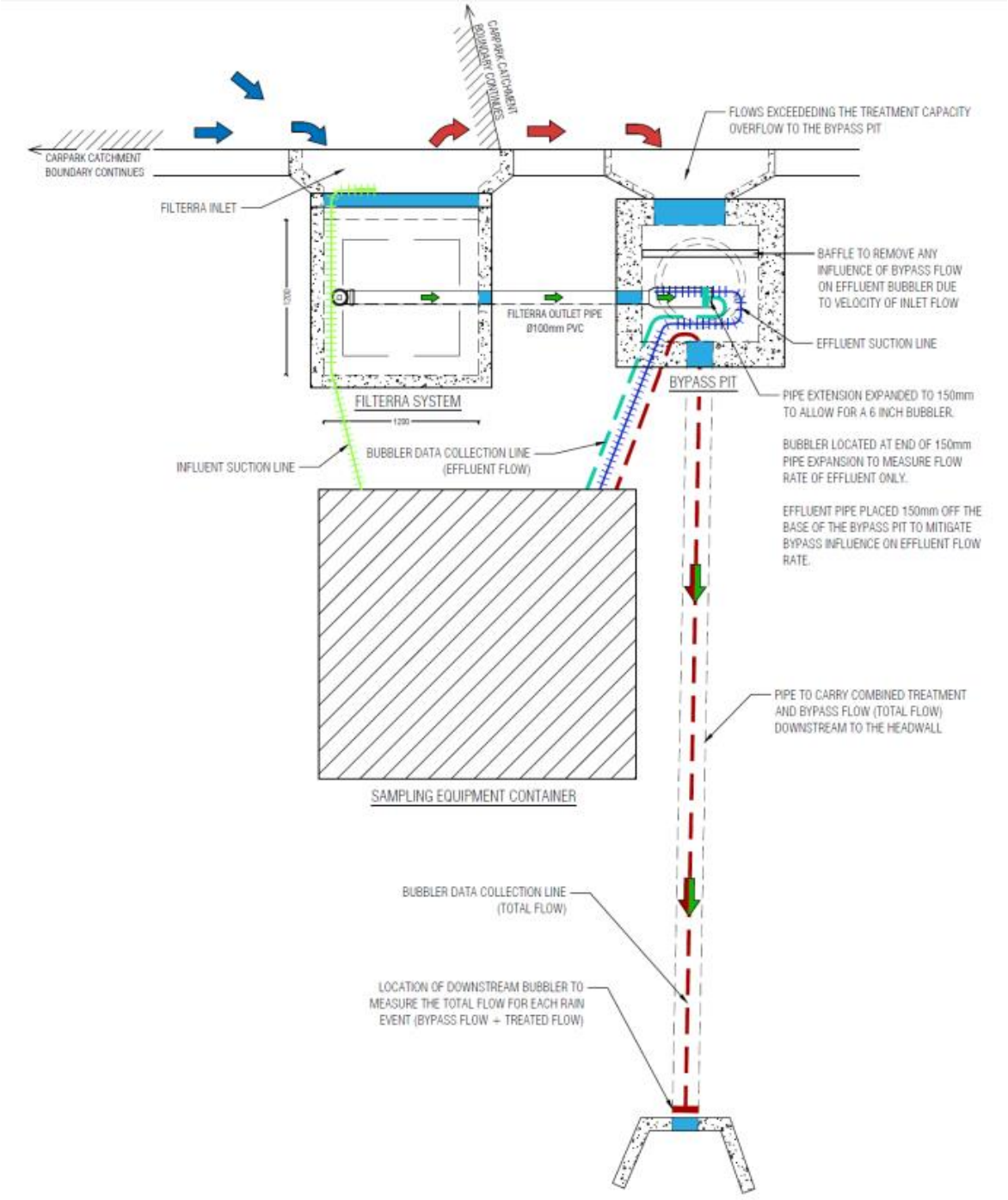


*Figure 4: Schematic plan of monitoring site arrangement at Kingswood Campus Carpark, Western Sydney University*

*Figure 5: Side Entry kerb and sampling facility at Kingswood Campus, Western Sydney University*

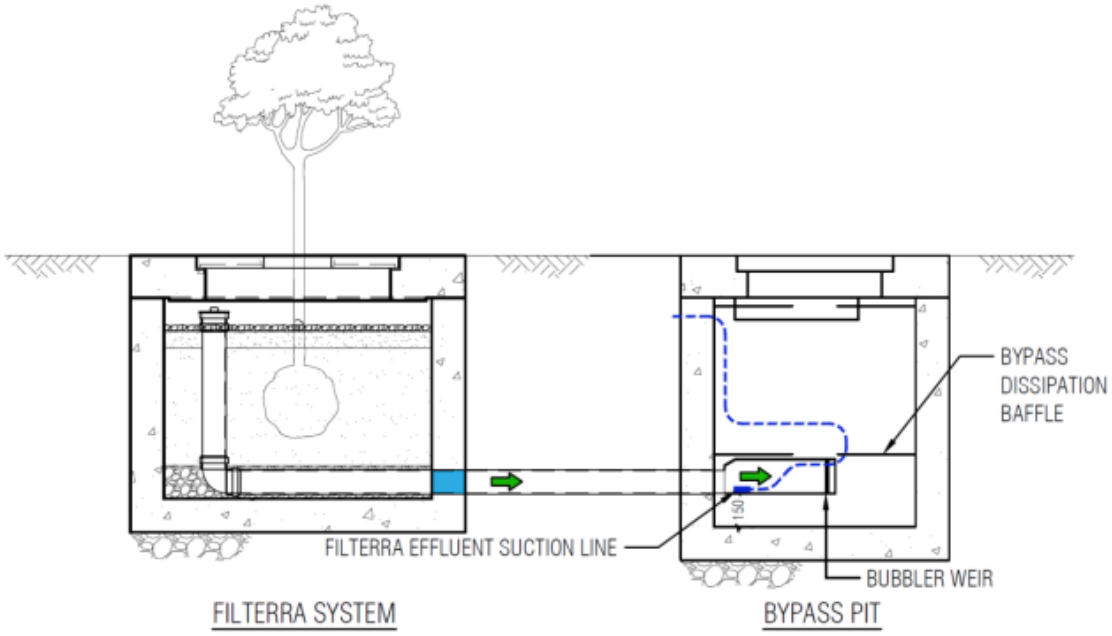


*Figure 6: Schematic section of Filterra monitoring system and bypass pit*

Monitoring was conducted following the SQIDEP protocols by monitoring rainfall, flow rates and collecting water quality samples at the inflows to the pit and of the treated outflow pipe. The flow monitoring equipment and approach included the following:

- Rainfall measured at 1-minute intervals using 2 x 0.25mm resolution ISCO 674 tipping bucket rain gauge;
- Flow rates measured using calibrated 203mm diameter Thel-Ma Weir;
- Influent and effluent sampling using ISCO 730 Bubbler Weir module connected to ISCO sampler installed within a preconfigured Thel-Mar weir;
- Effluent samples were sampled prior to mixing effluent flows with any bypass flows;
- Sampler was connected to and ISCO 6712Gi Global Digital Cell Ohone Modem for remote communication and data access;
- Influent and effluent sample collection were configured to collect a minimum of 8 aliquots per bottle;
- Following a precipitation event, Ocean Protect would dispatch ALS personnel to retrieve samples and reset automated sampling equipment. Only ALS collected and handled water quality samples and Ocean Protect took no part in sample collection.
- Sub-samples are delivered by ALS to ALS NATA accredited laboratory on ice and accompanied by chain-of custody documentation and analysis.

An analysis of rainfall over the 12 month monitoring period indicated that a diverse range of storm events was covered by the qualifying storms – small and large rainfall events. This was an unusually wet period due to a La Nina event with a high frequency of storms. On first principles this would probably have resulted in cleaner runoff than a typical or El Nino pattern where prolonged periods between rainfall can allow for greater build up of pollutants.

A total of 16 qualifying runoff events were recorded for the sampling period between 1 July 2021 and 31 August 2022. Reviewers were advised that Ocean Protect was unable to carry out monitoring between December 2021 and March 2022 though the system remained in place during that time.

Of these, 1 event had 7 aliquots, 6 events had the peak treatment flow exceeding 75% of the maximum treatable flow, and 5 events had the peak treatment flow exceeding the maximum treatable flow rate (**Table 1**). Additional observations are provided in **Table 3**.

***Table 1: Treatment flow events and aliquots***

| **Observations** | **Details** | **SQIDEP** |
|---|---|---|
| One event has 7 aliquots (others all have a minimum of 8 aliquots) | 6 April 2022 | 80% of events should have at least 8 aliquots |
| Six events exceed 75% of treatable flow rate | 10 Oct 2021, 4 Nov 2021, 7 Nov 2021, 24 Nov 2021, 8 Dec 2021, 2 Jul 2022 | At least 2 events should have 75% of treatable rate |
| Five events exceed maximum treatable flow rate | 4 Nov 2021, 7 Nov 2021, 24 Nov 2021, 8 Dec 2021, 2 Jul 2022 | At least 1 event should be greater than 100% treatable rate |

### 2.4 Performance claims

The performance treatment results provided for the biofiltration system are shown in **Table 2**. The BOE report does not state a specific treatment claim for the Filterra biofiltration system. However, based on the results and Table 4-2 of the BOE report, it is inferred that the claim is based on the efficiency ratio results. This corresponds to pollutant reduction treatment rates of 90% for TSS, 85% for TP and 47% for TN. Gross pollutants were not monitored but a 100% treatment efficiency is claimed.

It is noted that upon further review and discussions between Ocean Protect and the evaluators (August 2024), it has been agreed that the Efficiency Ratio Treatment results (ER %) are those that are appropriate.

***Table 2: Filterra biofiltration water quality treatment claims***

| **Parameter** | **Treatment Claim** | |
|---|---|---|
| | **Efficiency Ratio (ER) %** | **Load Reduction %** |
| Total Suspended Solids (TSS) | 90 | 97 |
| Total Phosphorus (TP) | 85 | 94 |
| Total Nitrogen (TN) | 47 | 73 |
| Gross Pollutants[1] | Not monitored | Not monitored |

1: Not monitored but a 100% treatment efficiency is claimed

## 3 SQIDEP COMPLIANCE

### 3.1 SQIDEP assessment

The minimum requirements from SQIDEP are reproduced in Table 1 and are evaluated against the data provided with the applicant's submission.

*Table 3: SQIDEP Compliance for Filterra Biofiltration System*

| Criteria | Requirement | Evaluation finding | Compliance Status |
|---|---|---|---|
| **Organisational Roles and Quality Assurance** | | | |
| Organisational Roles and Responsibilities | The claimant, sampling organisation, analytical laboratory and reporting organisation shall be clearly identified (especially in confirming independence requirements | No organisation chart was provided. However, the roles and responsibilities are described as follows:<br>• Ocean Protect – Study Lead, installed equipment, equipment calibration, monitoring, maintenance, communications with ALS, Body of Evidence Reporting<br>• ALS – Collection, handling and transport of samples, reset automated sampling equipment<br>• ALS – Water sample processing and laboratory analysis<br>It is not considered ideal that Ocean Protect undertook its own monitoring and reporting, as this may be construed as not being entirely independent.<br>However, it is acknowledged that Ocean Protect provided Statutory Declarations that the statements provided in the BOE are true. | Partly compliant based on the Statutory Declarations |
| Sampling QA and Quality Control | Operation and maintenance schedules for sampling equipment shall be provided. Chain of custody documents identifying sample, collection agency, collection time, preservation used and laboratory receipt of sample and sample condition shall be provided. | ALS laboratory provided Sample Receipt Notifications.<br>Not clear if random blanks and duplicate testing performed as part of Quality Control.<br>Chain of custody and sample preservation documented by ALS<br>Operation and Maintenance and calibration reports were included in the BOE application.<br>Duplicates and blanks were included as required. | |
| Reporting | By independent organisation | Ocean Protect have prepared and written their own report however it is clear that water quality results have been collected and tested independently with results and chain of custody documentation provided by ALS.<br>Individual storm reports were provided by Ocean Protect. | Partly Compliant noting independence has been achieved viz test results. |
| **Sampling Events** | | | |
| Type of Event | Rainfall Events | Real storm events were sampled | Compliant |

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| Minimum Number of Events | The greater of:<br>a. 15 events, and<br>b. Sufficient events to achieve 90% confidence interval. | 16 qualifying compliant events (over 12 months between 1 July 2021 and 31 August 2022) for TSS, TP, and TN samples | Compliant |
| Measuring Rainfall | Rainfall shall be measured by a rain gauge capable of sampling at intervals of 5 minutes or less, and in increments no greater than 0.25mm | Sampling interval of 1 minute recorded by electronic weather station at 0.25mm resolution | Compliant |
| Minimum Rainfall Depth | Sufficient to collect minimum sample volume (based on laboratory analytical requirements). | All were 2.5 mm and above | Compliant |
| Device Size | Full scale | Device is full scale. | Compliant |
| Runoff Characteristics | Target pollutant profile of influent and effluent | They are representative | Compliant |
| Runoff Volume or Peak Flow | At least 2 events should exceed 75% of the design water quality volume/ TFR and 1 event greater than 100% of the TFR. | 5 of the fully compliant events exceeded the total treatable flow rate of 2 L/s<br>6 events exceeded 75% of the treatable flow rate | Compliant |
| **Sampling Procedures and Techniques** | | | |
| Automated Sampling | Composite samples on a flow- (preferred) or time-weighted basis | Samples were collected on a flow-weighted basis and were composited before being split into sub-samples for analysis | Compliant |
| Minimum Number of Aliquots | 80% of field test collections should have at least 8 per event.<br>Notwithstanding aliquots should be collected to provide hydrograph coverage of rising and falling limbs. | Number of aliquots exceeds 8 for 15 of the 16 events (ie >93%) | Compliant |
| Hydrograph coverage | At least 50% of qualifying storms should include the first 70% storm hydrograph coverage (or, for storms longer than 8 hours, capture of the first 8 hours). Programs should aim to capture full hydrographs for all events, but flexibility will be considered for large volume, long duration events.<br>Dependent on catchment and rainfall patterns, multiple peaks should be accounted for (at least 1 occurrence). | The sampling covered a suitable range of events including multi-peak hydrographs. 8 of 16 or 50% of storms included the first 70% hydrograph coverage which meets the minimum standard specified by SQIDEP. | Compliant |
| Seasonality | Events to be distributed to capture seasonal influences | All seasons are covered by the data set | Compliant |

| | | | |
|---|---|---|---|
| Grab Sampling | Only for constituents that transform rapidly, require special preservation or adhere to bottles, or where compositing can mask the presence of some contaminants through dilution. | NA | NA |
| Sampling Location | As identified and agreed in the submitted QAPP. | Sampling undertaken at influent and effluent using suction lines. Effluent sampling was for treated flows only and did not include bypass flows. Locations appear to be appropriate and representative. | Compliant |
| **Sampling Procedures and Techniques** | | | |
| Chemical and Physical analytes | As identified and agreed in the submitted QAPP. | Dissolved nutrients as well as totals were analysed. | Compliant |
| Minimum and maximum (influent) pollutant concentrations for qualifying events | Minimum concentrations: exclude if below limit of detection. Maximum: mean+2SD for any single event, and mean +1SD in the aggregate dataset. Refer SQIDEP Table 1. | All influent concentrations are below the maximum concentrations permitted. | Compliant |
| Analytical Methods | NATA accredited sample handing and analytical methods. Refrigerated autosamplers may be required to adequately preserve samples. | Laboratory is NATA accredited and COC forms provided. | Compliant |
| **Requirements** | | | |
| Flow Measurement Location | Inlet, Outlet and Bypass, as applicable. Based on relevant accepted measurement protocols for flow type (e.g. open channel, in pipe) | Flow measurement locations are appropriate, no water level depths in the pit were presented. | Compliant |
| Precipitation Measurement | Automatic rain gauge (pluviometer) | ISCO 674 tipping bucket rain gauge | Compliant |
| Recording Intervals | 5 minutes or less | Complies | Compliant |
| Rainfall Recording Increments | No greater than 0.25mm | Complies | Compliant |
| Rain Gauge Calibration | Twice during monitoring period | Report states that calibration was completed by the manufacturer in the factory and did not require further calibration except to ensure no obstructions or interference with tip bucket | N/A |
| **Data Analysis and Reporting** | | | |
| Performance Indicators | Based on the Performance Claim stated in Detailed Performance Report. (Can include but not limited to TSS, Metals, TPH, TP & TN). | The performance claims relate to TSS, TP and TN which were included in the suite of parameters plus dissolved nutrient species. | Compliant |

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|---|---|---|---|
| | The target pollutants and testing rationale must be described in the QAPP & Detailed Performance Report.<br><br>Where a device is claiming total reductions of a particular pollutant, it is not necessary to include speciation. If speciation is not undertaken then reductions of sub-species cannot be claimed. | Gross pollutants not monitored but 100% treatment efficiency claimed.<br><br>It is considered that the device would be effective at gross pollutant capture until such time as bypass is engaged, at which point floatable gross pollutants may overflow from the device. However, the effectiveness of the system if clogged by gross pollutants and the impact on the treatment efficiency of the other pollutants is not clear. | |
| Performance Indicators Calculation | Concentration Removal Efficiency (CRE) (See Section 6.4.3) (Arithmetic average and median. If difference is 10% or greater, inspect data set closely). Reports may choose to present some, or all, of the metrics; however, as a minimum CRE and ER shall be provided.<br><br>Mass Removal Efficiency (MRE) (See Section 6.4.4) (Arithmetic average and median. If difference is 10% or greater, inspect data set closely)<br><br>Relative Achievable Efficiency (RAE) (See Section 6.4.5) (Arithmetic average and median. If difference is 10% or greater, inspect data set closely Summation of loads (SoL) (See Section 6.4.6) (Arithmetic Average and median. If difference is greater than 10% inspect dataset closely)<br><br>Efficiency Ratio (ER) (See Section 6.4.7) (Arithmetic Average and median. If difference is greater than 10% inspect dataset closely)<br><br>Flow Based Variability (FBV) (See Section 6.4.8), including a plot of one of the above performance measures against the 25, 50, 75, 100 and 125 percent of the treatable flow rate. Provide details on the selected curve and the associated $R^2$ value. | Sufficient data analysis was presented for Concentration Removal Efficiency and Efficiency Ratios.<br><br>CRE ratios not included in BOE Report but included in separate spreadsheet. Difference between average and median CRE reported as 6% for TSS, 10% for TP and 22% for TN (expressed as % of average CRE). The data presented is considered adequate to assess the performance claims. | Compliant |
| Performance Variability | Box and Whisker Plots of inlet and outlet EMCs. | Provided | Compliant |
| Statistical Significance Testing | Log-transformed inlet and outlet paired samples at 90% confidence level. | Over 90% confidence for TSS, TP and TN. | Compliant |
| Sizing Methodology | A sizing methodology must be provided that allows an evaluation of performance of other devices in a 'family' to be reviewed. | The device is sized based on hydraulic loading rate and claimed saturated hydraulic conductivity of 3,550 mm/hour. A sizing methodology has been proposed. | Compliant |

| | | | |
|---|---|---|---|
| | This should include relationships established under defensible theoretical/ modelled conditions or testing undertaken under either field or laboratory conditions. | Ocean Protect prefers the Filterra biofiltration system be modelled as a Bioretention Node. However, Ocean Protect is also amenable to modelling the system as a Generic Node, if necessary.<br><br>Based on discussions between Ocean Protect and the evaluators, modelling of the system as a Bioretention Node was considered appropriate using the Efficiency Ratio Treatment claims. | |

### 3.2 Treatable Flow Rate

The BOE information package included inflow hydrographs for 19 rainfall events. Of these, 16 events were analysed for the purposes of the report. Two events were excluded presumably because the rainfall duration was too short. Another event (21 July 2022) was not included due to TP exceeding the upper limit set in SQIDEP. Ocean Protect advised the Individual storm reports for the two events were included in error.

All the rainfall events monitored were multi peak storms. Data provided in the hydrographs included the treatment flow rate, date and time, and markers for influent and effluent sampling.

It appears that peak outflows were not monitored or provided. Hence the treatable flow rate from the Filterra biofiltration system is not clear from the information provided.

### 3.3 Pollutant removal and statistical analysis

A review of the analysis and approach undertaken for the Filterra biofiltration system indicates that it was robust. The reviewers therefore have no objection to what is presented nor to the claims of water quality improvements for flows up to the treatable flow rate.

## 4 DISCUSSION

### 4.1 Overall performance assessment

The evaluators are generally comfortable with the approach to the monitoring program, the installation of the field site, the number and variation of flow events monitored and the data analysis.

It is our opinion this program does reflect the field performance of the Filterra biofiltration system.

### 4.2 Gross Pollutant Removal

It is important to note that the treatment system adopted for the Kingswood carpark site at Western Sydney University site did not include any pre-treatment or gross pollutants at the inlet to the filtration system.

The impact of litter and other gross pollutants on the operation of the system has therefore not been evaluated. This is not withstanding the likelihood that the Filterra biofiltration system itself is likely to capture most of the gross pollutants.

It is considered that the provision of a gross pollutant removal device at the inlet would provide optimal performance of the Filterra system.

## 4.3 MUSIC node inputs

The MUSIC node modelling approach proposed by Ocean Protect for the Filterra biofiltration system uses the Bioretention Node. The adopted approach and parameters have been reviewed and are considered appropriate by the evaluators. The details are summarised in **Table 4**.

***Table 4: Recommended values for MUSIC Bioretention node for Filterra modelling***

| Parameter | Recommended value | Comments |
|---|---|---|
| **Inlet properties** | | |
| Low-flow bypass ($m^3/s$) | User defined | |
| High-flow bypass ($m^3/s$) | User defined | |
| **Storage properties** | | |
| Extended detention depth (m) | ≤ 0.3 | 150mm is a typical value, equal to the depth of air space above the mulch layer.<br><br>The mulch layer is 75mm thick and shall not be included within the EDD calculation. |
| Surface area | User defined | |
| **Filter and media properties** | | |
| Filter area ($m^2$) | User defined and to be at least 0.3% of the catchment area. | |
| Unlined filter media perimeter (m) | User defined | |
| Saturated hydraulic conductivity (mm/hour) | 3550 | |
| Filter depth (m) | 0.53 | |
| Total Nitrogen (TN) content (mg/kg) | 1000 | |
| Orthophosphate content | 40 | |
| **Infiltration properties** | | |
| Exfiltration rate (mm/hr) | User defined | |
| **Lining properties** | | |
| Is the base lined ? | User defined | |
| **Vegetation properties** | | |
| Plant selection | User defined | 'Vegetated with nutrient effective plants' recommended for optimal performance. |
| **Outlet properties** | | |
| Overflow weir width (m) | User defined | |
| Underdrain present | Yes | |
| Submerged zone with carbon present | No | |
| Depth (of submerged zone) | - | |

## 4.4 Verified Performance Claim

The performance claims verified by the evaluators are presented in **Table 5**.

***Table 5: Verified Performance Claims***

| Pollutant | Verified Performance Claims (% Reduction) |
|---|---|
| TSS | 90 |
| TP | 85 |
| TN | 47 |
| Gross Pollutants | 100 |

# 5 CONCLUSION

This assessment has considered a Body of Evidence submitted by Ocean Protect for the purposes of assessing the pollutant treatment performance of the Filterra biofiltration system.

The evaluators are in agreement with the approach and execution of the monitoring program. The evaluators are also in agreement with the performance treatment claims and bioretention MUSIC node modelling approach proposed by Ocean Protect for the Filterra system.

It is considered that pre-treatment of the inflows using a gross pollutant trap or similar would provide optimal performance of the filter.

# 6 REFERENCES


- Anderson A, Smolek A (2015). Filterra® Bioretention System Water Quality and Hydrologic Field-Scale Performance Evaluation. Prepared for Contech Engineering Solutions.
- Dalrymple B, Wicks M. (August 2024). Detailed performance report for SQIDEP review – Filterra biofiltration. Prepared on behalf of Ocean Protect.
- Ocean Protect (2019). Filterra® Operations & Maintenance Manual.
- Ocean Protect (2020). Filterra® Technical Design Guide.
- Pattle Delamore Partners Ltd, (2023), Letter re Coatesville Filterra Infiltration Trial, prepared for Stormwater360.
- Smolek A P, Anderson A R, Hunt W F (2018). Hydrologic and Water-Quality Evaluation of a Rapid-Flow Biofiltration Device. Journal of Environmental Engineering 144(2), February 2018.
- Statutory declarations from Ocean Protect personnel.
- Supporting information for the Filterra biofiltration technology monitoring at the study site at Western Sydney, including plan and section drawings, site photos, sample receipt notifications, chain of custody documentation, certificate of analyses, individual storm reports, and monitoring equipment calibration and maintenance logs.