Operation and Maintenance of the Hydro-Jet™ Screen at 6 Sites in South Wales

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ABSTRACT

The paper outlines the initial findings of a study into the Operation and Maintenance aspects of six (6) CSOs fitted with the Hydro-Jet™ Screen in the South Wales region of the UK. This involved regular site inspections coupled with telemetry monitoring of flow levels within a number of the installations over a seven (7) months period. Maintenance reports were also obtained from the company operating the Sewer Maintenance Contract and these coupled with the photographic evidence of the operational condition of the installations were used as a basis for assessing operation and maintenance aspects of the Hydro-Jet™ Screen.

The study provided confirmation that the Hydro-Jet™ Screen is robust and operates reliably in the combined sewer environment. A number of the sites required no maintenance what-so-ever over the study period. At sites where maintenance was required, this was generally found to be associated with blockages within the sewerage system due to items such as builder's rubble. Screen panels were generally found to be relatively clear at the end of spill events with no long-term retention or build up of solid material on the screen panels observed.

Where blockages occurred on the continuation flow, the Hydro-Jet™ Screen configuration with an integral screenings return flow component was found to provide a valuable bypass facility preventing discharge to the water course during dry weather flow.

Telemetry data obtained during the study was found to be useful especially in identifying when emergency maintenance is required at a CSO installation. Telemetry may be a useful aid for the provision of a cost effective maintenance regime at CSOs.

KEYWORDS

CSO, Maintenance, Operation, Screens, Flow Control, Telemetry, Hydro-Jet™ Screen

1.0 INTRODUCTION

The Water Industry in England and Wales is faced with a major challenge in the current AMP3 period (i.e. 2000 – 2005) with 85% of the 5,500 identified unsatisfactory intermittent discharges to be improved by 2005. This challenge has resulted in the emphasis for capital investments shifting towards reducing the pollution impacts of CSOs and other intermittent wet-weather discharge sources from overloaded drainage systems, and at inlets to wastewater treatment works.

The most stringent consent standards (relating to discharges to 'high amenity' waters) calls for separation, from the effluent, of a significant quantity of persistent material and faecal/organic solids greater than 6mm (1/4 inch) in any two dimensions. It is generally recognised that the most effective way of achieving 100% compliance with these requirements especially where significant quantities of neutral buoyancy aesthetic solids are present, is with a screening system.

When the above standards were first introduced as part of the AMP2 guidelines in 1993 [1], screening systems for use within combined sewer networks were poorly developed and at best unreliable and unproven. There are currently a growing number of screening devices and arrangements being used in CSO chambers. These include static screens (with or without a cleansing mechanism), screens with a powered cleansing mechanism and self-cleansing non-powered screens.

The ability and relative efficiency of 17 proprietary devices to remove sewer solids has been reported upon after two and a half years of work at the CSO test facility constructed at Wigan [2]. This work however did not assess the robustness, reliability and long-term performance and operational aspects of these screening systems primarily because there was insufficient time to test each individual screen type over a long enough period to establish meaningful reliability data.

The Hydro-Jet™ Screen is a novel non-powered self-cleansing mesh screening system specifically developed for the control of aesthetic pollutants at CSOs and other intermittent discharge sources with the potential for retrofitting into existing unsatisfactory rectangular CSO chambers. The system evolved from the tried and tested Storm King® Overflow Hydrodynamic Separator incorporating a rotary self-cleansing screen [3]. The Hydro-Jet™ Screen was first introduced into the market towards the end of the AMP2 period and represents the only non-powered self-cleansing screening system with no moving parts and minimal headloss.

The aim of the study reported in this paper was to assess the robustness, reliability and operational and maintenance aspects of the Hydro-Jet™ Screen. In particular issues such as the susceptibility of the system to progressive build up of screening material with successive spill events and its ability to cope with screening duties within a combined sewer environment. The study also assessed the applicability and usefulness of telemetry associated with a CSO installation.

2. THE HYDRO-JET SCREEN™

2.1 Operating Principles

A schematic representation of a single-sided linear Hydro-Jet Screen™ is shown in Figure 1. During a storm event, the dry weather channel fills up, causing flows to spill over the perforated screen, just as a high-sided weir chamber would overflow.

By means of a unique cyclic hydraulic backwashing process, solid debris collected on the screen is continually concentrated and flushed out of the chamber. The key element responsible for this is the novel patented self-priming siphon.

As the spill commences, water is initially held back by the siphon, causing the level beneath the screen to rise. As the water level reaches the top edge of the screen, the siphon primes, discharging the screened effluent from the chamber. Once the water level has fallen to a point corresponding to the bottom edge of the screen, the siphon breaks, allowing water to build up again. This cyclic process continues, causing water and air to be repeatedly forced upwards through the screen, dislodging

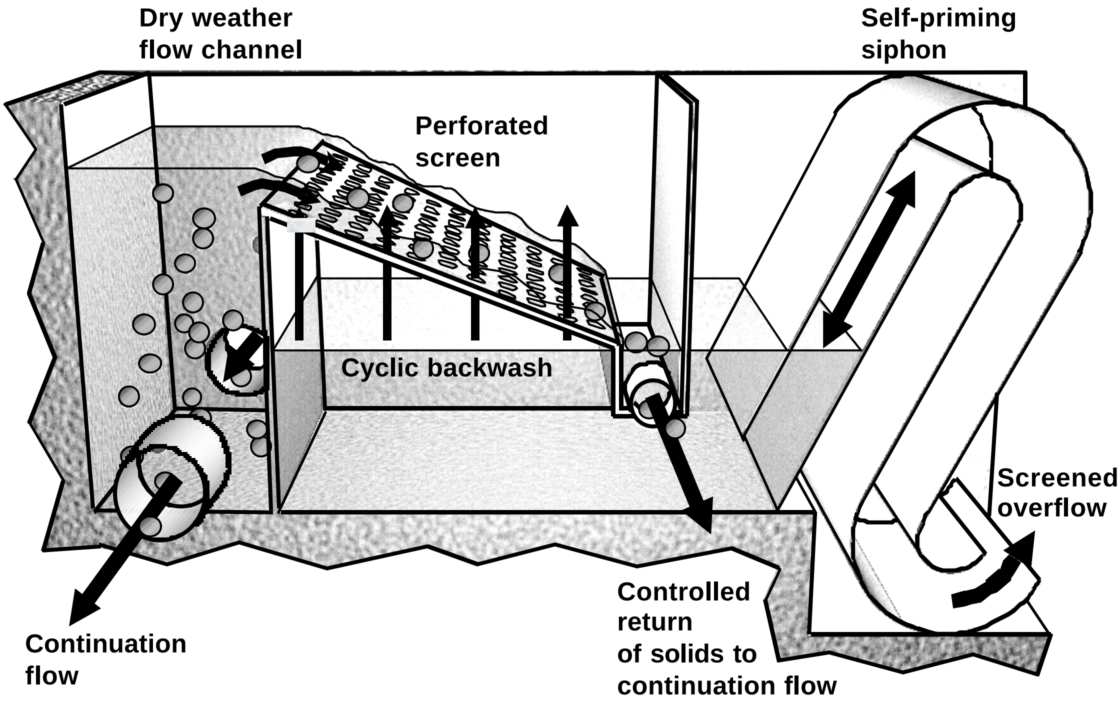

Figure 1 Schematic Representation of the Hydro-Jet Screen™

collected material. Flow of water over the surface of the screen washes the debris towards a collection trough, from which it is introduced back into the continuation flow.

2.2 Performance and Operational Issues

The Hydro-Jet Screen™ has been subject to rigorous testing, undertaken by both Hydro International, and also by independent parties [2,4,5,6]. To ensure that screened solids are efficiently flushed from the system during the drain down stage of the cycle, the system has also been optimised using CFD fluid flow simulation [7].

In addition to having no moving parts and no power requirements, the Hydro-Jet Screen™ has the following demonstrated performance attributes;

- Solids removal efficiencies are relatively high. This can be explained by the fact that solids are 'lifted', rather than 'scraped' from the screen surface. Additional removal of solids, particularly sediments, is possible via use of a rotary Hydro-Jet Screen™ combined with a hydrodynamic separator.

- The head loss through the Hydro-Jet Screen™ is minimal and steady during normal operation, since the screen is below, rather than above the level of the overflow weir. For other screen types where the screen is mounted on top of the weir, head loss becomes a direct function of the screen resistance.

- Accumulation of screened solids is minimised as screened material is re-introduced to the continuation flow via a downstream mixing chamber. On some other screening systems, collected solids are introduced directly back into the dry weather flow channel. Flow patterns within such channels have been known to cause recirculation and subsequent re-presentation of solids back to the screen.

- The screening return provides a by-pass facility in the event of a blockage occurring on the continuation flow thus preventing discharges to the watercourse during dry weather. This provides emergency relief and time for a maintenance response.

2.3 Installation Experience

Since its launch, over 50 Hydro-Jet Screens™ have been installed in the UK, with screened flow rates ranging from 15 to 2200 l/s. The first linear Hydro-Jet Screen™ was retrofitted into an existing high-sided weir in January 1999 and resolved previous problems of flooding and blinding at a CSO site that consisted of a static wedge-wire mesh screen [6]. Units have also been installed in the USA, Australia and mainland Europe, and a market has been identified in Japan, which is being actively pursued by NKK Corporation via a licensing agreement.

3.0 MONITORING OF SITES

3.1 Background and Overview

Between July 2000 and February 2001, as part of a monitoring programme, inspection visits were made on a monthly basis to 6 Hydro-Jet Screen™ installations in two adjacent catchments in South Wales, most of which were fitted with instrumentation and telemetry facilities (see Table 1). Maintenance reports from the Sewer Maintenance Contractor were also obtained to augment the visual and photographic data collected.

Table 1: Hydro-Jet™ Screen Sites

Site Number	Catchment	Weir Configuration	Max Design Flow (l/s)	Design Spill Flow (l/s)	Design Spill Frequency (per/yr)	Telemetry Installed?
1	Rhondda	Double Sided	411	320	20	Yes
2	Rhondda	Single Sided	111	57	5	No
3	Rhondda	Single Sided	239	200	(N/A)	No
4	Cynon	Double Sided	372	340	99	Yes
5	Cynon	Double Sided	157	133	69	Yes
6	Cynon	Double Sided	270	240	73	Yes

The telemetry installed at the sites was an IHS CSO monitor comprising of a downward looking intrinsically safe ultrasonic sensor installed in the CSO chamber above the dry weather flow channel. An enclosure on the surface houses the ISODAQ data logger, IS barriers, mobile phone, pager switch and supply batteries.

As none of the locations had mains power available the system was designed to run entirely off battery power. Power is kept to minimum by switching off the power to the mobile phone when it is not in use and only powering the sensors when readings are being taken (every 6 minutes). Remote communications allow remote configuration and data retrieval. Plate 1 shows a typical CSO monitor installed at one of the sites.

Plate 1. Photograph of IHS CSO monitor at one of the sites

Observations on the maintenance and operational aspects of the installations are outlined and detailed below for the sites in each of the catchments. At two sites, no maintenance was required at all over the 7 months period. Out of the 60 visits made, maintenance of the remaining systems was required on 8 occasions. However, in all cases this was directly associated with blockages of the sewerage system.

3.2 Site 1 - Rhondda Valley

This unit performed well with the screen panels being clear on all but one occasion (See Plate 2). Maintenance was required only when the 217mm diameter orifice plate flow control on the continuation sewer became blocked with a combination of a broken umbrella and rags. No discharge of unscreened sewage to the watercourse was observed at the time of inspection with dry weather flow sewage being returned to the downstream sewer via the screenings return Hydro-Brake® Flow Controls.

Plate 2. Site 1 - Rhondda Valley, 19th December 2000 showing typical state of screen after operation (emergency overflow weir and siphon visible to the rear of the picture).

3.3 Site 2 - Rhondda Valley

This unit, with a peak screening capacity of 100l/s is the smallest of the 6 monitored. The screen condition varied between 70% clear and 95% as the attached sequence of photographs illustrates. No maintenance of any sort was required during the monitoring period.

Site view

18th July 2000

10th August 2000

25th September 2000

27th October 2000

6th November 2000

13th December 2000

4th January 2001

From the frequent visual inspections it is clear that the unit is performing well and has not experienced any blinding or blockages. The pattern of debris and state of the mesh panels show that no long-term accumulation of material is occurring with debris left over being cleared by subsequent events.

3.4 Site 3 - Rhondda Valley

In common with the two other sites in the Rhondda Valley, this site has been visited 13 times over the 7-month period. No maintenance whatsoever has been carried out on the unit, which is reported to have performed well. The screen has varied between c. ~ 60% clear and 90% clear. Despite the pass-forward flow control having a 159mm aperture, there have been no reported blockages.

18th July 2000

10th August 2000

25th September 2000

27th October 2000

6th November 2000

19th December 2000

4th January 2001

3.5 Site 4 - Cynon Valley

Over 7 months of operation with site visits on a monthly basis by both the maintenance gangs and Hydro, the screen has required maintenance only on two occasions following blockages of the flow control. The cause of one of these blockages is shown in Plate 3**.** When cleared it was found to be caused by a lump of tarmac**.** A 184 mm Hydro-Brake® Flow Control was used in preference to the equivalent orifice plate which was only 115mm in diameter, due to the likelihood of the orifice plate blocking more frequently**.**

Plate 3. Showing cause of blockage to flow control (Site 4, Cynon Valley).

This blockage had resulted in flow passing over the screens and on to the continuation flow sewer via the screenings return Hydro-Brake® Flow Controls. During normal conditions this type of blockage does not result in a spill of unscreened sewage to the watercourse. This was the case during a visit on 25th September 2000 as illustrated in Plate 4.

A combination of sticks and rags had caused a partial blockage however the screens had remained at least 50% clear. This obstruction was cleared with a pole during the visit and the water level dropped back to normal dry weather flow conditions. This feature represents a significant advantage of the Hydro-Jet Screen™ over other screening screens. With other screening systems, if the main continuation flow control blocks, there is inevitably a spill to the receiving water course whereas with the Hydro-Jet Screen™ the screenings return Hydro-Brake® Flow Controls allow dry weather flow to be returned to the continuation flow preventing a continuous spill and allowing time for maintenance.

Plate 4. High level in dry weather flow channel due to partial obstruction of flow control (25th September 2000).

Plate 5. Typical view on inspection, 4th January 2001 with low flows passing through the dry weather flow channel and evidence of some debris left on screen from previous spill event.

3.6 Site 5 - Cynon Valley

The screen condition as observed during site inspections ranged from an estimated 30% to 95% clear. From the maintenance reports for the period, one of the two screenings return flow controls had been blocked by sticks and rags on one occasion however with this exception no maintenance was performed on the unit.

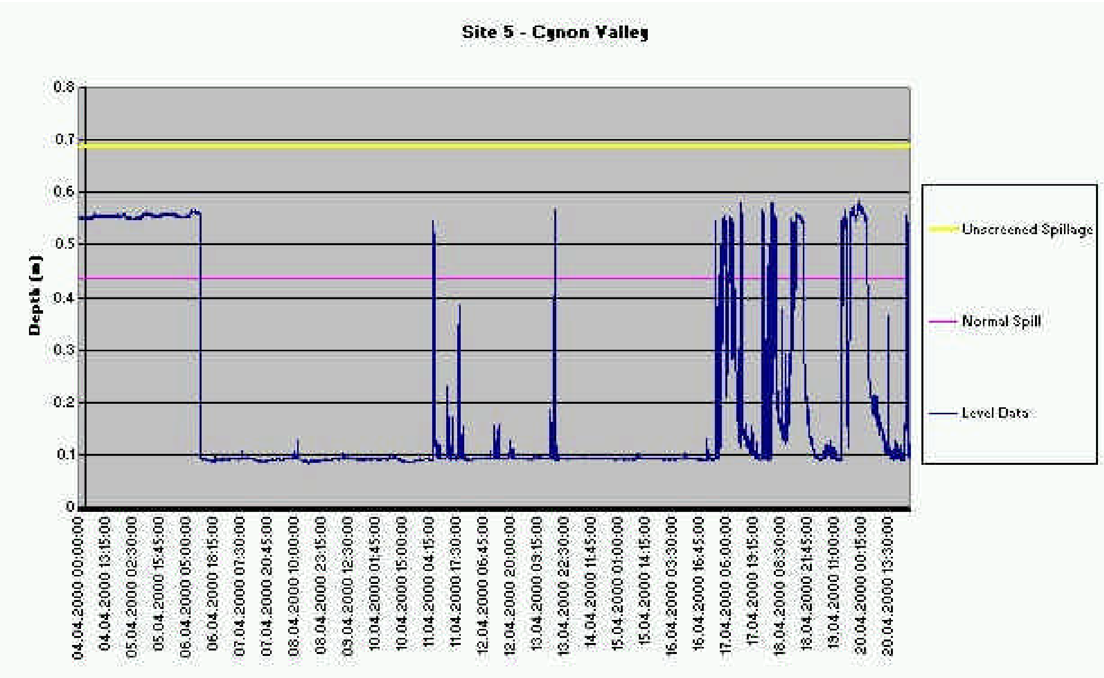

Figure 2 Telemetry Data for Site 5 in Cynon Valley

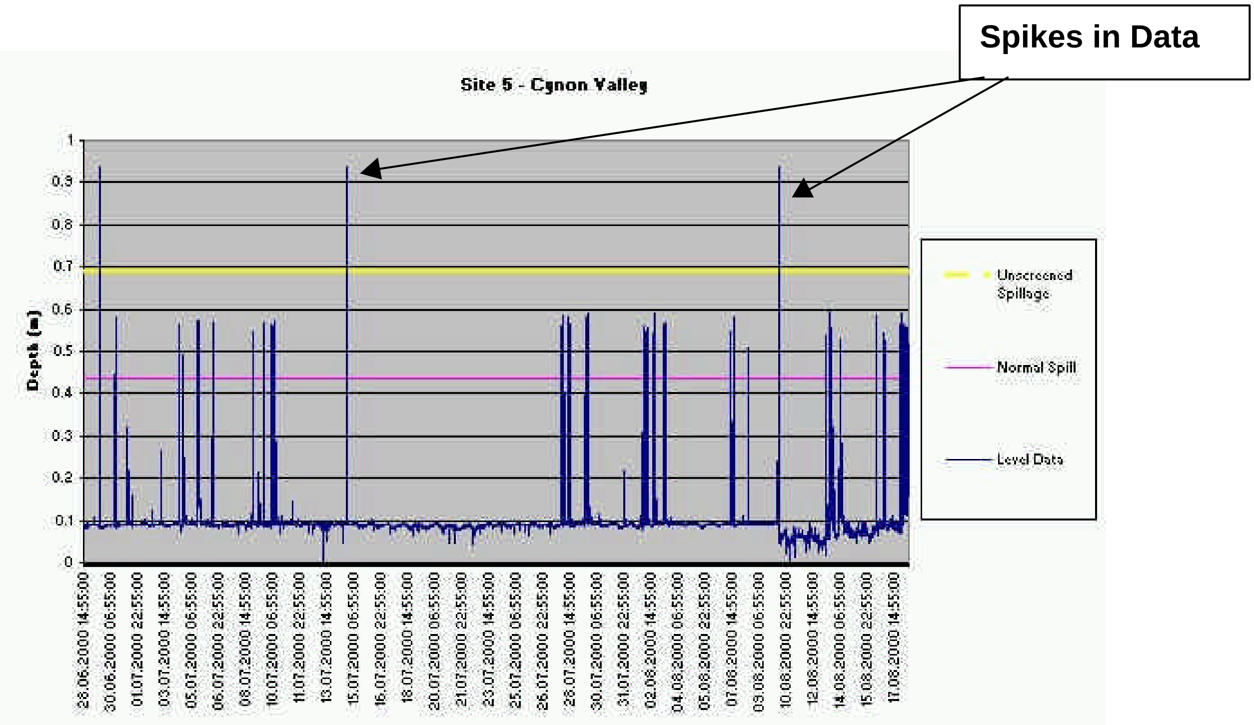

Figure 3 Telemetry Data for Site 5 in Cynon Valley showing examples of spikes in the "Raw Telemetry Data"

Examples of the initial telemetry data obtained in the raw unprocessed form are shown in Figures 2 & 3. This contains some spurious spikes (which is to be expected from raw unprocessed data) as shown in Figure 3. Data acquisition was at 5-minute intervals and water levels at a CSO installation is unlikely to rise above the emergency overflow level and fall to dry weather flow levels in a period of 5 minutes. However as can be seen in Figures 2 & 3, the output from telemetry monitoring is useful in identifying spill events in response to rainfall and ascertaining whether or not water levels have risen to the emergency overflow level over a long duration causing a sustained discharge of unscreened effluent to the watercourse.

3.7 Site 6 - Cynon Valley

On four (4) of the seven (7) visits to this site the screen panels were clear however some blinding was noted on the other three (3) visits. The Sewage Maintenance Contractor has subsequently reported that the downstream sewer had been blocked on several occasions at a local building site with shuttering bricks and rubble removed. This would result in a backing up of the sewer to the overflow, which would operate and ultimately lead to blinding of the screen if the screenings could not be passed on downstream. There was evidence of downstream surcharging of the system on all of our monthly visits, indicated by tidemarks in the screenings return chamber (Plate 6).

Plate 6. Photograph showing evidence of downstream surcharging of the flow controls.

4.0 DISCUSSION

Over the course of 7 monthly visits to all 6 sites and an additional 6 visits to the 3 units in the Rhondda Valley, a total of 60 visits have been made during which the screens have performed well in terms of their ongoing maintenance requirement. On 52 out of the 60 site visits, no maintenance was required. On the 8 occasions when maintenance was required, these were all due to operational issues related to the sewerage network in general rather than the screen itself and were directly attributable to a blockage on the continuation flow or further downstream.

Blockages routinely occur in sewers irrespective of whether a screen is fitted. CSOs represent the system "pinch-points" where pipe sizes generally reduce or throttles are located and it is inevitable that this is where blockages are likely to occur. Identifying whether a device has 'failed' or whether it is a result of 'normal' sewer operation is important when determining the reliability of a device. Long sticks jamming across flow control openings and rags collecting around them are normal events in the operation of sewerage systems.

Though Hydro-Brake® Flow Controls offer a way of maintaining a clear opening of typically 400 – 600% larger than the equivalent orifice or penstock, the fact that they are larger does not make them entirely immune from blockages (e.g. see Plate 3 showing the removal of a lump of road tarmac). The larger the opening is however the fewer blockages there will be.

An ongoing maintenance requirement must be anticipated for all types of CSOs. The key question is which type of device will require the least maintenance and provides features such as dry-weather flow by-pass in the event of a blockage on the continuation flow.

Routine visits - even if every 2 weeks cannot guarantee that a CSO installation is operating correctly in the intervening period. A telemetry system however is only useful if the system is working and the data produced is accurate. For telemetry to be an effective integral part of CSO maintenance regime, there must be some incentive to maintain data and equipment. If the collection of telemetry data is fundamental to the management and timely maintenance of a large number of CSO installations it may have the potential to save money by reducing the frequency of routine proactive inspections.

If the collection of this information can provide some other cost savings, there will be an incentive to do so. Any potential cost saving would take the form of a reduced planned maintenance regime with any planned maintenance being aimed at the telemetry system itself and maintenance of the CSO being mainly reactive to telemetry data.

4.0 CONCLUSIONS

The Hydro-Jet Screen™ is a self-cleansing screening system that has no moving parts and no power requirements. Independent evaluation of the system alongside other systems has indicated that it is highly effective and able to meet current regulatory requirements.

1. The 7-months inspection program coupled with the telemetry monitoring carried out on 4 of the 6 Hydro-Jet Screen™ sites has confirmed the robustness and effectiveness of the Hydro-Jet Screen™ as a CSO screening

device. In particular its self-cleansing backwashing mechanism was found to operate reliably within the sewer environment over a sustained period of time.

2. The screen panels were typically left 70 – 90% clear at the end of a spill event and it was evident that the material left at the end of one storm was removed at the start of the next. No long-term retention of solid material on the screen was apparent. The non-stick screen coating undoubtedly plays an important function ensuring that dried on material is easily removed at the start of a new storm.

3. The screenings return Hydro-Brake® Flow Controls - an integral part of the Hydro-Jet Screen™ design - provide a valuable bypass facility preventing a discharge to the water course (in dry weather) in the event of a blockage to the main flow control.

4. CSO Screens do present an additional maintenance requirement over existing overflows, which simply provide a hydraulic relief to the sewer network. Unlike static screens, which require maintenance after every storm event, and powered screens, which require replacement of mechanical parts, the maintenance requirements for the Hydro-Jet Screen™ are no more than that associated with the routine operation and maintenance of combined sewerage networks such as the clearance of blockages. When compared with the indicated spill frequency for the 6 installations over the study period, the 8 maintenance visits to the 6 units to clear blockages equates to a visit on less than 3% of spills.

5. Telemetry data could be useful in identifying when maintenance is required at a CSO installation. For the Hydro-Jet Screen™ which is shown to be self-cleansing during normal operation and requiring only a low level of routine maintenance, highlighting only those occasions when a maintenance visit is required could provide scope for considerable reduction in the number of planned maintenance visits providing the basis for a cost effective maintenance regime.

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The opinions expressed are those of the authors and do not necessarily reflect those of Dwr Cymru - Welsh Water.

6.0 REFERENCES

1. National Rivers Authority (1993). General Guidance Note for Preparatory Work for AMP2. Version 2.

2. Saul A J, (1999) Screen Efficiency (Proprietary Designs), UKWIR Report 99/WW/08/5.

3. Andoh, R.Y.G., 1998, “Improving Environmental Quality using Hydrodynamic Vortex Separators”, Water Quality International, January/February.

4. Andoh, R. Y. G, Smith, B. P. and Saul, A. J. (1999). The screen efficiency of a novel self-cleansing CSO. 8th ICUSD, Sydney, Australia, 30 August-3 September, 2067-2073.

5. Andoh, R. Y. G. and Saul, A. J. (2000). Field evaluation of novel wet weather screening systems. WEF Specialty Conference, Collection Systems Wet Weather Pollution Control: Looking into Public, Private, and Industrial Issues, Rochester, NY, USA, May 7-10.

6. Faram, M. G., Andoh, R. Y. G. and Smith, B. P. (2000). Hydro-Jet Screen™: a non-powered self-cleansing screening system for storm overflow screening applications. Wastewater Treatment: Standards and Technologies to meet the Challenges of the 21st Century. CIWEM/AETT Conf., Leeds, UK, 4-6 April, 205-212.

7. Faram, M. G., and Andoh, R. Y. G. (1999). Evaluation and optimisation of a novel self-cleansing combined sewer overflow screening system using computational fluid dynamics. 8th ICUSD, Sydney, Australia, 30 August-3 September, 1107-1115.