INNOVATIVE TREATMENT SYSTEM TRIAL ON INDUSTRIAL SITE

Dr Sean Finnigan (Fraser Thomas Ltd, 21 El Kobar Drive, East Tamaki, Auckland 2013)

ABSTRACT

The Pikes Point Refuse Transfer Station has a Resource Consent to authorize the discharge of contaminants onto or into land from an industrial and trade process (Refuse Transfer Station). This consent requires a stormwater treatment device to be installed to treat the transfer station forecourt area.

Following discussions with Auckland Council and a detailed evaluation of alternative treatment systems, PPTS decided to install a treatment device called "Drainfix Clean", which comprises a "treatment drain" partially filled with a proprietary treatment media providing both treatment and conveyance of stormwater. This technology was considered to be the best practical treatment option for the site, as it requires minimum space and shallow construction, can be retrofitted along the alignment of an existing drainage channel, and can achieve the desired treatment performance, including for dissolved heavy metals, based on overseas data from Drainfix installations, provided by the supplier.

Given this is new technology to New Zealand, PPTS decided to implement a treatment trial to test the performance, operation and maintenance requirements of this device before committing to larger scale implementation. Monitoring requirements were discussed and agreed with Auckland Council. This trial has recently been completed.

This paper provides an overview of the proposed treatment drain technology, a description of the trial, associated testing regime and trial results, and comments on potential applications of this new technology in New Zealand.

KEYWORDS

Industrial trade process stormwater treatment; media treatment drain

PRESENTER PROFILE

Dr Sean Finnigan is a senior environmental engineer with over 20 years experience and specialist stormwater expertise. He has been involved in over 130 stormwater projects, including integrated catchment management planning; design and consenting for residential and rural-residential subdivisions and commercial/industrial developments in the North Island and Canterbury.

1 INTRODUCTION

Pikes Point Transfer Station Limited (PPTL) manages the Pikes Point Refuse Transfer Station. Envirowaste Services Limited currently operates the Transfer Station on their behalf.

The Transfer Station is located at 81 Captain Springs Rd, Onehunga. The transfer station was operated under RMA existing use rights until 2007, when PPTL obtained a Resource Consent (32925) to authorize the discharge of contaminants onto or into land from an industrial and trade process (Refuse Transfer Station) (ITP consent) under rules contained within the then Proposed Auckland Regional Plan: Air, Land and Water (ALWP, June 2005). This consent is valid until 31 December 2027. The ITP consent required a rain garden treatment device to be installed to treat stormwater from the highest priority activity area, A1, which is subject to the most vehicle movements and closest to the transfer station building waste unloading area. The transfer station building, vehicle movement patterns and activity area, A1, are shown on Figure 1.

Figure 1: Transfer station showing waste processing building, vehicle circulation pattern and highest priority activity area, A1.

However, following discussions with Auckland Council and a detailed evaluation of alternative treatment systems by Fraser Thomas, PPTL proposed to Auckland Council to instead install a treatment device called "Drainfix Clean", which comprises a "treatment drain" partially filled with a proprietary treatment media providing both treatment and conveyance of stormwater. This technology was considered to be the best practical treatment option for the site, as it required minimum space and shallow construction, could be retrofitted along the alignment of an existing drainage channel, and could achieve the desired treatment performance, including for removal of dissolved heavy metals, based on overseas data from Drainfix installations, provided by the supplier.

Given this is new technology to New Zealand, PPTL decided to install a trial system to test the performance, operation and maintenance requirements of this device before committing to larger scale implementation. Details of the proposed trial were discussed and agreed with Auckland Council, including the provision of a Stormwater Monitoring Plan to Council for approval addressing the following matters:

- Trial description
- Proposed testing regime
- Construction site management plan
- Trial Communication procedures
- Contingency plan

This was done and the trial and plan were approved by Council.

The trial also involved installation of a new stormwater drainage pipe in parallel to the treatment drain to alleviate an existing stormwater ponding problem on the site.

2 INVESTIGATIONS AND CONSENTING

2.1 INVESTIGATIONS

Historical data confirmed that the proposed treatment system and new stormwater pipe were located within the footprint of the historic Pikes Point West landfill.

The trial involved relatively shallow excavations over an area approximately 30m long, by 0.6m wide and up to a depth of 1.3m for the new stormwater pipe. The soil disturbance of the site was around 26m^3, with about 6m^3 soil backfilled in the trench and approximately 20m^3 removed off site.

Field investigations were undertaken to:

- Determine the depth to landfill cap and refuse in the vicinity of the trial area, due to the trial area being located within the historical landfill footprint.
- Check for the presence of underground services within the trial area.
- Log the soil geology in the vicinity of the trial area.
- Test soil samples from in the vicinity of the excavation area for the presence of contamination.

Geotechnical investigation by Fraser Thomas found material inferred to be topsoil/fill at a depth of approximately 0.2-0.3m below the existing ground, underlain by tightly packed hardfill to variable depths of 1.1-1.9m. Material inferred to be landfill refuse made of wood, metal and plastic pieces with a strong organic odour was encountered below that. No groundwater was encountered.

The results of this geotechnical investigation confirmed the trial area was located within the area of the historic landfill, as expected. As the trial depth involved up to 1.3m of excavation depth, it was considered likely that refuse material would be encountered during trial installation, particularly in the vicinity of the existing catchpit CP2/8, and that the trial excavations would penetrate the tightly packed hardfill landfill cap, in order to install the new stormwater drainage pipe under the treatment drain in this localized area.

Soil sampling confirmed that the subsoils to be excavated for drain construction could be disposed of as cleanfill.

2.2 CONSENTS

The historic landfilling activity and the proposed works triggered the need for resource consents under both district and regional plans, including NES requirements, with the overall consent status being **discretionary**. Resource consents were applied for and granted by Auckland Council, along with corresponding building consents.

The AEE considered the potential effects of the proposed works on the environment in relation to relevant matters. It included assessing potential landfill gas issues. Previous investigations by others in 2006 (2 monitoring rounds) found non-detectible to very low levels (<0.5%) of surface methane emissions. Landfill gas emissions are expected to have decreased in the ensuing nine year period since then. Landfill gases will mainly be a potential issue during construction works. Hence, part of the Site Management Plan provided appropriate management and mitigation measures to protect human health in relation to temporary landfill gas effects during this time.

Overall, the potential effects related to short term, localised construction activities which were assessed to have less than minor effects, while there will be some long term environmental benefits resulting from the project as a result of providing treatment of stormwater runoff from activity area, A1, shown on Figure 1 to a high standard.

3 TECHNOLOGY OVERVIEW

3.1 DRAINFIX CLEAN TECHNOLOGY

The Drainfix Clean system performs a combination of collection and treatment of stormwater runoff. It comprises heavy duty "Faserfix Super" channels complete with ductile iron grates[1]. Each channel contains a carbonate rich substrate filter for runoff treatment in its lower half, the carbonate having both a low pH buffering capacity and the ability to form insoluble metal compounds with dissolved heavy metals. Pollutants such as copper, zinc, lead and hydrocarbons are trapped within this material. At the same time the upper section of the channel provides large retention capacities to deal with high water volumes. It is available in various load classes to cater for different traffic loadings.

[1] www.hauraton.com

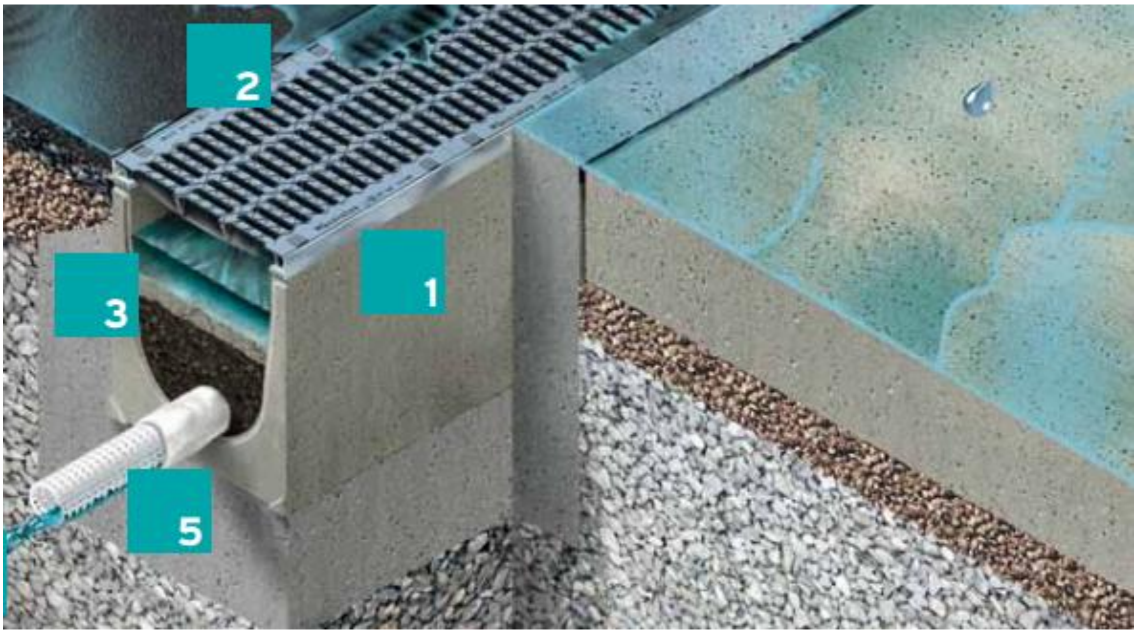


Figure 2: Drainfix Clean device. Key: 1 = drainage channel; 2 = channel grating; 3 = filter media; 5 = treated runoff drainage collection pipe (image courtesy of Hauraton)

Laboratory performance test data from the NZ supplier, Hauraton, is summarized in Table 1, demonstrating suspended solids (TSS), total petroleum hydrocarbons (TPH) and copper and zinc removals in excess of 99%.

Table 1: Drainfix Clean Laboratory Test Results

Testing Report No. 7311238-01 LGA TÜV Rheinland			
Testing criteria: Zulassungsgrundsätze des DIBt für "Niederschlagswasser-behandlungsanlagen", Draft January 2011, including SVA-resolutions 14.01.2011. The pollutant load of 10 years has been applied.			
Pollutant	**DRAINFIX CLEAN**		**DIBt**
	Degr. of Efficiency (%)	Outflow (%)	Tolerated outflow (%)
TSS	99,5	0,46	8
TPH	99,9	0,046	20
Zn	99,8	0,11	30
Cu	99,8	0,14	20

Polluatant loads / concentrations: TSS 3000 g Silica fines Millisil W4, TPH 40,8 g Diesel EL, Zinc 62500 µg$Zn_{dis/l}$ Copper 7200 µgCu_{dis}/l

➔ **DIBt-Certificate: Z-84.2-7**

LGA TÜV Rheinland, Würzburg, 23.05.2011

Additional lab testing results was provided by the supplier from 24 samples for dissolved metals removal for copper and zinc. Based on an influent zinc concentration of 62.5mg/L, the average dissolved zinc effluent concentration was 0.071mg/L (or 0.035mg/L ignoring one likely outlier), while for an influent copper concentration of 7.2mg/L, the average dissolved copper effluent concentration was 0.010mg/L, representing in excess of 99% removal of both contaminants.

Drainfix Clean has been installed in more than 100 projects since 2011, primarily in Europe (France, Austria, Romania, UK, Switzerland, Netherland and Germany). Areas of installation include loading areas at industrial sites, parking areas, residential areas, and roads with low and high traffic frequencies (7000 vehicles per day).

4 TRIAL OVERVIEW

The ITP consent required sub-catchment A1 to be treated, which comprises the transfer station forecourt and entrance/exit area. The trial treated runoff from part of this area – namely Subcatchment C4 (SubC4), while runoff from the adjacent Subcatchment C3 (SubC3) was not treated but was still tested, thus forming a "control" for the trial. These two sub-catchments are of similar area and use. They are shown in Figure 3 below.

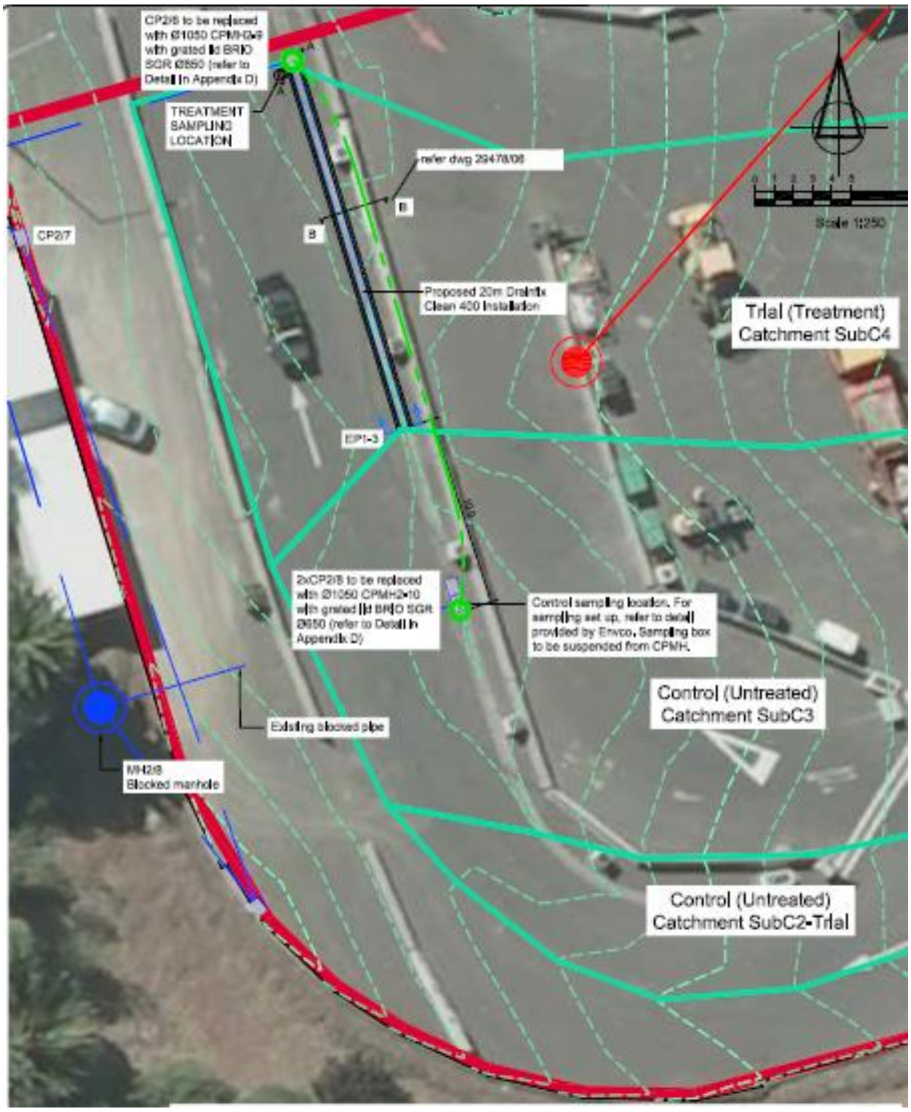


Figure 3: Trial areas, showing control (untreated catchment) and test (treated catchment); treatment drain is represented by parallel black lines.

4.1 TRIAL DETAILS

Subcatchment C4 (922m^2 area) was the test catchment. 20m of 400mm wide Drainfix was installed in this sub-catchment along the alignment of the existing open channel drain – i.e. from EP1-3 to CP2/6 as shown in Figure 3.

The Drainfix channel (Recyfix Clean or Drainfix Clean) is approximately 500mm deep and filled with proprietary Carbotec60 media to a depth of 260mm. Runoff flows into the treatment drain from the transfer station yard and flows vertically down through the treatment media and is conveyed by a 100mm dia collection pipe in the bottom of the channel to the discharge point. The drain has approximately 1.2m^3 storage capacity in its upper half above the treatment media for the temporary storage of incident runoff until it soaks through the treatment media, while the total storage capacity of the drain including the media is 2.2m^3 (110L/m drain length). The top of the new drain was recessed approximately 60mm into the ground in order to provide a flowpath for excess flow to travel directly to CP2/6.

The treated stormwater is discharged from the base of the treatment drain near CP2/6 via the lateral outlet in the Drainfix channel into a separate new sampling chamber (600mm dia x 600mm deep), which was connected to CP2/6 via a new 100mm diameter pipe fitted with a Wastop valve to prevent potential backflow in a storm event from CP2/6 into the sampling chamber and potential sample contamination. A purpose built sampling box was fitted into the sampling chamber beneath the treatment drain outlet, with a V-notch weir cut into it. Stormwater samples were extracted from here initially using a time sampler and then switching to a flow proportional sampler in later trials, while the water level was also recorded and converted to a flow rate. In a heavy rainfall event, when the temporary detention storage within the channel was full, excess untreated stormwater was discharged directly into CP2/6. Refer Figure 4 for details.

Subcatchments C3 (1084m^2 area) and C2 (231m^2 area) are the control catchments. CP2/8 is an existing double catchpit where water currently ponds due to issues with the discharge pipe from MH2/8. Before the trial started this catchpit and associated pipework were cleaned out to avoid compromising the trial results, with all sediment disposed of to an appropriate disposal facility. A new 200mm dia PE100 SDR17 pipe (30m length) was then installed from CP2/8 to CP2/6 to provide an alternative conveyance route to solve the blockage problem. The pipe connection between MH2/8 and CP2/8 was capped.

Runoff currently flows into CP2/8 from 4 directions – along a vee-shaped concrete apron drain from North and South and direct overland flow across the yard from East and West. A purpose built sampling tray with a vee-notch weir cut into it was installed under this catchpit to collect and sample dirty runoff for testing as a trial "control".

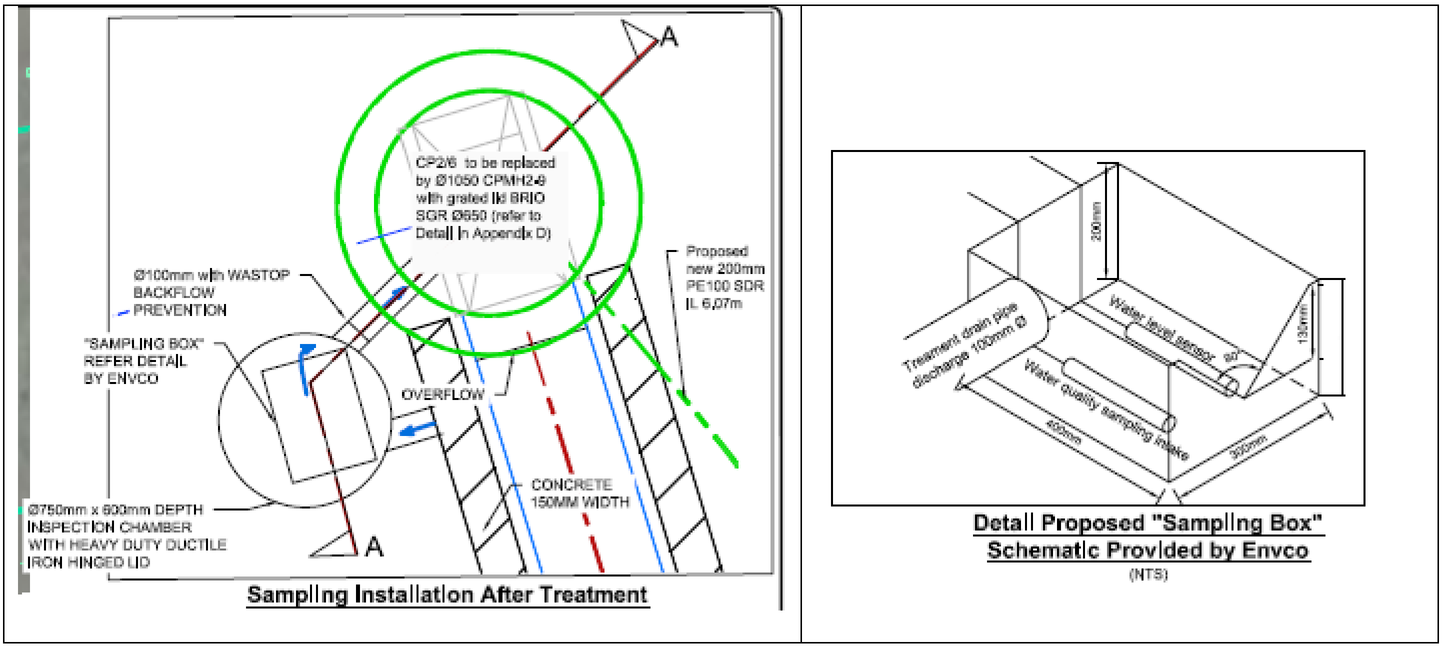


Figure 4: Sampling setup – treated stormwater from treatment drain is collected by bottom drain pipe and conveyed into "sampling box" and passes over vee-notch weir into discharge manhole.

4.2 STORMWATER TRIAL SETUP AND TESTING REGIME

Installation of the Drainfix stormwater treatment trial system at the Pikes Point Refuse Transfer Station (PPRTS) in Onehunga was completed in April 2016 and stormwater sampling took place following that until late September 2016.

The primary purpose of the trial was to verify the performance of the Drainfix device in this application in accordance with Council's criteria, which required stormwater samples to be collected for at least three first flush events, corresponding to rainfall in the range of 6-10mm, following 72hr of dry weather. The trial also tried to capture different conditions such as seasonal changes in weather and variable contaminant loads.

The trial setup is shown in Figure 4 and Photograph 1. The monitoring equipment for the trial comprised separate monitoring equipment for the trial and control catchments, comprising Aquistar pressure transducers coupled to iRIS 350FX dataloggers and ISCO 3700/6700 portable automated sampling units. The device setup is shown in Photographs 1 (a) and (b). The sampling trays upstream and downstream contained V-notch weirs which were used to set trigger levels, are shown in Photographs 1 (c) and (d).

	
(A) Upstream (control) sampling device set up with rain gauge on top of trailer.	*(B) Downstream (trial) sampling set up*
	
(C) Upstream sampling tray inside manhole	*(D) Downstream sampling tray inside sampling chamber*

Photograph 1: Sampling Setup

The monitoring equipment was installed at CP2/8, catching the untreated water from the site and in a separate new sampling chamber connected from CP2/6 via the lateral outlet catching the treated water after it runs through the Drainfix treatment device.

Samples were tested for the following parameters, as agreed with Auckland Council:

- pH
- Total suspended solids (TSS)
- Copper (dissolved and total)
- Lead (dissolved and total)
- Zinc (dissolved and total)
- Oil and grease
- Polycyclic aromatic hydrocarbons (PAHs)
- Total petroleum hydrocarbons (TPHs)
- 5-day biochemical oxygen demand (BOD_5)
- Chemical oxygen demand (COD).

All stormwater samples were collected in laboratory supplied containers suitable for the analytical parameters detailed above and refrigerated. Samples were submitted to Hills Laboratory following standard 'chain of custody' protocols. The sampling methodology was consistent across all sampling rounds and undertaken by a suitably experienced staff from Fraser Thomas.

Sample results were compared for the trial and control sub-catchments and assessed against the ANZECC marine (95% protection) guidelines, with an appropriate dilution factor of 10 for discharge to the coastal receiving environment. Essentially, control catchment runoff collected in the sampling box represents raw (untreated) stormwater, while trial catchment runoff collected in the sampling box represents treated stormwater.

4.3 RESULTS

4.3.1 MAIN CHALLENGES

The main challenges during the trial are summarized here, with key points then explained in more detail with reference to the results:

- Uncooperative weather (i.e. lack of rain and difficulty satisfying Council criteria).
- Difficulties matching timer based sample collection to 6-10mm of rain, resulting in a change to flow proportional (volume based) sampling.
- Some trial and error involved in determining appropriate sampling triggers and volumes for each sampler, with these differing between the control and treatment catchments.
- Sampling equipment malfunction on a number of occasions.
- Clogging of the treatment device following an oil spill on-site affecting the 22 June sampling event requiring a fine oily film to be removed from the media surface.
- Overall higher silt/sediment and oil/grease loads than expected, with considerable variability in these loads. Chemical oxygen demand (COD) and Biochemical oxygen demand (BOD) are also relatively high.

4.3.2 SATISFYING RAINFALL CRITERIA

The biggest trial challenge was satisfying Council's rain event criteria and ensuring similar samples were collected from the control and trial setups.

The trigger level (= flow depth (mm) over vee-notch weir) is the point at which sampling was initiated. It was set to avoid sampling starting in too small rain events.

The sampler was initially set up to sample at a fixed time interval. The trigger level was set to 110mm and the sampling frequency was set to every 3 minutes. Two sampling rounds were completed, with the sample bottles being filled after 72 minutes. This setup is effective for a heavy rainfall event and eliminated difficulties in trying to collect samples on a flow proportional basis (as described later). However, both sampled rainfall events were low intensity events, so that the sampling bottles were filled before 6mm of rain had occurred.

This was discussed with Council and they confirmed that it was necessary to have data from rainfall events in the range 6-10mm, as agreed earlier: "*This data is necessary to gauge performance under first flush scenarios. Lags in contaminant mobilisation may not be recorded in smaller events. The data from smaller events would also be useful to indicate any variations in seasonal performance or received volumes.*" For these reasons, these sampling events and their results have been included in this paper.

A switch was then made to flow proportional sampling. With this regime it was difficult to set the triggers on the upstream and downstream devices so that they both started sampling around the same time. It was also difficult to set the "volume per sample" setting so that similar numbers of samples were collected in both upstream and downstream samplers over the 6-10mm rainfall range. The filtration capacity of the downstream sampler is initially controlled by its media, but then becomes controlled by the thickness of the "filter cake" that develops on the media surface over time. After the 22 June event, the filter surface was inspected and was found to have been clogged by a gelatinous film. This layer was removed, restoring the filtration system capacity, but the extent of restoration was underestimated in setting the volume per sample setting for the next event (8 July). The volume setting was adjusted again for the 13 July trial with the best match between upstream and downstream samples being obtained. Better agreement was generally obtained in subsequent trials.

These issues are reflected in the storm event rainfall variability summarized in Table 2. Overall, three rainfall events satisfy Council's rainfall criteria well, while a number of other events approximated it. Furthermore, during all rainfall events, it was observed that the initial runoff (up to 6mm) appeared to contain a higher amount of contaminants than later in the rainfall event, based on colour. Therefore, we consider that the sampling data from the other events that do not strictly satisfy Council's criteria is suitable for inclusion in the trial.

Table 2: Storm Event Rainfall

Sampling Events	72hr dry weather pre-sampling	Rainfall Collected for Testing (mm)	
		Control (no treatment)	Trial (with treatment)
24 April 2016	Yes	1.0	1.6
6 May 2016	Yes	0.5	0.5
22 June 2016	Yes	4.6	4.3
28 June 2016	Yes	6.0	2.2
13 July 2016	Yes	7.0	7-10
24 August 2016	Yes	8.1	10.2
15 September 2016	Yes	8.3	3.6
20 September 2016	Yes	8.2	22.3*
24 September 2016	Yes	8.6	10.3

* actual rainfall likely to be less than this due to overflow bypass in action for part of rain event. Shaded cells comply with Council rainfall criteria.

4.3.3 VISUAL OBSERVATIONS

Visual observations of individual and composite samples from the trial (with treatment) and control (no treatment) setups showed clear differences in colour, with the control sample being significantly darker than the trial sample. This is shown for two storm events in Photograph 2.

8/07/16: Control Trial

14/07/16: Control Trial

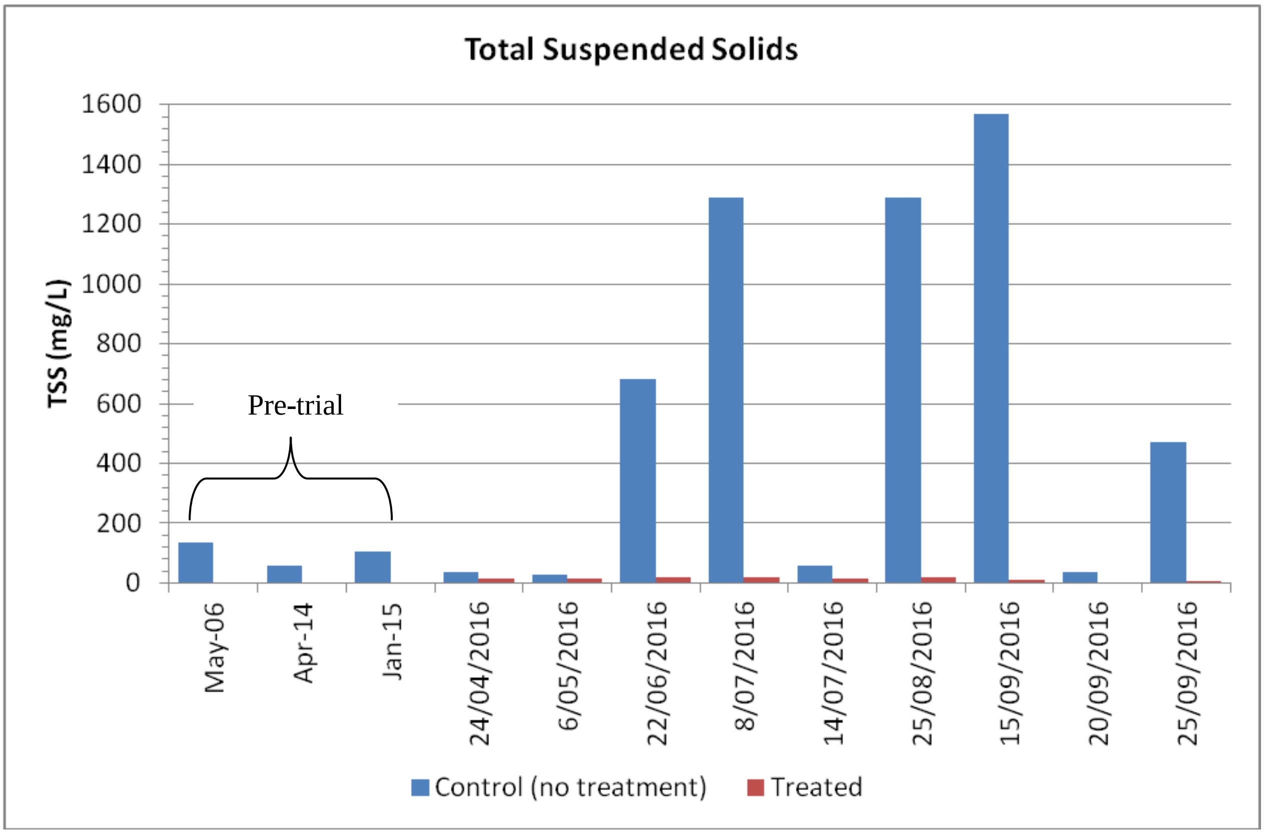
(no treatment) (with treatment)

Photograph 2: Visual Differences between Control and Trial Samples

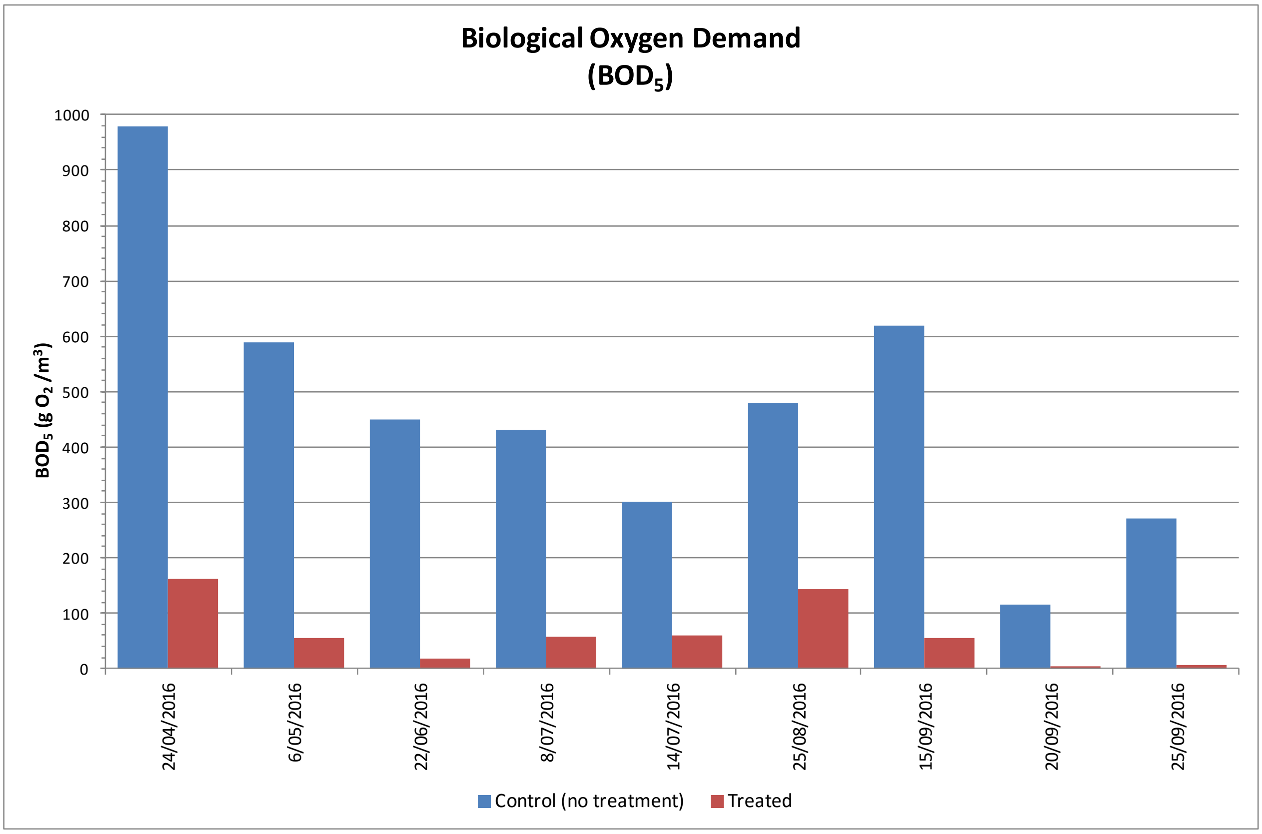
4.3.4 TREATMENT PERFORMANCE

Figure 5 shows all trial results for suspended solids, BOD and the heavy metals tested. These graphs also include three samples taken before the treatment device was installed as well as the two trial samples collected for the timer based trial, that have been included for completeness.

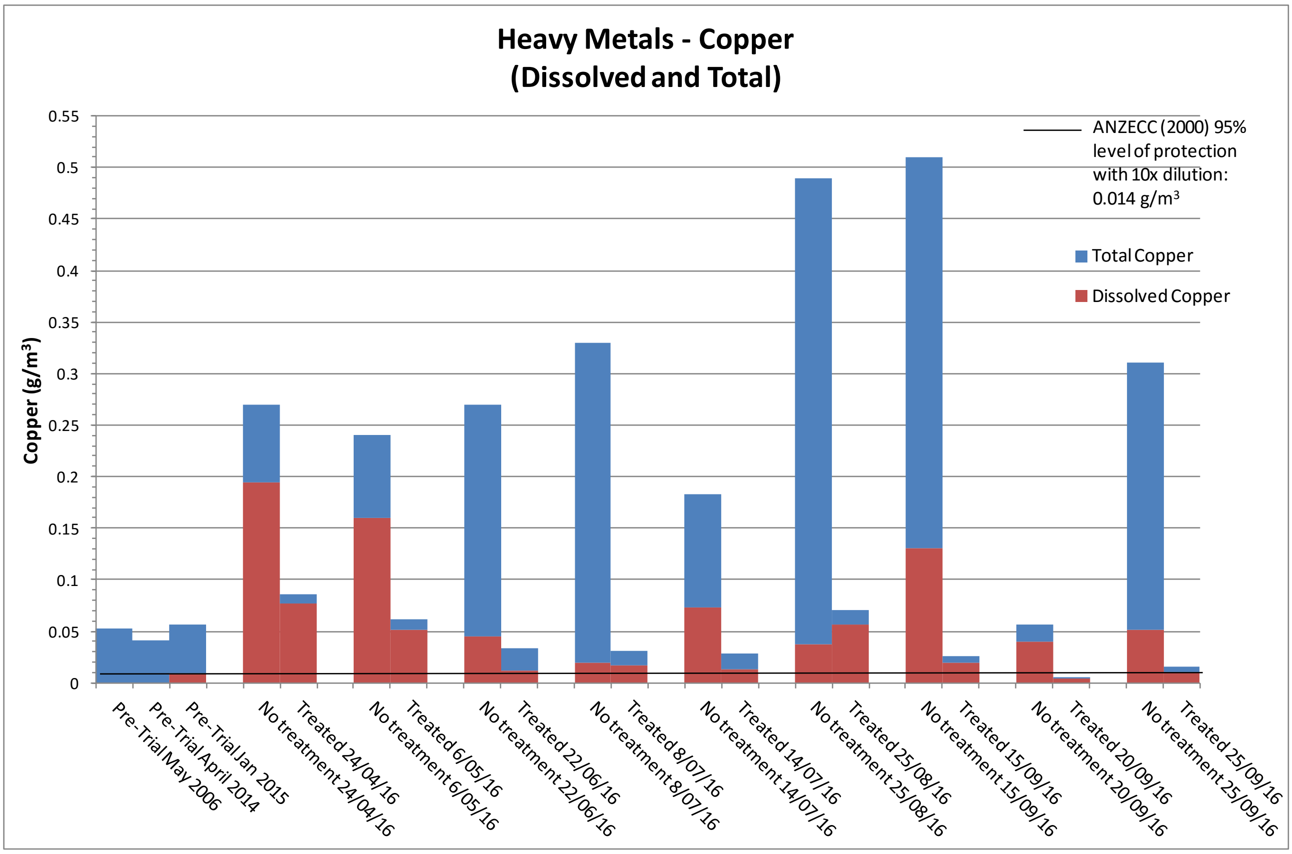
The data graphed represents control (no treatment) and trial (treated) sampling results for each sampling event and are grouped by date.



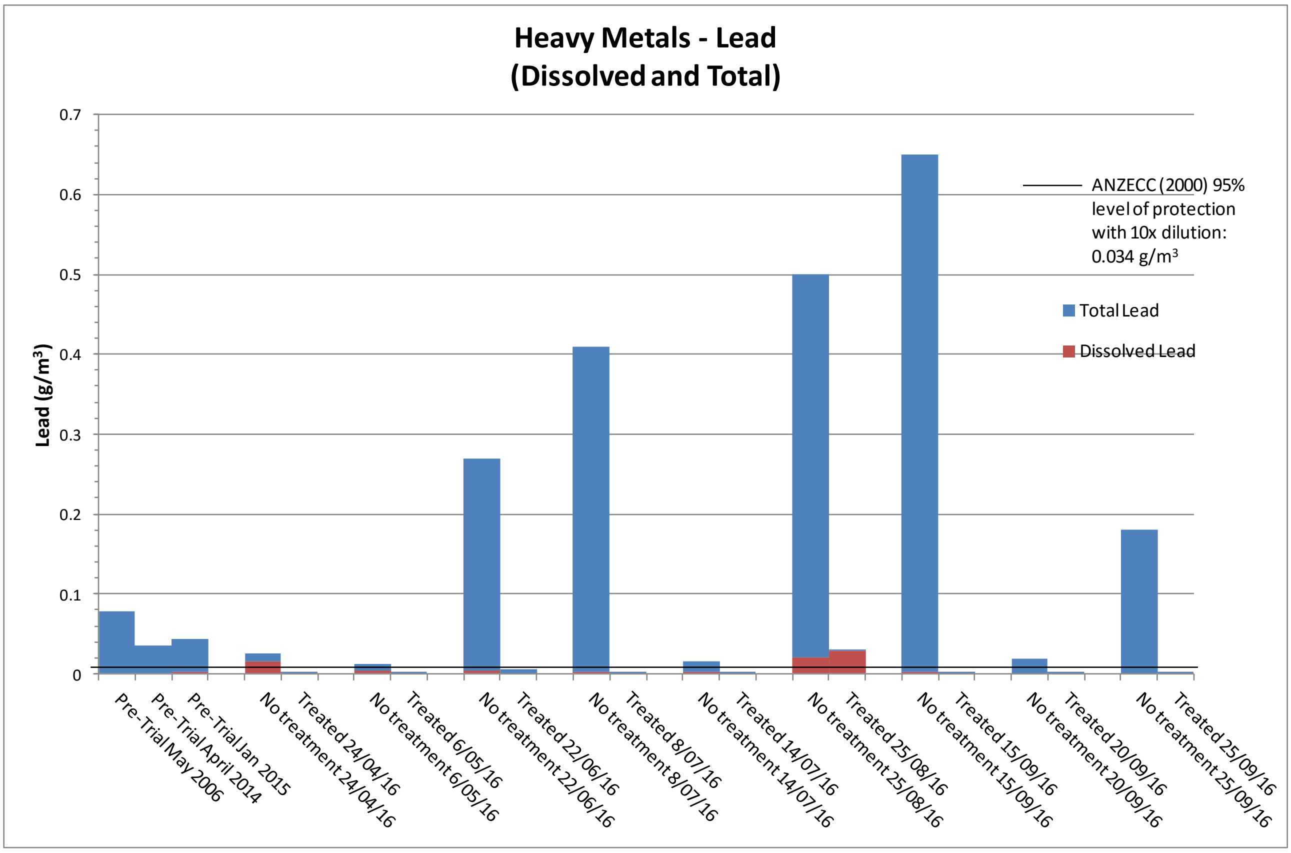
(a) Suspended Solids



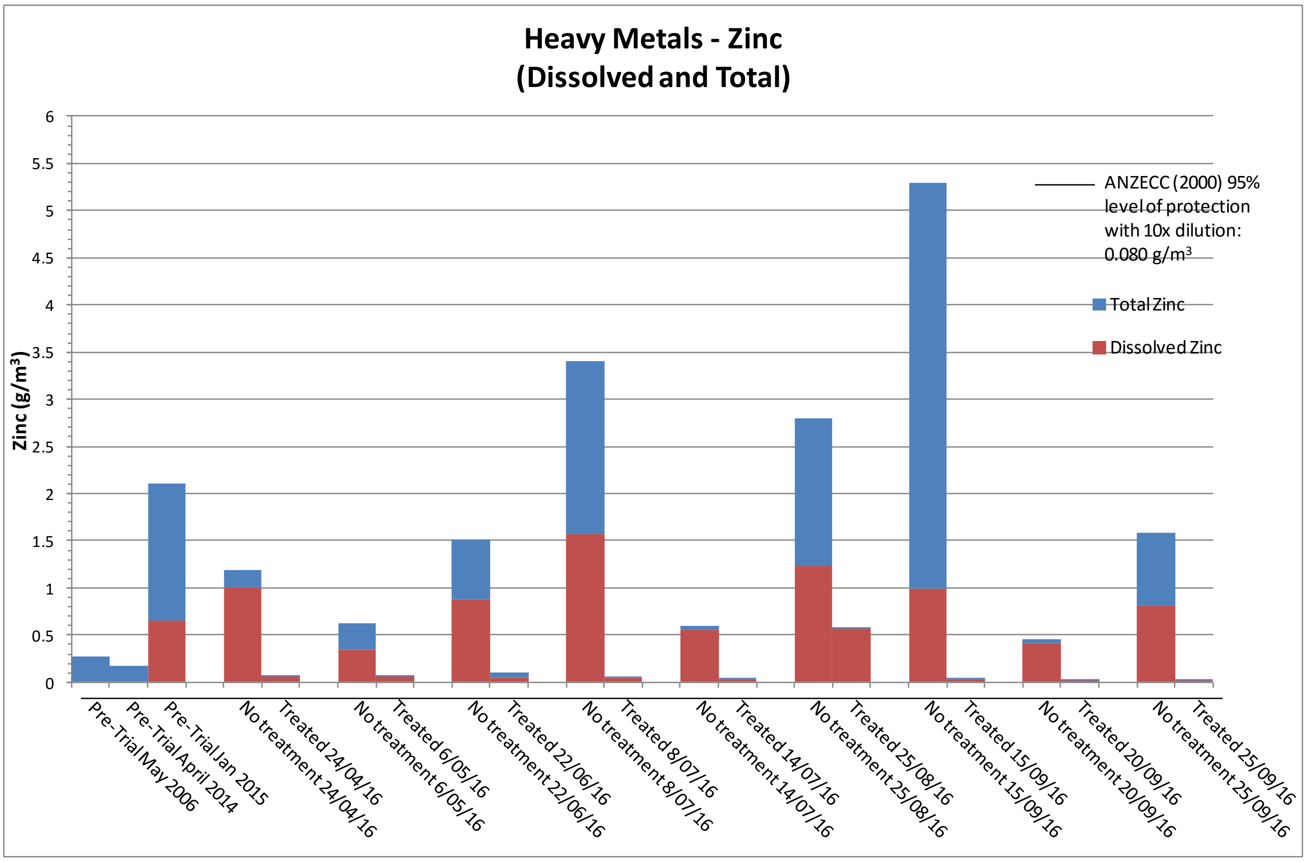
(b) Biochemical Oxygen Demand, BOD_5



(c) Copper



(d) Lead



(e) Zinc

Figure 5: Sampling Results for TSS, BOD copper, lead and zinc (from top to bottom).

These results show:

- Average total suspended solids removals of 84% were obtained, satisfying Auckland Council Technical Publication 10 requirements.
- Average dissolved and total copper removals of 58% and 74% were obtained respectively. If the 25 August anomalous result is removed, average dissolved copper removal increased to 77%. Dissolved copper levels complied with the adjusted (10x dilution factor) ANZECC 95% protection level standards for four of the nine rainfall events sampled.
- Average dissolved and total lead removals of 63% and 95% were obtained respectively. If the 25 August anomalous result is removed, average dissolved lead removal increased to 81%. Dissolved lead levels complied with the adjusted (10x dilution factor) ANZECC 95% protection level standards for all nine rainfall events sampled.
- Average dissolved and total copper zinc removals of 87% and 92% were obtained respectively. If the 25 August anomalous result is removed, average dissolved zinc removal increased to 93%. Dissolved zinc levels complied with the adjusted (10x dilution factor) ANZECC 95% protection level standards for eight of the nine rainfall events sampled.

- Average BOD and COD removals of 84% and 70% were obtained respectively.
- Dissolved organic carbon was added as a test parameter for the last four sampling rounds, with an average removal of 70% being achieved, or 86% with removal of the 25 August anomalous result.

Research, including information provided by Hauraton, suggests that the primary reason for variable copper removal results between the two tests in July is attributed to dissolved organic carbon (DOC) levels in the stormwater. Copper ions show a high affinity to organic carbon especially in DOC form, and may pass through the filter media, ligated to the DOC using it like a vehicle. There is a close correlation between copper concentrations and DOC. For this reason, DOC was added as a test parameter for this rainfall and subsequent rainfall events.

The August-September test results appear to support this. The DOC concentration measured at Pikes Point over this period averaged 170mg/L with a range of 63-310mg/L, which is relatively high. It is considered that the DOC concentrations may also lead to contaminant re-mobilisation, as is evident in the 25 August trial, where relatively minor DOC removal was achieved.

Dissolved organic carbon comes from decaying organic material (and other sources), which is present in some of the loads being brought into the site and may also derive from silt/sediment/leaves, etc. deposited on the surface of the media.

This issue was raised by Auckland Council as their main concern with the performance of the treatment device.

Another issue was that the contaminant loading was significantly higher than estimated pre-trial. The stormwater samples collected pre-trial had low TSS (suspended solids) concentrations ranging from 58-134mg/L (3 samples), indicating the refuse transfer station site had a relatively low sediment load. This was consistent with comments from Envirowaste staff during system design that the Pikes Point transfer station was a relatively clean site, compared with other refuse transfer stations, and our experience of other transfer stations.

Over the duration of the trial (8 samples), suspended solids ranged from 29-1570mg/L, including 3 readings of 1290-1570mg/L, significantly higher than previously estimated. There have also been some higher than expected oil and grease readings (range of <4 to 109mg/L).

These issues, particularly the contaminant loading, were addressed by further trialing the installation of a filter fabric (300 micron rating with tolerance of ±90 micron) secured under the treatment drain grating and above the media as a temporary measure on 14 September to try and reduce the loading on the treatment device. The three sets of results collected since then show improved metals removal results (90-99% for total metals and 66-98% for dissolved metals).

Photograph 3: Addition of filter fabric to treatment drain

Council was impressed with these latest results, particularly following installation of the temporary pre-treatment filter cloth, and agreed that sufficient sampling has been undertaken in the trial and no further sampling is necessary, provided that a permanent pre-treatment solution is put in place to mimic the behaviour of the filter fabric. Work is in progress on design of an appropriate pre-treatment system.

5 POTENTIAL APPLICATIONS

The Drainfix Clean device is designed primarily for applications involving the treatment of stormwater from surfaces exposed to traffic – e.g. carparking areas, paved yards, roads with heavy traffic. It relies on stormwater entering the device as "sheet flow" – i.e. shallow, evenly distributed flow and flowing through the treatment media to a catchpit for discharge to a downstream public stormwater network, or receiving environment.

This technology can be used on both greenfield (new) and brownfield (retrofitting) sites. It requires minimum space and shallow construction, can be retrofitted along the alignment of an existing drainage channel, and provides good removal of suspended solids, dissolved and particulate heavy metals, BOD, COD and oil/grease.

This trial indicates it also has potential for use in medium-high risk industrial trade process sites, but may need some form of pre-treatment if the contaminant load is too high, or the runoff contains significant concentrations of dissolved organic carbon.

6 CONCLUSIONS

This technology has been installed in over 100 locations primarily in Europe. It has potential for widespread application in New Zealand involving the treatment of stormwater from surfaces exposed to traffic – e.g. carparking areas, paved yards, roads with heavy traffic. It relies on stormwater entering the device as "sheet flow" – i.e. shallow, evenly distributed flow and flowing through the treatment media to a catchpit for discharge to a downstream public stormwater network, or receiving environment. It can be used on both greenfield (new) and brownfield (retrofitting) sites. It requires minimum space and shallow construction, can be retrofitted along the alignment of an existing drainage channel, and provides good removal of suspended solids, dissolved and particulate heavy metals, BOD, COD and oil/grease.

This trial has shown that the Drainfix Clean stormwater treatment device achieved significant removals of suspended solids, dissolved and particulate heavy metals, and even BOD, COD and oil/grease from stormwater runoff from a high risk industrial trade process site – i.e. refuse transfer station. In this case, pre-treatment is also being required by Council to reduce the device contaminant loading and enhance heavy metal removal.

ACKNOWLEDGEMENTS

We wish to thank PPTL for allowing Fraser Thomas to prepare and publish this conference paper and Hauraton and Hynds for their technical advice and assistance during the treatment trial.

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Note: Multiple other references were in German (and are not included here) with Hauraton providing summaries of relevant information in English; e.g.

HAHN, M.; KÖNNEMANN, T.; MANGOLD, S.; OUERFELLI, I.;PREUß, V.; SCHÖPKE, R.; SONNTAG, B. (2000): Literaturstudie zum Thema: Darstellung und Bewertung des Wissensstandes zum Schadstoffabbau und -transport in natürlichen Böden; Schriftenreihe Siedlungswasserwirtschaft und Umwelt, Bd.4; ISBN 3-934294-03-0