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Division of IT, Engineering and the Environment

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Water quality improvement performance of the Enviro Australis 'Enviro EPS' system

AFMG Job No. A2001003

Prepared for	Enviro Australis PO Box 34 Angaston, SA, 5353 Attention: Mr Leo Crasti Director Engineering, Enviro Australis
Prepared by	Dr Baden Myers Australian Flow Management Group, School of Natural and Built Environments Division of IT, Engineering and the Environment University of South Australia Telephone +61 8 8302 6760 Facsimile +61 8 8302 3386
Contact	Dr Baden Myers Telephone +61 8 8302 6760 Mobile phone +61 409 986 042 Email baden.myers@unisa.edu.au
Date of Issue	21 February 2020

Summary

In December 2019, Enviro Australis approached the Australian Flow Management Group (AFMG) at the University of South Australia to witness testing on the Enviro Australis 'Enviro EPS' (the 'Enviro EPS') stormwater treatment device at their test premises located in a manufacturing facility in Edinburgh North, SA. The Enviro EPS is an in-line stormwater quality improvement device used to treat runoff from urbanised catchments.

The key aim of the Enviro EPS performance testing was to examine the water quality improvement performance of the system for the following pollutants:

a. Total suspended solids (TSS)
b. Total phosphorous (TP)
c. Total nitrogen (TN)

The performance of the Enviro EPS was tested in accordance with a procedure developed by Enviro Australis. The performance test was conducted by pumping potable water into the unit at half the treatment flow rate in addition to a concentrated pollutant mixture. The concentrated pollutant mixture was a mixture of leaves, grass clippings, soil and potting mix prepared by Enviro Australis, reflecting an intention to conduct a test on the device conditions where the device intercepts vegetation and soil litter mobilised by a storm in a small catchment. The device was then subjected to inflow spiked with the concentrated pollutant mixture in a laboratory setting on a full scale device, and testing was witnessed by UniSA AFMG representative Dr Baden Myers. UniSA AFMG also collected inflow and outflow samples (two of each) which were analysed to determine:

- The concentration of total suspended solids (TSS)
- The concentration of total phosphorous (TP) and total dissolved phosphorous (TDP)
- The concentration of total nitrogen (TN) and total dissolved nitrogen (TDN)

For a specific flow treatment rate (16 L/sec), the results showed that 94% of TSS was retained by the system, 97% of TP and 85% of TN, however all forms of nutrients were dominated by their particulate forms and there was and there was very little TDP or TDN present to compare inlet and outlet concentrations. Comparison with the performance of other devices should be undertaken with caution as there are no set test procedures for comparative purposes and there may be variation in the dissolved nutrient concentrations adopted.

It is noted that the results for nutrient concentrations are highly dependent on the nature of particulate and nutrient sources used in testing, and that field testing may be a more useful measure of nutrient treatment performance. We note that based on our conversations, Enviro Australis intends to conduct further testing at different flow rates to further identify the treatment capacity of the system when subject to flows higher or lower than that adopted for this testing. It is also noted that all testing was undertaken on an Enviro EPS E45.

Contents

1 Introduction

1.1 Background

Enviro Australis is an Australian company specialising in water quality improvement solutions, particularly stormwater. In December 2019, Enviro Australis approached the Australian Flow Management Group (AFMG) at the University of South Australia (UniSA) to witness testing proposed for the water quality improvement performance of the Enviro Australis 'Enviro EPS' E series treatment system (the 'Enviro EPS'). The Enviro EPS is intended to be placed in-line within stormwater drainage pipe systems to improve catchment runoff quality through the retention of sediment, nutrients and other associated pollutants such as heavy metals and natural organic matter. The system treats stormwater flows up to a specified maximum treatment flow rate. A conceptual image of the unit is provided in Figure 1 courtesy of Enviro Australis.

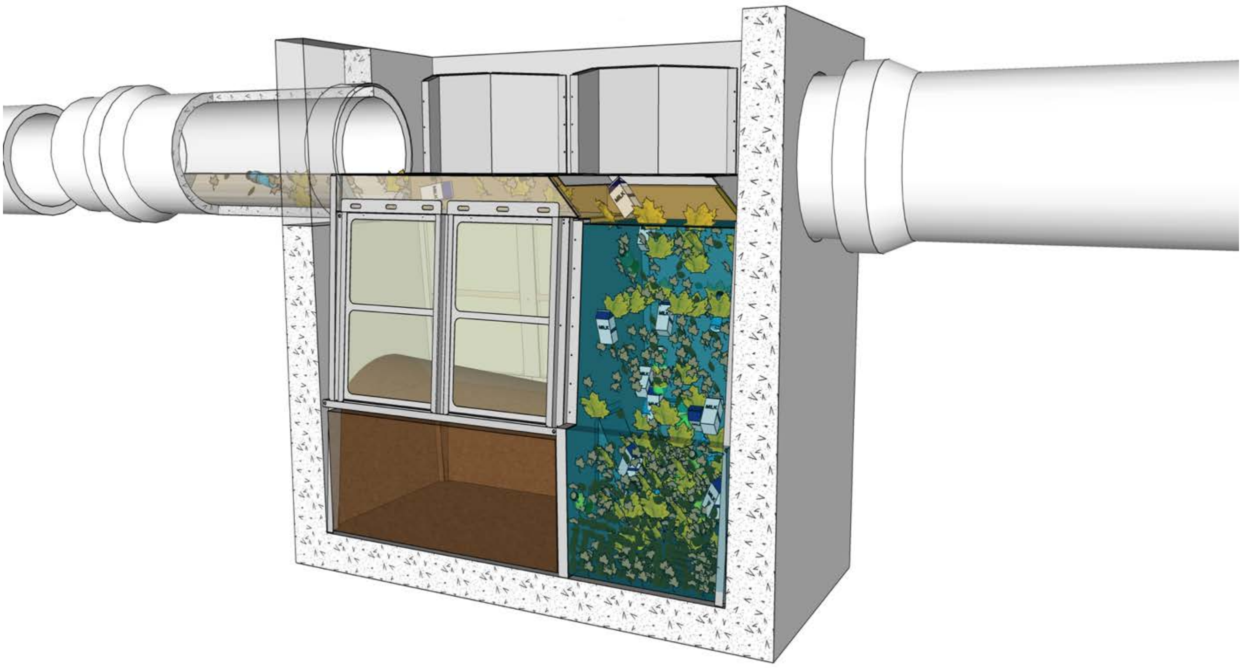

Figure 1 – Internal structure of the Enviro EPS system (Image courtesy of Enviro Australis)

The AFMG subsequently witnessed a water quality improvement test on an Enviro EPS unit at a specified flow rate (16 L/sec) using a synthetic stormwater produced by Enviro Australis based on organic matter and sediment collected form an urban catchment surface.

1.2 Objectives

The key aim of the Enviro EPS performance testing witnessed by the AFMG was to examine the water quality improvement performance of the system for the following pollutants:

a. Total suspended solids (TSS)

b. Total phosphorous (TP) and total dissolved phosphorous (TDP)
c. Total nitrogen (TN) and dissolved total nitrogen (TDN)

2 Methodology

All testing of the Enviro EPS was conducted on an Enviro EPS treatment, Model E45. The unit was installed in a test rig located at one of the Enviro EPS manufacturing facilities (Civilmart Adelaide, Edinburgh North, South Australia). The device had the manufacturer specifications provided in Table 1. In the absence of any laboratory testing protocol for stormwater treatment devices at the current time, a test method was proposed by Enviro Australis. The test method was carried out by Enviro Australis and was witnessed by a UniSA AFMG representative (Dr Baden Myers), who also undertook water sample collection, processing and delivery to a NATA accredited laboratory for analysis. The methodology for the water quality improvement performance of the device is provided in Section 2.1.

Table 1 - Manufacturer and test specifications of the Enviro EPS Model E45

Description	Manufacturer data
Treatment flow rate (L/s)	66 L/sec
Maximum flow rate (L/s)	362 L/sec
Capacity (L), chamber volume	2,000 L
Height (mm) differential in vs out	25mm
Inlet diameter (mm)	450mm
Outlet diameter	450mm

2.1 Water Quality Improvement Testing

The performance of the Enviro EPS was tested in accordance with a procedure developed by Enviro Australis. The performance test was conducted by pumping potable water into the unit at half the treatment flow rate in addition to a concentrated pollutant mixture. The nature of the concentrated pollutant mixture is described in Section 2.1.1. The device was then subjected to inflow spiked with the concentrated pollutant mixture in accordance with the procedure in Section 2.1.2. During this flow testing with polluted water, samples were analysed from the inlet and outlet of the device to determine:

- The concentration of total suspended solids (TSS)
- The concentration of total phosphorous (TP) and total dissolved phosphorous (TDP)
- The concentration of total nitrogen (TN) and total dissolved nitrogen (TDN)

Analysis for TSS, TP and TN were delivered to a NATA accredited laboratory for analysis (ALS Laboratories, Adelaide). Underlying methodology and results for this analysis are reported in full in Appendix A.

2.1.1 Concentrated pollutant mixture

The synthetic pollutant mixture used during testing is acknowledged to be a difficult component of laboratory based full scale stormwater treatment device testing (Modra and Drapper, 2010). It is a difficult aspect of testing because stormwater is highly variable and the adoption of different soil types and characteristics to represent stormwater particles can influence test results, as can the selection of how to incorporate appropriate TP and TN levels. There is no 'off the shelf' product available to simulate stormwater particles, nor is there a standard which specifies what should be used to represent stormwater particles or nutrients like TN and TP in their particulate and dissolved forms. For the testing of the Enviro

EPS, synthetic stormwater was produced by dosing a flow of potable water with a concentrated pollutant mixture during the test procedure.

The preparation of the concentrated pollutant mixture in this testing was not witnessed by UniSA AFMG due to the time involved for collection and storage. However, samples were visually inspected and samples collected immediately prior to testing for laboratory analysis.

According to Enviro Australis, the sediment and nutrient collection phase proceeded as follows:

1. A concentrated pollutant mixture was collected comprising of leaf litter (approx. 25% by volume), grass clippings (approx. 25% by volume) and soil with potting mix (approx. 50% by volume) from an urban catchment area to represent material that runoff may transport from a catchment to a treatment device. Decomposing animal matter was excluded from this mixture due to health risks in a controlled test environment.
2. Immediately after collection and blending the material was wetted so that a wet weight could be measured.
3. An equivalent mass of water was then added, creating a 50% ratio of sediment/nutrient mix to water.
4. The NTM and water composite was exposed to ambient outdoor temperatures inside a lightly sealed plastic container for a period of seven days at the Enviro Australis office in Angaston, South Australia. This was to allow for nutrient release from organic matter to occur, to replicate typical field conditions.

2.1.2 Performance testing of the Enviro EPS

After preparing the sediment and nutrient mixture, the Enviro EPS performance was examined in a laboratory setting using a full-scale Enviro EPS exposed to inflow spiked with the concentrated pollutant mixture. All testing was conducted at the premises of the Civilmart Adelaide, Edinburgh North, South Australia and was witnessed by UniSA AFMG. In addition to witnessing the test, UniSA AFMG collected inflow and outflow samples and conducted sample processing. The procedure took place on a test layout at Civilmart Adelaide, which is conceptually represented in Figure 2.

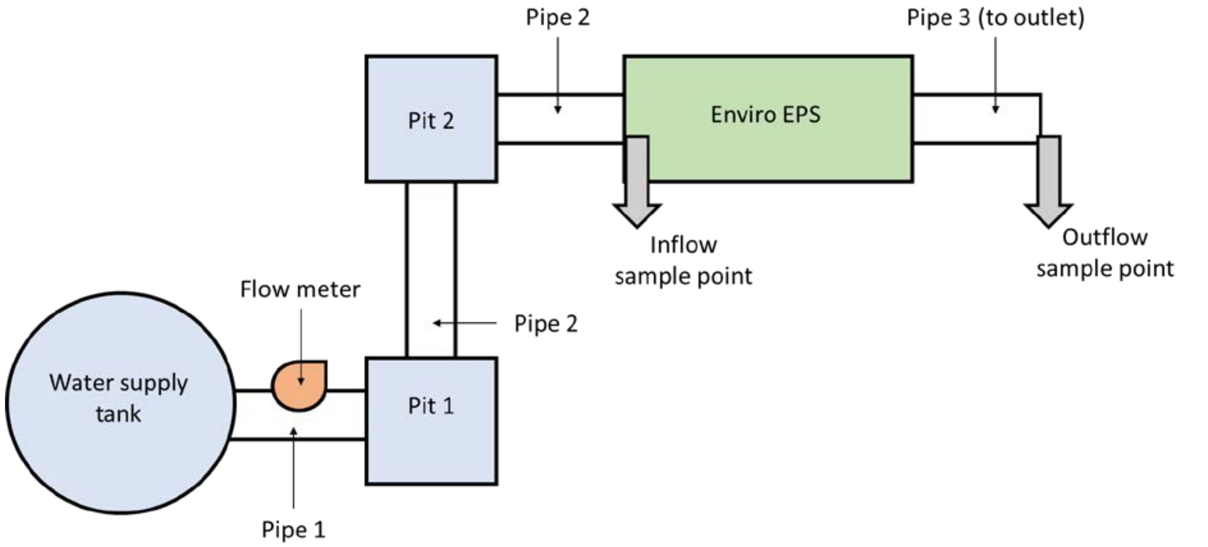

Figure 2 – Conceptual layout of the stormwater treatment device performance test rig at Civilmart Adelaide, Edinburgh North, South Australia (not to scale)

The procedure for this testing was as follows:

1. A quantity of the sediment and nutrient mix was placed into four plastic bags, each containing one kilogram of material.
2. A sample of the sediment and nutrient material was also sampled into a soil sample jar for analysis of TP and TN.
3. The test flow rate (16 L/s) was established and left for a period of two minutes to ensure it was stable.
4. After the two-minute stabilization period, two functions occurred simultaneously:
    a. Start a timer and
    b. Gradually add the sediment and nutrient mix to Pit 1, such that one kilogram was added every 60 seconds
5. Water sampling proceeded during the test as follows[1]:
    a. A sample was collected at the inflow point – first at one minute and again at 3 minutes.
    b. A sample was collected at the outflow point at 2 minutes, and then 4 minutes.
    c. Sample collection at inflow and outflow was in a bulk composite container and processed immediately after testing as follows:
        i. Subsamples were placed directly into bottles for TSS analysis
        ii. Subsamples were placed directly into bottles containing preservative (nitric acid) for TP and TN analysis
        iii. Subsamples were filtered through 0.45 µm filters and placed directly into bottles containing preservative (nitric acid) for TP (dissolved) and TN (dissolved) analysis

[1] The time for flow to travel from the Pit 1 through the pipework (via Pit 2) to arrive at the Enviro EPS inflow sample point was estimated to be one minute based on previous testing by Enviro Australis. The residence time of flow through the Enviro EPS was also estimated to be one minute based on previous testing by Enviro Australis.

6. Samples were chilled and immediately delivered to a NATA accredited laboratory to determine TSS, TN and TP by a representative of UniSA AFMG (Dr Baden Myers).

3 Results

3.1 Water Quality Improvement Testing

Water quality improvement testing was undertaken on Thursday 16 January 2020. The water quality improvement of the device is presented for TSS, TP, TDP, TN and TDN.

3.1.1 Total Suspended Solids

The inflow and outflow results for TSS are shown in Table 2. The results indicate that sediment was removed from the inflow water. The average inflow concentration was 243 mg/L and the average outflow concentration was 14.5 mg/L. The overall concentration of TSS in the outflow was reduced by 94%. Figure 3 also shows a photograph of samples from the inlet and outlet during testing, indicating that water quality improvement of the Enviro EPS system was visually apparent.

Table 2 - Concentration of TSS in inflow and outflow samples from the Enviro EPS

	Sample 1 (mg/L)	Sample 2 (mg/L)	Mean (mg/L)
Inflow	362	124	243
Outflow	7	22	14.5

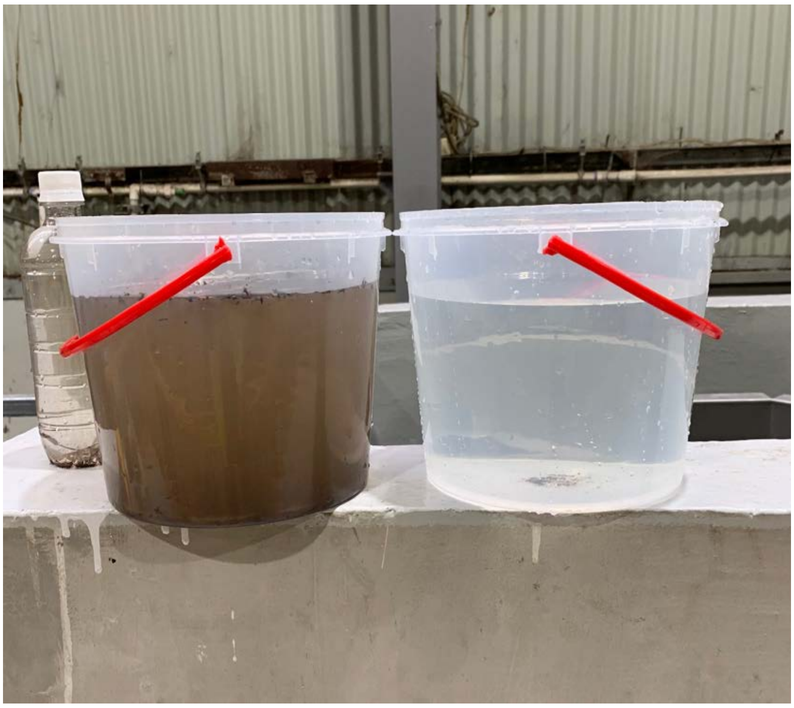

Figure 3 – shows an inflow and outflow sample from the Enviro EPS for visual comparison

3.1.2 Total Phosphorous

The inflow and outflow results for TP are shown in Table 3. The results indicate that total phosphorous was removed from the inflow water. The average inflow concentration was 0.365 mg/L and the average outflow concentration was < 0.01 mg/L. The overall concentration of TP in the outflow was reduced by more than 97%. However, it should be noted that almost all of the phosphorous in water samples at the inlet and outlet of the Enviro EPS was in particulate form, as evidenced by the concentrations of dissolved phosphorous (at or near the adopted detection limits for the water quality laboratory, 0.01 mg/L).

Table 3 - Concentration of TP in inflow and outflow samples from the Enviro EPS

	Sample 1 (mg/L)	Sample 2 (mg/L)	Mean (mg/L)
TP			
Inflow	0.62	0.11	0.365
Outflow	0.01	0.01	0.01
TDP			
Inflow	0.03	<0.01	~0.02
Outflow	<0.01	<0.01	~0.01

3.1.3 Total Nitrogen

The inflow and outflow results for TN are shown in Table 4. The results indicate that TN was removed from the inflow water. The average inflow concentration was 3.15 mg/L and the average outflow concentration was 0.45 mg/L, representing a reduction of 85%. In the case of nitrogen, dissolved nitrogen was also lower at the outlet, however in the absence of a specific mechanism of removal the means of a dissolved nitrogen (TDN) reduction should be treated with caution. The results also show little influence of the device on oxidised nitrogen (NOx) and as such the performance will be dependent on the relative magnitude of NOx in source waters. For the nitrogen present in samples, almost all of it was soured from organic sources, which is typical of the sources adopted during this performance test (i.e. organic litter and soil).

Table 4 - Concentration of TN and constituents of TN in inflow and outflow samples from the Enviro EPS

	Sample 1 (mg/L)	Sample 2 (mg/L)	Mean (mg/L)	Sample 1 (mg/L)	Sample 2 (mg/L)	Mean (mg/L)
TN				**TDN**		
Inflow	4.70	1.60	3.15	0.60	0.40	0.50
Outflow	0.40	0.50	0.45	0.20	0.10	0.15
Oxidised nitrogen, NOx (Nitrite, NO_2 + Nitrate, NO_3) (All)				**NOx (Dissolved)**		
Inflow	0.13	0.14	0.13	0.15	0.13	0.14
Outflow	0.14	0.18	0.16	0.14	0.13	0.13
Total Kjeldahl Nitrogen, TKN (Organic N + Ammonia + Ammonium)				**TKN (Dissolved)**		
Inflow	4.6	1.5	3.05	0.5	0.3	0.4
Outflow	0.3	0.3	0.3	0.1	0.1	0.1

Reviews of stormwater quality indicate that nitrogen is typically present in a dissolved form in stormwater due to the presence of oxygen in overland flow (Duncan, 1999, Duncan, 2005) however this finding has also been challenged in other literature (Lucke et al., 2018). As a conservative measure, any claim regarding the removal of nitrogen by a stormwater treatment device should be made and received with caution, and if possible with source catchment data (although this is seldom available). We note that similar products tend to have lower levels for TN treatment for the purposes of MUSIC modelling, as follows:

- Ecosol recommend 45% for the Ecosol GPT
- Humes recommend 30% TN removal for the Humeceptor
- Rocla recommend between 0 and 79% removal for their product range

4 Discussion and Recommendations

1. The AFMG recommend that while the results of this testing are appropriate for the adopted test method, the results should not be used to compare the performance for other systems due to the varying test methods adopted. For example, the treatment performance reported in this report is based on an inflow dominated by organic nitrogen in particulate form – comparison of the device with one which has had a higher or lower proportion of oxidised nitrogen included in the test method is not appropriate. It is also noted that the particle size distribution of the solid material adopted during testing is unknown, and may or may not be representative of that in Australian catchments as reported and used by software commonly applied for performance assessment, the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) (eWater, 2014).
2. Based on conversations with Enviro Australis, it is apparent that Enviro Australis is aware of developments regarding the Stormwater Australia Stormwater Quality Improvement Device testing protocol (Stormwater Australia, 2018) and are aware of the substantial reliance on field evaluation in this protocol. It is the view of Enviro Australis that field evaluation has limited capacity to evaluate the full scale of performance and are therefore relying on stress-testing in a laboratory setting before becoming engaged in field evaluation. It is highly recommended that Enviro Australis remain aware of developments regarding the Stormwater Australia Stormwater Quality Improvement Device protocol. It is also noted that this protocol is scheduled to also consider laboratory testing in future iterations but the timing for release is not currently available.
3. The water quality improvement testing of this project was conducted only once and below the treatment flow rate. It is probable that the performance of the Enviro EPS will be improved at flow rates lower than the treatment flow rate, and potentially lower at the highest treatment flow rate. It is recommended that field or laboratory testing be conducted at flow rates below and above the flow rate tested in this procedure, up to the maximum treatment flow rate, to acquire further information on the system performance.
4. The current guidelines for stormwater quality improvement device evaluation allows for a body of evidence as well as field testing. Historically, there has been a varying preference for test results under controlled laboratory conditions (like that documented here) or for field test results. Based on conversations with Enviro Australis, we note that they are considering how to engage in field evaluation as a supplement to controlled testing currently undertaken.
5. The testing in this report was witnessed on one system size – though testing on larger units could be considered. Though testing of varying sizes would be ideal the difficulties and costs associated with larger sized systems is acknowledged.
6. We note that testing in this report was based on a limited water quality sample size – two samples at the inlet an outlet. More confidence in the results would be achieved by increasing the test duration and the period of sampling to acquire more samples to attain average inlet and outlet concentrations. This is acknowledged by Enviro with proposals to conduct further tests.

5 References

DUNCAN, H. P. 1999. Urban stormwater quality: A statistical overview. Melbourne, Australia: Cooperative Research Centre for Catchment Hydrology.

DUNCAN, H. P. 2005. Urban stormwater pollutant characteristics. *In:* WONG, T. H. F. (ed.) *Australian runoff quality.* Canberra, ACT, Australia: Engineers Australia.

EWATER 2014. MUSIC by eWater User Manual. Canberra, ACT, Australia: eWater.

LUCKE, T., DRAPPER, D. & HORNBUCKLE, A. 2018. Urban stormwater characterisation and nitrogen composition from lot-scale catchments — New management implications. *Science of The Total Environment,* 619-620**,** 65-71.

MODRA, B. & DRAPPER, D. 2010. Environmental technology verification testing for stormwater quality improvement measures in Australia. *Stormwater 2010.* Sydney, Australia.

STORMWATER AUSTRALIA 2018. Stormwater Quality Improvement Device Evaluation Protocol - Version 1.2. Stormwater Australia.

Appendix A – TSS, TP and TN Results

The certificate of analysis for the analysis of TSS, TP and TN for inflow and outflow sample analysis conducted by ALS Laboratories is presented on the following pages.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM2000738**	Page	: 1 of 5
Client	: **Enviro Australis Pty Ltd**	Laboratory	: Environmental Division Melbourne
Contact	: Baden Myers	Contact	: Customer Services EM
Address	: PO Box 34 Angaston 5353	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: ----	Telephone	: +61-3-8549 9600
Project	: AFMG A2001003	Date Samples Received	: 17-Jan-2020 10:55
Order number	: ----	Date Analysis Commenced	: 21-Jan-2020
C-O-C number	: ----	Issue Date	: 24-Jan-2020 14:33
Sampler	: Baden Myers		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 9		
No. of samples analysed	: 9		

NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC

RIGHT SOLUTIONS | RIGHT PARTNER

Page	: 2 of 5
Work Order	: EM2000738
Client	: Enviro Australis Pty Ltd
Project	: AFMG A2001003

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

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Work Order : EM2000738
Client : Enviro Australis Pty Ltd
Project : AFMG A2001003

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	EA-IN-Soil	----	----	----	----
			Client sampling date / time	16-Jan-2020 10:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EM2000738-009	--------	--------	--------	--------
				Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	70.3	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	5390	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	5390	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	1030	----	----	----	----

Page	: 4 of 5
Work Order	: EM2000738
Client	: Enviro Australis Pty Ltd
Project	: AFMG A2001003

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	EA-IN-01-NF	EA-IN-02-NF	EA-OUT-01-NF	EA-OUT-02-NF	EA-IN-01-F
			Client sampling date / time	16-Jan-2020 10:30	16-Jan-2020 10:30	16-Jan-2020 10:30	16-Jan-2020 10:30	16-Jan-2020 10:30
Compound	CAS Number	LOR	Unit	EM2000738-001	EM2000738-002	EM2000738-003	EM2000738-004	EM2000738-005
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	362	124	7	22	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	0.13	0.14	0.14	0.18	0.15
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	4.6	1.5	0.3	0.3	0.5
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	4.7	1.6	0.4	0.5	0.6
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.62	0.11	<0.01	<0.01	0.03

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Work Order : EM2000738
Client : Enviro Australis Pty Ltd
Project : AFMG A2001003

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	EA-IN-02-F	EA-OUT-01-F	EA-OUT-02-F	----	----
			Client sampling date / time	16-Jan-2020 10:30	16-Jan-2020 10:30	16-Jan-2020 10:30	----	----
Compound	CAS Number	LOR	Unit	EM2000738-006	EM2000738-007	EM2000738-008	--------	--------
				Result	Result	Result	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	0.13	0.14	0.13	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.3	0.1	<0.1	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	0.4	0.2	0.1	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	<0.01	----	----