REPORT BY THE FOUNDATION FOR WATER RESEARCH

WASTEWATER RESEARCH & INDUSTRY SUPPORT FORUM

CSO SCREENS – A DESIGN AND INSTALLATION REVIEW

A Workshop Held

Wednesday 6th July 2005

at

The Visitor Centre, Cropston, Nr Leicester

Evans, T. D. and Eadon, A. R. (editors)

SPONSORED BY SEVERN TRENT WATER, FWR AND WAPUG

Foundation for Water Research, Allen House, The Listons, Liston Road, Marlow, Bucks. SL7 1FD, UK

FWR (Foundation for Water Research) is an independent charity dedicated to education and information exchange. Its subjects are the science, engineering and management of water resources, water supply, wastewater disposal and the water environment in general. FWR brings together and disseminates knowledge and makes this available widely.

WaPUG (Wastewater Planning Users Group) is a not-for-profit organisation established over fifteen years ago to promote best practice in the wastewater industry. Its terms of reference are to:

- Provide a forum for discussion between users
- Facilitate the exchange of information between relevant organisations
- Identify areas for improvement or modifications to and associated research and development of wastewater planning modules
- Identify education and training needs and encourage the necessary education and training.

First published September 2005

Any enquiries related to this report should be addressed to:-

Foundation for Water Research
Wastewater Research & Industry Support Forum
Technical Secretary, Dr. T. D. Evans,
Allen House, The Listons, Liston Road,
Marlow, Bucks. SL7 1FD, UK
Tel: +44 (0)1628 891 589
Fax: +44 (0)1628 472 711
Email: office@fwr.org.uk

Acknowledgements

FWR and WaPUG are very grateful to Severn Trent Water Ltd. for generously hosting and supporting this workshop

1 Executive summary

This workshop was instigated by WaPUG members through presentations and a preliminary forum at the WaPUG Conference (Blackpool) in November 2004 (WaPUG, 2004).

Combined Sewer Overflows (CSOs) are essential safety valves for the sewerage network. It is inevitable that the volume of surface water will sometimes exceed the capacity of the sewer pipes when a storm event is intense enough. It would be irresponsible to design without allowing for this possibility. If a pumping station should fail, for a power outage or some other reason, or if there is a blockage the sewage will back up faster than expected in normal rainfall and defeat the practicable response time. In these situations the CSO diverts the excess volume to a least bad point of discharge: inevitably this will cause some pollution, but it is less bad than flooding people's houses, shops, places of work, etc. CSOs are thus analogous to emergency spillways on dams; these divert excess water in order to prevent the level behind the dam exceeding the designed top-water level and overtopping the dam with potentially catastrophic consequences. The potential impact is carefully assessed at the planning stage in order that there shall be minimal affect on the environment and part of this is to fit fine mesh screens to prevent the discharge of sewage debris.

Within the 2000-2005 Asset Management Plan (AMP3) the water industry has built and upgraded between 2,500 and 3,000 CSOs at a total cost of about £1 billion. The outfalls from these CSOs (or the ones they replaced) had been identified by the Environment Agency as Unsatisfactory Intermittent Discharges (UID). This equates to completing one or two capital schemes valued at about £300,000 each every day of the 5 year (1,825 day) period.

Remediating these UIDs involved variously increasing storage to lessen the frequency of discharge of BOD-laden (biological oxygen demand) wastewater and installing screens to prevent solids > 6mm in any 2 dimensions from being discharged and causing aesthetic contamination of receiving water courses.

This workshop reviewed the construction of new or upgraded CSO chambers and installation of screens within them. It benefited from open and frank discussion and a willingness to share information. Lessons have been leaned from AMP3 any areas for improvement identified.

At the start of AMP3 screening CSOs was unproven technology. It was not simply a matter of buying tried and tested equipment. A national testing facility was established funded by the water industry to increase understanding of the fundamentals of screening overflows and to test manufacturers' products. Two water companies established their own facilities to complement and extend the work.

Screen technology has developed significantly as a result of the testing work and experience gained from completed schemes.

It became apparent during the workshop that in the dash to complete the very large number of schemes many were signed off before they were finished. Sometimes suppliers were required to install screens before the construction work had been completed. Sometimes the electricity supply had not been provided so it was impossible to test powered screens.

Four water companies collaborated in an independent review of 201 schemes all of which were supposed to have been completed. 34% were found to be still under the control of the contractor. Only 43% of the CSO chamber-screen combinations were judged to be "acceptable" based on scoring against 3 performance indicators. Only 28% of the operatives present on the day of inspection were fully aware of the operation of the overflow and had received appropriate training. The suppliers had provided operating manuals but frequently they had not been passed to the operational staff. The review turned out to be more of a snagging exercise than the intended Post Project Appraisal (PPA). The workshop heard that the problems found had been remedied but would they have been had it not been for this survey?

The workshop agreed that PPA should be a routine feature of all capital projects, but that it should not be conducted until the scheme had been in operation after handover to the owner for a recommended 6 months. It was agreed that the cost of PPA should be included in the budget for each scheme. Engineering is to some extent an iterative and evolutionary discipline that learns from past examples. PPA is essential to avoid repeating mistakes.

The workshop heard that the standard of workmanship on the construction of CSO chambers was often very poor. As a result the chambers did not conform to their design tolerances; for example if was not exceptional for weirs to be curved, which was an obvious problem when fitting a rectilinear screen frame. It appeared that the level of supervision of construction contracts was woefully deficient.

One very simple area for improvement that has been recognised would be to photographically record the condition of the screen and receiving water prior to the work; to remove residual Sewage Related Debris (SRD) from the screen as part of the project; and record the post-project conditions.

The Environment Agency, which instigated the work, secures the funded improvements through consents to discharge; it is up to the discharger to comply. The EA has not been afforded the resources to complete a comprehensive PPA or consent compliance assessment by inspecting all completed schemes and the receiving watercourses. The EA has assumed that the expenditure has been worthwhile and the situation has been improved because otherwise there would have been complaints from the public.

Insufficient resources are being allocated/approved for proactive maintenance of sewers (routine cleaning and removal of blockages) and maintenance of CSOs. This deficiency could be alleviated by monitoring and telemetry, which is readily available and proven technology. For example monitoring can identify occasions when CSOs spill at times when rainfall has not been exceptional, or where flows are deeper than expected, both of which would be indicative of downstream restrictions to the flow and a need for investigation and cleansing.

The workshop agreed that there would be considerable benefit from information sharing, knowledge management, and succession planning and training. It was felt that there would be benefit to water companies from sharing their knowledge and experiences and that there is really no competitive advantage to one company being better than others in managing its CSOs.

It also agreed that it would be very helpful if the water companies' teams and the contractors' team shared information to the benefit of the projects, and, especially for fast-learning situations, if they were co-located. This method of working is "Partnering" as recommended in the report entitled 'Rethinking Construction' that was produced by the Construction Task Force, chaired by Sir John Egan, and published in July 1998; it was commissioned by the Deputy Prime Minister. The Task Force was set up to examine the scope for improving quality and efficiency in UK construction. It is very effective when the culture change required has worked through and been fully embraced by the participants.

Valuable lessons have been learnt from AMP3. Too many projects entailing unproven technology were committed too quickly and without due regard to good contracting practice regarding supervision. As a consequence the cost was almost certainly greater than it need have been. The cost could also have been less had sufficient resources been allowed for proactive sewer cleaning and maintenance. However there is evidence to show that surface water quality and amenity use have improved substantially.

CONTENTS

2 Introduction

This workshop was instigated by WaPUG members through presentations and a preliminary forum at the WaPUG Conference (Blackpool) in November 2004 (WaPUG, 2004).

Combined Sewer Overflows (CSOs) are essential safety valves for the sewerage network that carry storm runoff as well as sanitary sewage[1]. It is inevitable that the volume of surface water will sometimes exceed the capacity of the sewer pipes when a storm event is intense enough. It would be irresponsible to design without allowing for this possibility. If a pumping station should fail, for a power outage or some other reason, or if there is a blockage the sewage will back up faster than expected in normal rainfall and defeat the practicable response time[2]. In these situations the CSO diverts the excess volume to a least bad point of discharge: inevitably this will cause some pollution, but it is less bad than flooding people's houses, shops, places of work, etc.

Within AMP3 (2000 – 2005) the water industry has built and upgraded between 2,500 and 3,000 CSOs at a total cost of about £1 billion. The outfalls from these CSOs (or the ones they replaced) had been identified by the Environment Agency as Unsatisfactory Intermittent Discharges (UID). This equates to completing one or two capital schemes valued at about £300,000 each every day of the 5 year (1,825 day) period.

Remediating these UIDs involved variously increasing storage to lessen the frequency of discharge of BOD-laden (biological oxygen demand) wastewater and installing screens to prevent solids > 6mm in any 2 dimensions from being discharged and causing aesthetic contamination of receiving water courses.

At the start of AMP 3 screening CSOs was unproven technology. It was not simply a matter of buying tried and tested equipment. Consequently a national testing facility was established and funded by the water industry to increase understanding of the fundamentals of screening overflows and to test manufacturers' products. Two water companies established their own facilities to complement and extend the work.

In 2003/4 four water companies collaborated in funding an independent review of 201 of their schemes, all of which were supposed to have been completed. A summary of this work was presented to WaPUG in November 2004 (WaPUG, 2004). 34% of CSOs were found to be still under the control of the contractor. Only 43% of the CSO chamber-screen combinations were judged to be "acceptable" based on scoring against 3 performance indicators. Only 28% of the operatives present on the day of inspection were fully aware of the operation of the overflow and had received appropriate training. The suppliers had provided operating manuals but frequently they had not been passed to the operational staff. The review turned out to be more of a snagging exercise than the intended Post Project Appraisal (PPA). The workshop heard that the problems found had been remedied but would they have been had it not been for this survey?

Screen technology has developed significantly as a result of the testing work and the experience gained from completed schemes, but this knowledge is not yet fully absorbed and applied by the water industry.

[1] It is very unlikely that consent would be given for an overflow on a sanitary-only network unless it was so remote that emergency repair teams could not get to the site within 3 hours.

[2] Sewerage undertakers have a target 3-hour response time for pumping station outages. Pumping stations have monitoring, telemetry, 3-hour capacity sumps and facility for alternative power supply (including emergency generator input) to enable this response time.

3 Workshop Conclusions

The workshop was very productive and successful. Delegates represented the breadth of the stakeholders involved with upgrading CSOs and especially installing screens to prevent aesthetic pollution of water courses, apart from the civil engineering contractors. Delegates shared information about their experience in an open and co-operative fashion.

CSOs serve an essential function as safety releases on the sewerage network. To some extent the frequency of spills could be reduced by proactive cleaning and maintenance of the networks to maximise their capability for unrestricted conveyance of combined sewage. However there will be occasions associated with extreme rainfall when the volume of combined sewage exceeds a sewer’s capacity; on such occasions a CSO is essential to divert excess flow to a point of discharge where it will cause least harm. It would be irresponsible to design sewerage networks without allowing for this inevitable possibility. Much has been learnt in AMP3 to improve the performance of CSOs and minimise their environmental impact; further development of CSO design, screens, monitoring, etc. will add to this improvement.

The whole equipment selection, design and construction exercise would have benefited from the application of the principles of partnering that has been adopted more fully elsewhere in the construction industry.

The programme of CSO upgrading and construction would have been more cost effective if it had been “paced” more judiciously so that it was less rushed and if contracts had been supervised more closely. The total outturn cost would probably have been less and the performance would have been better if these classic principles of good engineering/contracting practice had been applied. As it was, construction often failed to meet reasonably expected tolerances and projects were signed off before they had been completed.

A considerable amount has been learnt about the principles and performances of screens for CSOs. They are now much more reliable and fit-for-purpose than at the start of the programme. This information has been shared within the industry but delegates felt there was room for increasing and improving information sharing and information management.

Delegates agreed that there is much to gain from proper post project appraisal (i.e. when the project has been operated by the owner for at least 6 months) and that PPA should be included in the capital allocation to each project.

Delegates agreed that the transfer of information to (and training of) operatives could be greatly improved. Their performance is compromised because of this lack of relevant information. Often the suppliers’ operating manuals are stored remote from the front-line operatives and they never have access to or benefit of this information.

The prevailing maintenance regime is not delivering the greatest operability of the sewerage network and security against flooding. Maintenance has been mainly focussed on rectifying faults; there has been insufficient proactive maintenance. An indication of this is that screen suppliers are not selling the amount of spares that they had anticipated for the maintenance of their equipment. More attention to proactive maintenance would have obviated the need for some CSOs, i.e. had the sewers been clean they would not have spilled.

Overall it was felt that aesthetic pollution of watercourses has been reduced by screening CSOs although the Environment Agency that was the instigator of the work had not been afforded the resources to complete a comprehensive PPA or consent compliance assessment by inspecting all formally inspect the results.

4 Recommendations

- The design of schemes and selection of equipment should be decided on the basis of Whole Life Cost (WLC), probably discounted over 20 years. It would be desirable if there was some degree of harmonisation of WLC principles across the water industry – a good practice standard for WLC with a consistent approach to discounting and renewals.
- WLC should include the cost of providing adequate access to CSOs and adequate training and maintenance throughout the whole of the period.
- Manufacturers and contractors should be involved early in the design process.
- Benefit would be gained from allocating more resources to proactive maintenance of the sewerage network. More resources should be allocated to ensuring the maximum operability and conveyance capacity of each network.
- More use should be made of monitoring to identify the scheduling and need for [proactive] maintenance and intervention in the sewerage network. This would entail installing more monitoring and telemetry but it would be a cost-effective tool for targeting resources.
- Handover should not be accepted until the scheme has been snagged and all defects have been rectified. Ideally assessment of schemes for handover of CSOs should include observations in storm/spill conditions.*
- There should be more attention to snagging and site supervision; these should be a routine parts of all projects.*
- Good construction practice, which should include construction to acceptable tolerances, should be reinforced.*
- Post Project Appraisal should be practised more widely. The cost of PPA should be written into projects as an essential part of the scheme. PPA should not be undertaken until the project has been handed over to the owner and operated by it for a recommended period of 6 months.*
- There should be more consistency about PPAs: delegates favoured a good practice guide for PPA, possibly produced by WaPUG.*
- The water industry should embrace the principles of “Rethinking Construction” (Egan, 1998) especially for intensive investment programmes such as improving UIDs. Some companies have already adopted ‘partnering’ but co-locating teams and changing [bunker mentality] cultures have not been adopted universally.*
- Information should be shared more widely between, and within, companies. This would be of mutual benefit to all involved and improve the cost-benefit ratio for customers. It is considered that whilst there might be competitive edge in operating more cost-effectively there is no competitive advantage in being better at protecting water courses from aesthetic pollution and sharing information so that all are aware of lessons learned in this regard would be to the benefit of the whole water industry because all can be tarnished by bad publicity in this area.
- Information sharing should extend to the front-line operational personnel. They should have adequate training and ready access to all the relevant information about each CSO. An encapsulated summary datasheet (see for example Figure 5) at each CSO could be considered good practice. They should have access to the operating manuals provided by suppliers.*
- Large environmental programmes such as improving UIDs should be programmed over a sufficient period that they are practicable and sensible. It might look good on paper to achieve such programmes within a 5-year period but the reality on the ground is that resources are stretched and details are overlooked in order to get schemes “ticked off”.
- There should be a continuous improvement cycle in which information gained during operating and maintaining facilities, including CSOs, is fed back into the design teams.

- Other ways to deal with surface water from extreme rainfall events should be looked at; this is especially pertinent with climate change. If the excess surface water were not mixed with sanitary sewage the discharge of this excess water would have little or no polluting effect.
- The initial [pre-project] condition and the post-project condition should be recorded photographically.*
- There should be research into the likely effects that Climate Change will have on the duties that will be required of CSOs and the performance they will achieve.
- It should be recognised that improved CSOs are sustainable for their designed circumstances; building development, water usage and climate change can all impact on the expected life of installations and may lead to a need for further work.

---

* these items are new topics in a revision of the WaPUG CSO Design Guide (www.wapug.org.UK), which was commissioned following this workshop and is due for publication in Autumn 2005.

5 Background to CSOs - David Balmforth

MWH

Combined Sewer Overflows (CSOs) are, as the name implies, overflow weirs installed in the side of a combined sewer (one that carries surface water as well as sanitary sewage). If the flow should exceed the downstream capacity of the sewerage the weir spills the excess flow to an escape channel which diverts the excess flow to a river or the sea. On a long sewer there might be more than one CSO. It cannot be emphasised too strongly that CSOs are necessary because they provide a vital function. They protect the downstream treatment works from being flooded and they prevent uncontrolled flooding by diverting excess flow and discharging it at a location where it is expected that it will have the least bad consequence (Figure 1). To this extent they are like electrical fuses and circuit breakers that protect appliances, downstream circuits and components and people who might otherwise be electrocuted. However the constituents of discharges can pollute receiving waters biologically/chemically and aesthetically. Like circuit breakers they are essential but it is undesirable for them to blow unnecessarily.

Figure 1 Consequences of combined sewer flooding (left to right) flooding in a residential area without the benefit of a CSO to divert the flow; chemical/biological plume from a CSO; litter caught on the outlet screen of a CSO discharge

People in the UK are unusual in disposing sanitary products to sewer; in many other countries they are disposed as part of the solid waste stream. Campaigns such as “Bag it and Bin it” and “Think before you flush” have had limited effect on changing behaviour. The slowly degradable elements of sanitary products (plastic, rubber) are the most obvious evidence of unsatisfactory intermittent discharges (UID). They can remain snagged on downstream vegetation and other items for month if not years. The hygiene, convenience and health benefits of appliances such as Nappigon for disposal of sanitary and incontinence products means that most care homes, hospitals, and other institutions use them in preference to storing solid waste on site. Irrespective of domestic behaviour screenings are going to remain a fact of urban wastewater. The biodegradable constituents of CSO discharges can strip the oxygen from the receiving water with consequential fish kill.

The design of CSO chambers within the UK has been driven by a series of laboratory studies and fieldwork evaluations conducted over the past 40 years, commencing with work done by Sharpe and Kirkbride in 1959 which was developed by many researchers during the 1960s, ‘70s and ‘80s, culminating in the first UK design guide for CSO chambers, (WRc, 1988). This Guide gave recommendations for the hydraulic design of four types of CSO chamber, being the high side weir, stilling pond, vortex with peripheral spill and hydrodynamic separator (Figure 2). Subsequent research showed that the gross solids retention performance of these chambers was relatively poor, with solids simply dividing proportionate to the flow split during overflow events. As a result, a revised guide was published (FWR, 1994).

Measurements show that bed solids are picked up quite early in the response to a storm event (Figure 3) with the sharp peak in the concentration of solids in the flow occurring on the rising front of the hydrograph.

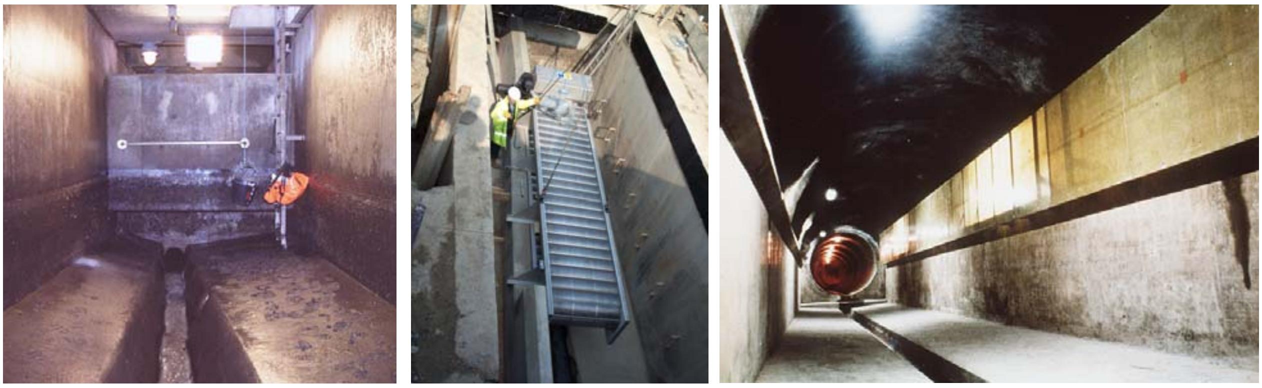


Figure 2 Historical perspective - different methods of solids retention (left to right) stilling and dynamic separation; screens; and storage

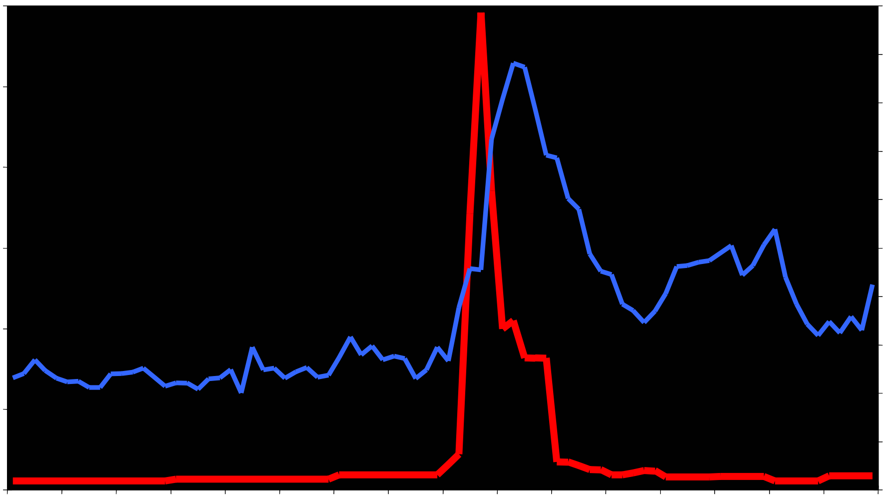


Figure 3 Hydrograph of flow in a sewer through a storm event (blue) and the solids discharge from a CSO downstream of storage (red)

The water industry's third business planning cycle (AMP3) Asset Management Plan delivered 2000 to 2005 contained new obligations including requirements to fit screens on "unsatisfactory intermittent discharges" generally to prevent the passage of solids exceeding 6 mm in two dimensions (the Environment Agency's "6 mm x 2D" standard). Although other EA standards exist, including "10 mm x 1D" and "Good Engineering Design" their application has been limited, partly because of the anticipated poor solids retention performance of a chamber designed against them, and partly because screen design has defaulted to the most stringent of the standards likely to be encountered.

In practice 6 mm x 2D means that which is visible from the river bank. The biggest difficulties were the number of UIDs designated (2500-3000) was equivalent to completing 1 or 2 schemes per day throughout the period (365 x 5 = 1825 days) and the fact that installing such screens in CSOs was largely unproven.

The Water Industry established the National CSO Test Facility at Wigan WwTW (Figure 4), to conduct full-scale research, primarily into solids retention and reliability was included as a subsidiary objective. Later United Utilities and Yorkshire Water set up testing facilities at Warrington and Knostrop WwTWs.

Figure 4 The National CSO research facility showing sensors for flow measurement and excess flow up-welling through a screen, also a failed screen (right)

Some screens failed because the forces involved and the vibration they would have to endure had not been anticipated; rivets dropped out and/or bolts failed (Figure 4 right). It was found that the hydraulics could give rise to a standing wave that could result in vibration that destroyed screens. Manufacturers were very cooperative in building improvements to their products. It was found that getting the screenings return right was very important. This work led to publication of a guide to the design of CSO chambers to incorporate screens (WaPUG, 2001) which continues to be the industry standard in the UK.

The WaPUG Guide focuses primarily on the design of a chamber to incorporate an appropriately designed screen. The Guide seeks to ensure that flow patterns are commensurate with effective screen operation, the chambers are compact and therefore more cost-effective, and the risk of sedimentation or blockage is minimised. It gives the minimum dimensions and basic rules that should be applied. However the WaPUG Guide does not attempt to advise on the selection, design, installation or operation of screens.
Screens create a head loss and can cause a backup on the rest of the network. Screen cleaning is essential as is good access.

GROSSIM (Gross Solids Simulator) has been developed as part of a collaborative project with Imperial College, Sheffield Hallam University and the University of Sheffield to predict the quantity and temporal distribution of solids in urban catchments by simulating flows that drive a solids transportation component. It has been calibrated and verified using three sets of sampling data that collected solids from the sewer system in dry and in wet weather. The model replicates the disposal of sanitary products and faecal material from each individual household and predicts the movement of solids at any modelled location. It then simulates deposition and storage of these solids in dry weather and their subsequent flushing out in wet weather. Spills from CSOs are modelled from data collected on full-scale structures. Because the model carefully replicates each stage of the process, it allows various 'what if' scenarios to be tested in developing the most cost-effective and economic solutions to this problem.

AMP3 delivered an unprecedented number of CSO solutions to time and cost. The suppliers delivered screens largely to programme. The expected problems with screen performance did not materialise and we learned lots of lessons and probably need to learn some more.

For the future we shall need post project appraisal to evaluate the CSO solutions when they have been in operation for some time. Almost inevitably we shall need new screen technologies, a better understanding of solids loading and improved guidance for difficult locations. We shall also need better data on maintenance, improved monitoring and real time operational control and maintenance.

6 **AMP3 CSO Screens: Operational Experience** – David Hanson

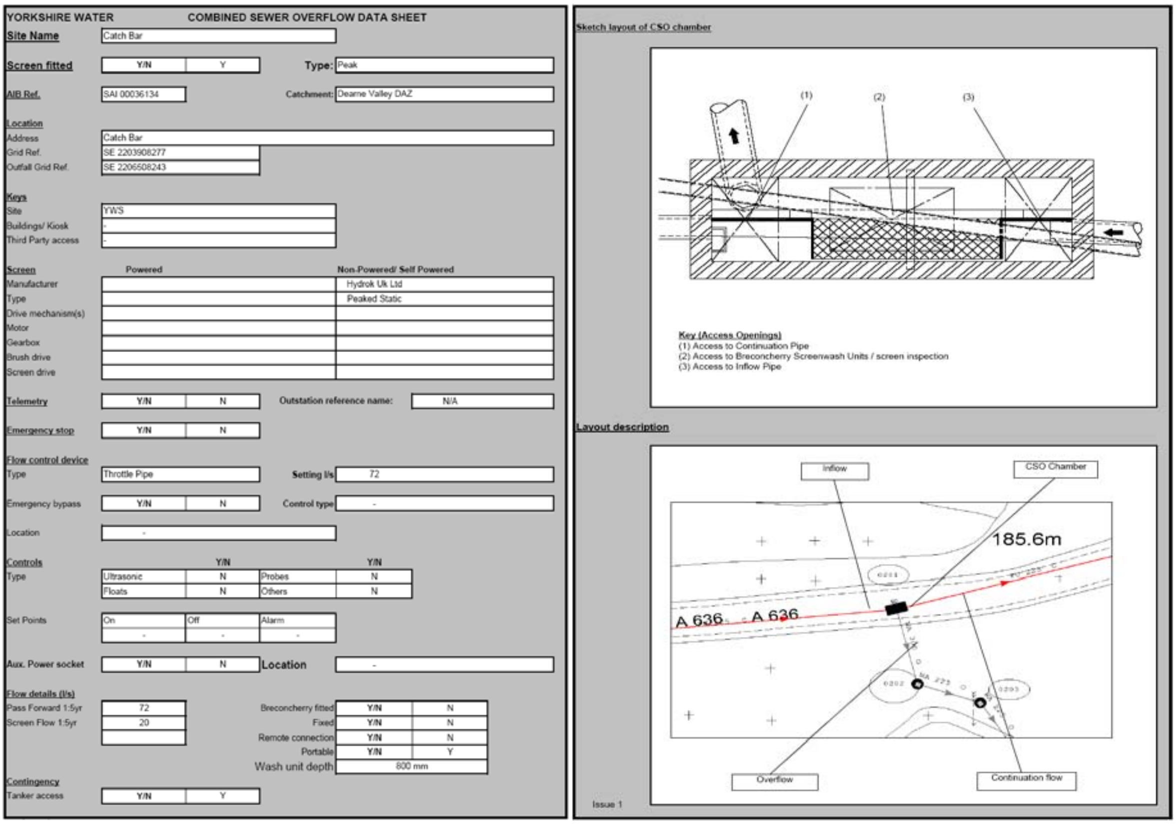
Yorkshire Water

Yorkshire Water has undertaken Post Project Appraisal (PPA) to evaluate its design, maintenance, operation and construction procedures and to capture feedback from those who work with the CSOs. This was not just a construction audit. 15 CSOs were evaluated over a 6 month period; they included covered static, powered and self cleansing screens. 6 CSOs had Flow Survey Data obtained by conventional depth-in and depth-out measurements.

Some screens were identified to blind more frequently than designed and as a consequence version 4 of Yorkshire Water's guidelines has been revised:

- The loading rate for Self Cleansing Screens has been revised down from 225 $l/s/m^2$ to 150 $l/s/m^2$.
- The maximum flow for Static Screens has been reduced from 1000 $l/s/m^2$ to 800 $l/s/m^2$ and the spill rate has been reduced to 30/annum for low amenity waters and to 12/annum for medium amenity.

This revision has in turn influenced a shift from static screens to powered screens.



YORKSHIRE WATER COMBINED SEWER OVERFLOW DATA SHEET

Site Name: Catch Bar
Screen fitted: Y/N Y — Type: Peak
AIB Ref.: SAI 00036134 — Catchment: Dearne Valley DAZ
Location
Address: Catch Bar
Grid Ref.: SE 2203908277
Outfall Grid Ref.: SE 2206508243
Keys
Site: YWS
Buildings/ Kiosk: -
Third Party access: -

Screen	Powered	Non-Powered/ Self Powered
Manufacturer		Hydrok Uk Ltd
Type		Peaked Static
Drive mechanism(s)		
Motor		
Gearbox		
Brush drive		
Screen drive		

Telemetry: Y/N N — Outstation reference name: N/A
Emergency stop: Y/N N
Flow control device
Type: Throttle Pipe — Setting l/s: 72
Emergency bypass: Y/N N — Control type: -
Location: -

Controls		Y/N		Y/N
Type	Ultrasonic	N	Probes	N
	Floats	N	Others	N

Set Points: On - / Off - / Alarm -
Aux. Power socket: Y/N N — Location: -
Flow details (l/s)
Pass Forward 1:5yr: 72
Screen Flow 1:5yr: 20

Breconcherry fitted	Y/N	N
Fixed	Y/N	N
Remote connection	Y/N	N
Portable	Y/N	Y
Wash unit depth	800 mm	

Contingency
Tanker access: Y/N Y

Figure 5 Example of a typical encapsulated data sheet showing layout, location, and key components that is located at every CSO in YW so as to inform maintenance personnel.

The maintenance regime has also been revised:

- Clear instructions are now given to maintenance personnel; these include inspecting the outfall in addition to the CSO screen.

The physical location of the CSO, its general layout and a schedule of all key components is shown on laminated sheets located in the inlet manhole or kiosk (Figure 5).

Conclusions

Breconcherry units (http://www.breconcherry.com/) were found to be very effective, but only when used correctly (e.g. in terms of design, pressure and frequency of cleaning). The positioning of the unit, the depth within the chamber, the pressure applied and the duration of the spray cycle all govern the effectiveness (Figure 6). The latter two points require skilled staff who understand their equipment and its operation with each CSO requiring its own optimized settings. Worksheets ensure that the Service Provider is aware of the correct height, duration and location of the mobile units for each CSO.

Figure 6 The position of vents and high weirs have been found to cause shadows and impaired maintenance of static screens.

Handover Procedures from the “Capital Service Partner” (CaSP) to YW were found to be important constituents of success and they have been improved to minimise risk of failure, for example it was found that initially, no maintenance was possible due to failure of handover of the control box keys. Handover procedures now allow maintenance to be undertaken without delay. Photos of the screen and the outfall are now provided as part of the handover process as verification of satisfactory performance.

Some powered screens were shown not to be able to keep sufficiently clean so as to avoid excessive head being required to drive the flow through the screen. This has prompted investigations into the following:

- changes to the screen program to allow it to run on for some time after a spill
- variable speed screens to cope with the first flush
- provision of a baffle to prevent all the sewage solids being presented to the screen face
- increased maintenance

In the future the detailing within chambers at the approach to sluice breaks will be amended to remove dead zones and the brush-clamps on powered screens will be redesigned because protruding wires have been found to be the cause of a number of failures.

Yorkshire Water has found that this PPA exercise has validated our procedures but has also shown areas for improvement. Many issues raised in the PPA have already been resolved in later versions of YW’s guidelines. PPA was not cheap but it has been very cost effective due to its full coverage of the end to end process and identifying areas for improvement so as to avoid continuing to repeat the same mistakes. The results have been fed back into YW’s guidelines.

7 Discussion session 1

David Gordon - Every water company has a different standard for its design. For static screens they range from fewer than 12 spills a year up to 30 spills a year and the range of flows is 200 $l/s/m^2$ to 1000 $l/s/m^2$. Why is there this difference in standards? Is effluent in Yorkshire different from every other region? Why don't we have an industry standard?

David Balmforth - Loading rate is a critical parameter but it is not a good design parameter for static screens because the solids are delivered to the screen during the high flow event and washed off later. What is the maximum flow rate? In principle there shouldn't be a need to have a maximum flow. Presumably, aim to have a system of static screens to take any volume of flow. The critical issue is the solids loading rate. Wigan Screens Survey gave a lot of information on what might be suitable for loading rates. Not so much the volume, more the loading rate. Where there is an extremely high spill runoff rate, we would oversize the screen.

It's not just the loading rate; it is also the spill frequency. If fewer than 12 spills a year (in Yorkshire it used to be fewer than 30) then you have a static screen.

Jeff Pierson - Is the position of the CSO along the network important in such situations? There is a cumulative effect of screenings down to the last screen and ultimately to the WwTW.

Jonathan Cutting - Is the difference between Severn Trent and Yorkshire anything to do with the maintenance regimes? If they were maintained more often, would the build up of solids be relatively lower?

D Gordon - Every water company wants the optimum number of maintenance visits to be as infrequent as possible without compromising service. Within Severn Trent, one of the reasons we use 12 spills a year is it equates to one a month. We are trying to monitor the performance of overflows and trying to "tweak" the maintenance regimes. Conversely only doing once every 2 months; it is down to the individual site and individual characteristics.

David Hanson – No, more than 12 visits is not cost effective.

Andy Eadon - Maintenance procedure is important in design. Are we able to identify the maintenance cost of individual screens? Does anyone know? Or, is it just lost in general accounting? Is it something we can define?

John Blanksby - We are actually carrying out a project which does bring in those issues. We can highlight the direct and indirect costs associated with maintenance. The answer is simply "yes". The direct costs are labour force. We are calculating the whole life cost of sewerage.

Andy Eadon - Do we know nationally, how much we spend?

John Blanksby - Need to take into account the unit load and the load going through it and the area of the screen and the overflow. Cleaning regimes need to match the frequency of the run etc.

Tim Evans - You said, John, that you are doing a whole life cost of sewerage. 10 years ago I did business planning in this area and I found it incredibly difficult to extract the costs attributable to different processes. At that time the accounting system could not go to that level of detail to get reliable numbers. Have things changed so much?

John Blanksby - Yes, we can do it. Organisations are able to allocate and account for costs.

David Gordon – Severn Trent has found that we have had very little success to date in capturing data about overflows. A lot of data are down to operators. If you are an Operations Manager and you have 20 jobs in one day, cleaning a static screen may not be top of the list.

David Balmforth - A lot more maintenance is needed for this to work if we are going to assess that link between variation in maintenance standards and maintenance costs. We are getting better on "whole life costing" but need to get a handle on operating costs. Once we have a handle on costs, we shall have a much better idea of controlling them. What would it take to get that information? What more would it take to start to manage maintenance costs? Could we use monitoring more effectively to manage maintenance?

Chris Lee - Whole life costs, maintenance of screens. Are you taking into consideration the maintenance of other items upstream that would primarily affect the screens – which would mean that the performance of the screens would suffer?

David Gordon - We have not taken these things into account.

Chris Lee - I would totally disagree with that; anything that goes into a sewerage system would need maintenance.

David Balmforth - Maintenance of the screen itself, the chamber and other associated bits of kit. If we are recording maintenance costs then it might be difficult to identify these separate costs. Looking at other controls, sensors, for example, and dealing with these at the same time.

Chris Lee - When you clean the screens the actual flow is not getting away from the CSO chamber.

Steve Dempsey - You are going to maintain a pumping station, but don't maintain the valve chamber. You have to take that sort of thing into account or you won't get realistic figures.

We deliver 600 CSO screens a year. Success depends on the design and clear instructions to the designers. What is actual flow volume that is going to be treated? Everybody deals with 1 to 5. If the spill flow per year differs, the whole issue of how you size the screen comes into question; you need to take into account a whole lot of other things. Need to take into account spill flows. 60 spills a year. It is only if you had an in depth analysis of what is going on, you would be able to analyse this. Screen design is part of the failures we have had.

David Gordon - Within Severn Trent if spills were 60 a year we would put in a mechanical screen.

Mike Wood – No, there are other reasons for having a separation. If a screen functions once a year, it should function 100 times a year, it should work in the same way.

David Gordon - A lot of "rules of thumb" are used in the industry, there is little scientific basis for them.

Mike Wood - Some water companies have those figures.

The different companies set different standards because they have different tolerances of risk.

8 **A Designer's Review Remediating UIDs** - Mark Shimwell

Severn Trent Engineering

Historically, the design of CSO chambers was aimed at providing adequate hydraulic relief of the sewerage system and to effectively control the pass-forward flow so as to protect the downstream system from overloading. Little regard was given to the separation and retention of solids. This left a legacy, particularly in the River Tame catchment, of a collection of chambers, some of which are structurally and hydraulically deficient, that do not perform effectively in the retention and separation of Gross Solids (Figure 7).

Poor hydraulic and solids-separating performance associated with the traditional chambers such as the hole in the wall, leaping weir, low sided weir and early types of siphon overflows are prevalent in many of the CSO structures within the Tame catchment. Hydraulic defects at Leaping weirs and surcharge relief chambers often resulted in downstream flooding where apertures have been incorrectly sized.

Figure 7 Traditional designs of CSOs (clockwise from top left) Low sided weir; Leaping weir; High sided weir; Siphon

Figure 8 Some CSOs had screens before AMP3 (such as this static screen) but they weren't necessarily effective

It was inevitable that poor separation of gross solids and excessive spill frequencies have led to the snagging of rags around flap valves, collections around outfalls and visual pollutants hanging high and dry in overhanging branches along the banks of receiving water courses (Figure 1 and Figure 18). This led to complaints from members of the public. The AMP 3 UIDs were originally identified by the Environment Agency as a result of customer complaints generated from the visual nature of aesthetic pollutants.

When designing works to solve UIDs, especially in city centres, the location of the existing CSO, finding space to build a new chamber new, diversion of mains and services and power supply delivery were all difficulties that had to be overcome.

Figure 9 The location problems associated with the Digbeth UID in central Birmingham

Digbeth UID is a prime example of the issues (Figure 9) it is in one of the main arterial roads out of the city of Birmingham and very close to the new prestigious Bullring development. The bus stops opposite the UID serve 17 different routes out of the city. The UID is at a location where pedestrians regularly cross to catch buses. There is nowhere suitable place to relocate the CSO that would cause less traffic management problems than the old location. There is a 16” cast iron gas main running to the left hand side of the UID.

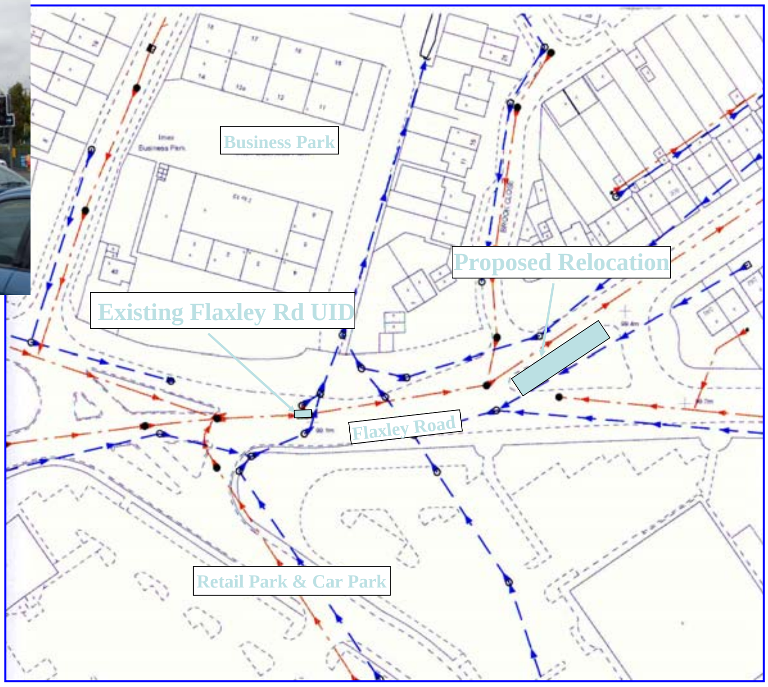


Figure 10 Flaxlet Road UID; another difficult location, but one where the CSO could be resited

Flaxely Road UID (Figure 10) was also at a very difficult location: as can see from Figure 10 this UID was at a very busy junction where there are seven sets of traffic lights in a very small area controlling traffic to the retail park in the background a major bus route just to the right and a business park to the left. Also to the left are about 20 properties straddling the outfall to the UID overflow where there have been historical records of complaints about sewage smells caused by the venting of the UID. Closing any part of the road would have been unacceptable. The incoming and outgoing sewers are 2.55m wide by 1.53m deep with about 1.5m cover. There is a large array of utility services at this junction.

The CSO was modelled using SIMPOL3[3], it had a requirement class of ‘Moderate Amenity’ and >30 spills/year requiring 6mm screen and a WaPUG chamber. In this case the solution was to abandon the existing UID and construct a new CSO off-line of the next manhole downstream. This is located off the main bus route on a very large refuge island with very few utility services and very little disruption to the local traffic.

Figure 11 Three examples of problems cause by not having a power supply from the start of a CSO screen becoming operational

In rush to sign off UIDs some of the screens were installed before there was an electricity supply to the CSO; Figure 11 illustrates the problems that resulted with screen performance compromised and the need for cleaning work that was necessary to remedy the situation when the supply did become available.

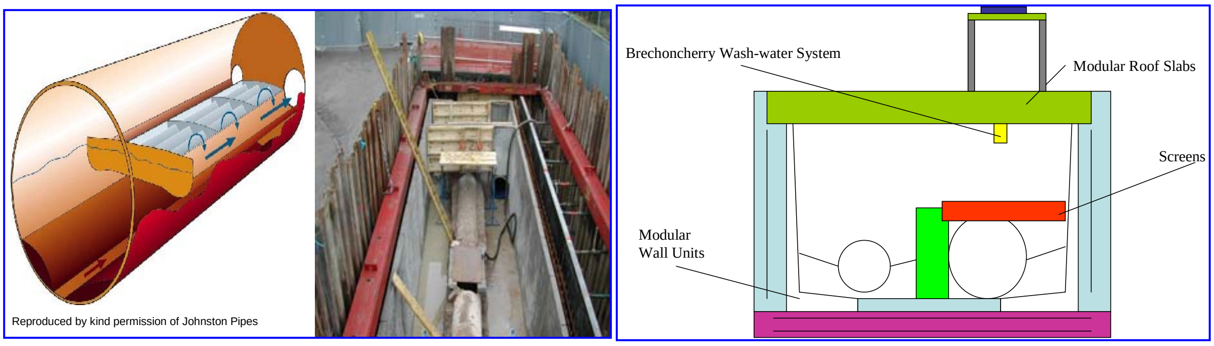


Figure 12 Examples of pre-fabricated CSOs

Where it has been considered appropriate, pre-fabricated units have been used to minimise on-site-time and traffic etc. disruption. Manufacturers of proprietary unit provided details of their own systems based on identical data used when sizing from WaPUG. There was little difference

[3] SIMPOL3 is a WRc
modular modelling package which is regularly used for a range of environmental applications (e.g. diffuse pollution, highway runoff, bathing water compliance and UPM).

in the chamber sizes as both were determined from the incoming pipe diameter, flow rates and screen size.

There have been several instances of construction-related issues, mostly due to failure to construct to the design tolerances (curved weirs, etc.) and, when emergency baffles, etc. were raised, failing to raise the height of the associated walls to match the hydraulic heads. These defects have compromised the performance of screens, in extreme cases to the extent that they were by-passed entirely and never worked.

Successes and Achievements

It has not all been bad news, there have been successes as well. The company developed a process and tools that gave a consistent approach to screen selection (Figure 13) and CSO design that uses an Excel workbook to guide the user through the process (Figure 14).

Figure 13 Choosing the right screen

It was also decided that we would consider both built in situ structures and proprietary (pre-fabricated) units to house the screens, and select whichever was more appropriate for the location. With details of spill frequency, design inflow, carry forward flow and spill flow already available from the hydraulic analysis it was possible to determine the most suitable screen type and its size using the CSO Selection Guide workbook.

When the spill frequencies were only between 3 and 7 per annum it was determined that prime consideration would be given to static screens; this had the additional benefit of avoiding difficulties associated with obtaining planning permission for controls and power supplies.

Conversely, the spill rates through the screens on the 5 year critical duration design storms were high resulting in oversized screens that could not be housed in a truly compliant WaPUG

chamber, thus requiring oversized chambers, a factor that was unhelpful due to the availability of sufficient space and would have to be addressed by appropriate means.
Computational Fluid Dynamics confirmed there would be no significant detrimental effect on the dynamics in a longer, narrower chamber to house a slightly oversized screen.

To ensure the screen selection guide and WaPUG guide were used consistently between schemes a chamber design spreadsheet was built. The spreadsheet incorporates the information from the CSO design guide and following the input of spill flow and frequency and answering some questions regarding the specific site a screen type is selected. The dimensions if the screen and chamber from the CSO design guide are then calculated. Further modelled information is then entered to allow the chamber size required to conform to the WaPUG design Guide. A chamber size is then computed that conforms to both criteria.

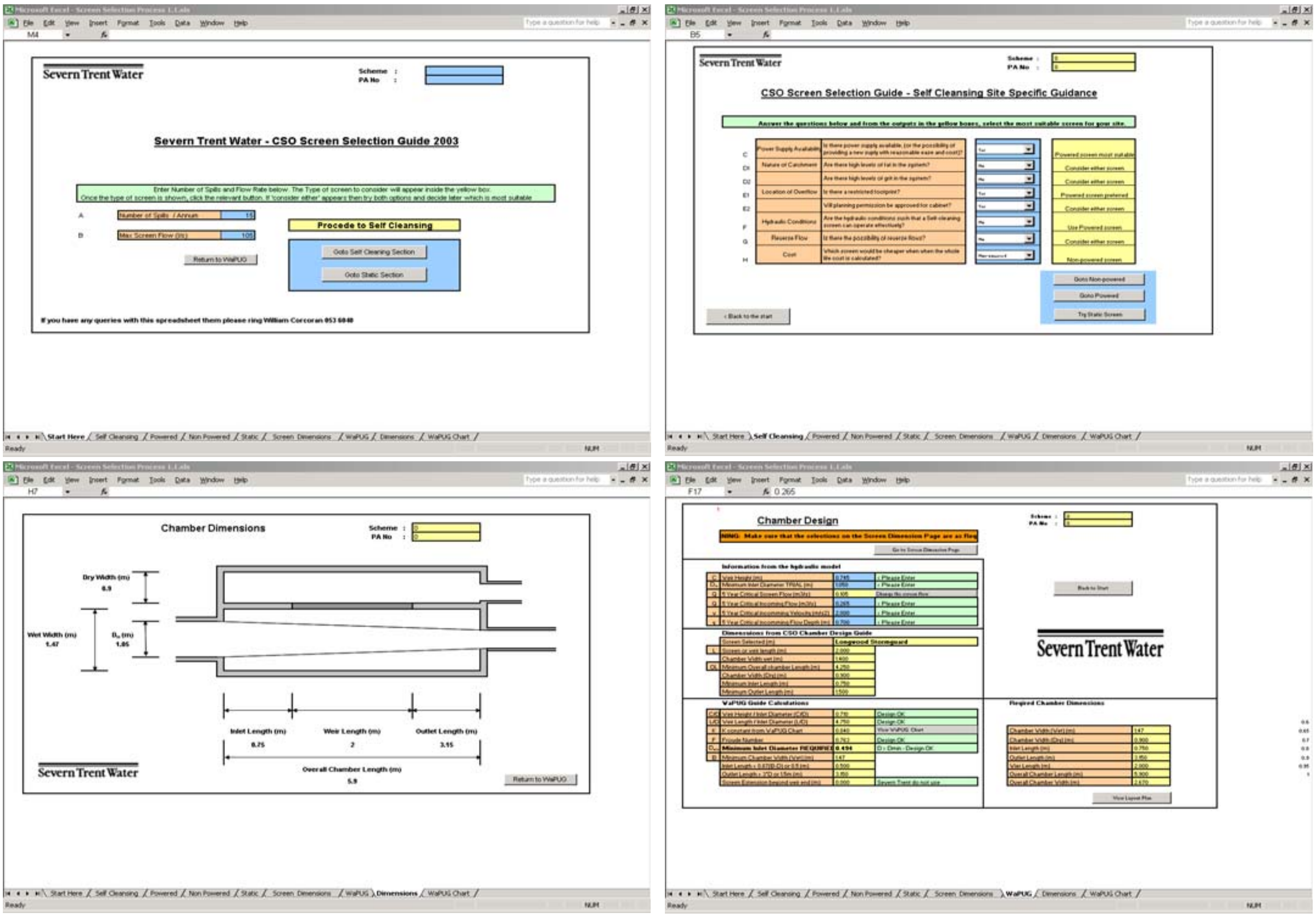


Figure 14 Examples of screens from the CSO Selection Guide workbook: clockwise from top left: start screen; input for self-cleansing; data input for WaPUG design; WaPUG dimensions

Where the chamber size calculated from the design guide cannot physically be located within the footprint available, or the existing chamber size is such that there is an option to retrofit a screen, then computational fluid dynamics (CFD) can be use to prove that the non standard arrangement performs as effectively as the WaPUG chamber.

For example the Rabone Lane UID was one of the UIDs in the Hockley Brook Aesthetic batch; it would have required extensive utility diversions if the standard WaPUG chamber had been used. Two different chambers were found that could fit in the tight footprint available. One was a long thin chamber while the other was a short wide one. They were both investigated using the CFD software. The standard WaPUG chamber was also analysed to give benchmark results against which the two options could be compared.

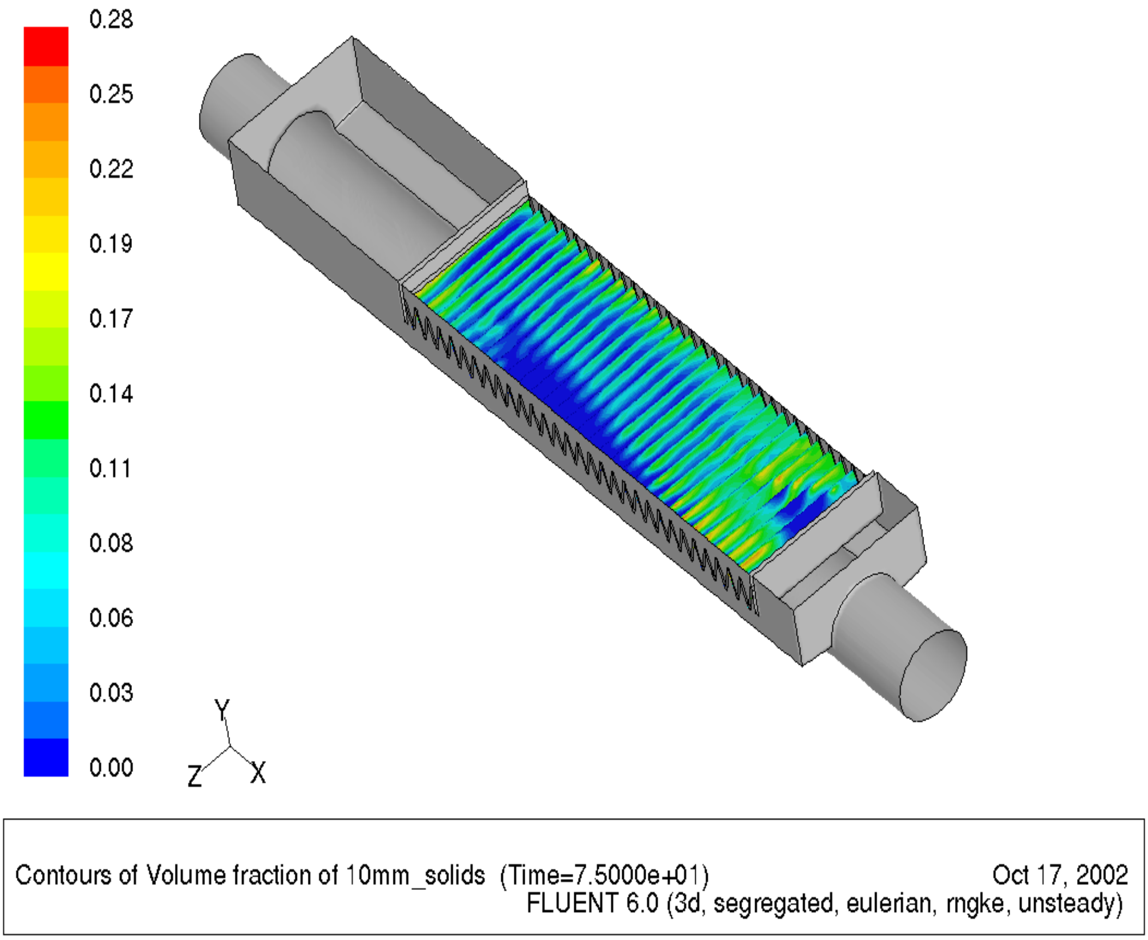


Figure 15 CFD analysis of one of the chamber options for Rabone Lane - green shows where blinding occurs first (flow bottom right to top left).

Figure 15 shows an image is from the CFD package. The green areas show the parts of the screen that are blinded first. Inflows are run through the chamber and particles of different sizes are introduced and their passage through the chamber is mapped. From this example it can be seen that screen, which is positioned over the flow, starts to blind at the upstream end and at the side adjacent to the weir first.

To compare the different chamber sizes the CFD analysis was used to compare the time that would be taken for the screen to completely blind. The patterns of blinding that would be experienced with the alternative designs. The velocities that would be generated within the chamber and the areas where solids were deposited were recorded so that the benching could be included in the chamber to reduce the maintenance requirements.

The AMP3 UID remediation process has generated design innovation within Severn Trent in the form a screen auto-wash system. The pilot site was Stanhope Road in central Birmingham. It was already fitted with a semi-automatic system so minimal conversion work was required. The kiosk required planning permission and Statutory Undertakers were required to supply electricity, telecom and water. The system comprises a control panel with a 240v single phase supply and a pumpset to deliver 120 l/min at 9 bar to Brechoncherry screenmaster cleaning head. The water is supplied from a 950 litre break tank which is also sited in the kiosk.

The CSO level is monitored constantly by an ultrasonic level monitoring device, which has a controller built into the control panel; it is configured to recognise when a flood event occurs.

The auto-wash has proved to be operationally reliable and fully automatic. The telemetry signals any malfunction and this has proved reliable. Noise reduction has been affected and this has reduced environmental impact. The Severn Trent Auto-Wash cleans the screen immediately after the event when the screenings are easier to remove. It eliminates risk to operatives and members of the public because road closures, footpath diversions and traffic regulation are not required. It has reduced the whole life cost and reduced the risk of pollution.

The challenges ahead are to improve knowledge management, to continue to learn from mistakes, building on success , which inevitably mean taking the time to review schemes to look for mistakes and successes, these feed into a process of continuous improvement for the whole design, delivery and operation process. We plan to improve the longer term visibility to our supply chain, develop the AMP4 Procurement Strategy, develop [even] more effective communication and develop the templates as a guide to selection, design, installation and operation.

9 **Post Project Appraisals** – Barry Thompson

ThompsonRPM

The objective of this exercise conducted on behalf of Scottish Water, Severn Trent, Southern Water and Welsh Waste was to survey a representative sample of CSOs constructed / commissioned within AMP3 and to quantify progress, compliance and success within the current AMP Period with a view to seeking policy, protocol and guidance for use in the next AMP Period. The numbers of CSOs were 18, 89, 26 and 68 respectively for the companies; a total of 201. 34 shaft tanks were also surveyed for Severn Trent.

The CSO chambers were identified according to type; design guide compliance; location and who was currently responsible. Chamber access was assessed generally as well as access for vehicles and for people and access in relation to screen removal and maintenance. The performance of each CSO and its screen was assessed as to the effectiveness of operation of relief, whether there was premature operation and whether it was self cleansing. Operators were questioned about their general awareness of the CSO and the maintenance routine. The assessment of the CSO was completed with an inspection of the outfall and the condition of the receiving watercourse. Individual site specific inspection reports were written for each CSO and a Project End Report.

The aim was that the project would yield generic findings that would feedback to design processes and update design guidance. It was also intended to produce site-specific findings, site-specific action plans and additions to “snagging lists”. All the findings were to be delivered to a roll-out workshop. The findings were intended to identify where additional OPEX is required within the current AMP period and where additional CAPEX will be required during the next AMP period.

The project was conducted at the end of AMP3 and it turned out that many CSOs were essentially unfinished because to the dash for completing schemes and getting them signed off, for example sometimes before an electricity supply had been laid, which meant that screens were not powered. To this extent much of the survey output could be more correctly described as a snagging exercise rather than post project appraisal. The issues identified have subsequently been resolved.

Figure 16 Examples of compromised access to CSOs

Figure 16 illustrates the problem of access to CSOs being compromised. The picture left shows a CSO that has been "landscaped" as a beer garden for the pub on the other side of the road, it is undoubtedly attractive but there are issues of access (clearing the beer garden) and safety, and also possible odour complaints. The photo right shows a CSO chamber located at the traffic-light controlled road junction; access and consequently maintenance are virtually impossible because of the disruption (possibly road closure and diversion) that would be entailed.

Other examples were found such as a CSO chamber 200 m from the nearest road in a field with no water supply, no hardstanding around the manhole and no vehicular access. Lack of hardstanding around a manhole means that safety tripods cannot be used, which in turn means that access for maintenance is impossible under health and safety rules.

Figure 17 Examples of bad installation

Figure 17 shows two examples of the many cases of poor installation. In the left hand picture the weir is not straight and the tie-down brackets have bent because they are not substantial enough to resist the upwards pressure of water. The problem of curved or misaligned weirs severely compromises the 6mm x 2D standard; in the photo (left) there is a 25 mm gap between the weir and the frame of the 6 mm screen. The photo right shows that the jet heads are not sufficiently high above the screen to wash the whole of the screen area; in addition there is no spray jet for the middle portion of the screen. In another case the only screen washing was from surface water leaking around the manhole. Sometimes construction debris was found on top of the screen that the contractors had failed to remove and the client owners had not demanded to be removed. The undersides of some screens were festooned with solids that should have dropped off when the flow returned to dry-weather flow but had not; clearly they would compromise performance at the next flood and increase back-pressure up the system.

The owners (water companies) had said that all 201 CSOs had been commissioned, completed and handed over. 59% of the CSOs inspected were standard (WaPUG) Side Weir Overflows; 70% of these CSOs complied with contemporary design guidance in most major respects.

The following is a summary of the findings regarding access:

- 25% of the CSOs inspected are located in highways / carriageways
- 46% are located in other public spaces or private ground owned by others
- 29% are located within land owned by the relevant Water Company
- 34% of the CSOs inspected were found to be still under the control of the construction contractor on the day of the inspection
- 81% of the CSOs inspected have vehicle access within 10 m of the chamber
- 32% of the CSOs have personnel access to both sides (Continuation & Spill) of the CSO
- 46% of the CSOs require special tools (of a type not normally carried by Operatives) to effect full entry
- 46% of the CSOs inspected have full plan area access above the screen

In summary there was restricted access to either the chamber, or the screen, or both, at 55% of the CSOs inspected; this restricted access was considered likely to restrict the level of maintenance carried out.

Regarding the type, installation and performance of screens, 35% of the CSOs inspected had powered screens, 62% had non-powered screens, and 3% had no screens. Of the CSOs with non-powered screens, 12% were self-cleansing and 88% were static; 37% of static screens had spray-bar cleansing systems.

Considering screen installation:

- The screens at only 52% of the CSOs inspected can be described as fully and correctly installed
- The screens at 95% of the CSOs inspected can be described as being in 'good' condition mechanically / structurally

Based on three performance indicators:

- The performance of 43% of the CSO / screen combinations inspected were found to be 'acceptable'
- The performance of 45% of the CSO / screen combinations inspected were found to be 'average' but
- The performance of 12% of the CSO / screen combinations inspected were found to be 'unacceptable'

The performance indicators for the CSO/screen combination were:

- Was there any evidence of spilled flows overtopping the screen?
- Did the CSO appear to be able to provide the intended relief function when required (i.e. no evidence that spill was caused by downstream blockages)?
- Where screens intended to self-cleanse were used, were they in fact keeping themselves clean?

The record was not good regarding operation and maintenance either; the operatives present on the day of inspection at only 28% of the CSOs were fully aware of the operation of the overflow, and had received appropriate training, some had never been to the site before the day of inspection. Routine, planned preventative maintenance was found at 62% of the CSOs; and in these cases it was being adhered to in general.

Evidence of Sewage Related Debris (SRD) was found in the receiving watercourse or adjacent to the outfall structure at 50% of the CSOs inspected but whether this was remnant from before the CSO scheme or whether it was due to poor performance is unknown (Figure 18). Whichever was the case the SRD would have been evident to members of the public.

The roll-out workshop concluded:

Location / Access - Location is generally driven by circumstance, there is often little choice, but design guidance / policy would be useful regarding access, ladders, etc.

Figure 18 Illustrations of the problems of not recording the initial condition of the receiving watercourse and not cleaning outlet screens as part of the CSO project

Hand–Over – This remains a grey area, contract documents often fail to identify procedures sufficiently, there is potential for standardisation or at least for improvement by adopting good contracting practice

Installation / Commissioning - Improved liaison between parties is required, ownership needs to be defined and the hand-over needs to be improved, commissioning should include completion

Equipment Selection / Standardisation - Standardisation would not address all Water Company / End User needs, and it could stifle innovation

Operation & Maintenance – There is not enough specific training, maintenance is reasonable but service levels are expected to deteriorate as more screens are installed but without the commensurate increase in personnel.

Post–Project – This is often neglected, responsibility is confused, it is not written into the scheme and therefore there is a funding issue, procedures based on existing work (UKWIR, YW, UU, TRPM) would be useful. Without genuine PPA we cannot learn from our mistakes.

It was generally agreed by those at the roll-out meeting that ‘parallel’ guidance covering the above issues be useful.

10 **CSO screens: a supplier’s view –** Frank Evans,

CSO Technik

The supplier or contractor must address issues related to design, installation, operation and maintenance to suit particular chambers and locations. When it comes to design there is often insufficient space in an existing chamber or in a new build, which could mean the screen and chamber design is compromised from the start, this presents the screen manufacturer with a problem, which is sometimes avoidable, but there is also often an issue that the design flow rates and/or heads given to the designer are wrong.

90% of all installation problems are due to poor civil engineering work completed to poor tolerances. With the pressure to complete there is seldom time to survey the completed civils in order to tailor the screen to the as-constructed geometry. Sometimes civil works have been finished after the screen has been installed.

From a supplier’s perspective the operational issues are frequency and efficiency of cleaning static screens and the inadequate access for cleaning at some installations of static screens.

Screen performance is compromised by insufficient frequency of inspection (ideally it should be looked at after every event) and lack of maintenance. Sometimes access is inadequate for screen removal and sometimes screenings get trapped at the end of a screen. Inadequate maintenance (some would say “what maintenance?”) can result from difficult access to the manhole and/or confined space, which makes it difficult to access the screen, and very often that operators aren’t given the manuals. Suppliers are asked to provide manuals but all too often these are stored in some office away from operational front-line staff who never have access to them.

Some of the answers to solving these problems would be achieved by involving the manufacturer soon rather than later. Installation and performance would be easier if the civil contractors were set specific tolerances and held to them, and that civil engineering work has been completed before installing the screen. It would be worth considering pre-fabricated standard sized chambers teamed with standard sized screens, probably a limited range of sizes would fit 80% of situations.

Chambers and access should be designed to facilitate cleaning and maintenance; in most cases it should be possible to design out confined space maintenance. To an extent a contract is no better than the morale and supervision; this applies equally to outsourced maintenance as it does to civil engineering. It is essential that the operators buy-in to the solution. There needs to be regular inspection and regular maintenance; CSO screens are not “fit and forget”. Complexity should be minimised and there should be clear cleaning frequency and efficiency targets. It is OK to select the lowest maintenance option provided that it is adequate and fit for purpose.

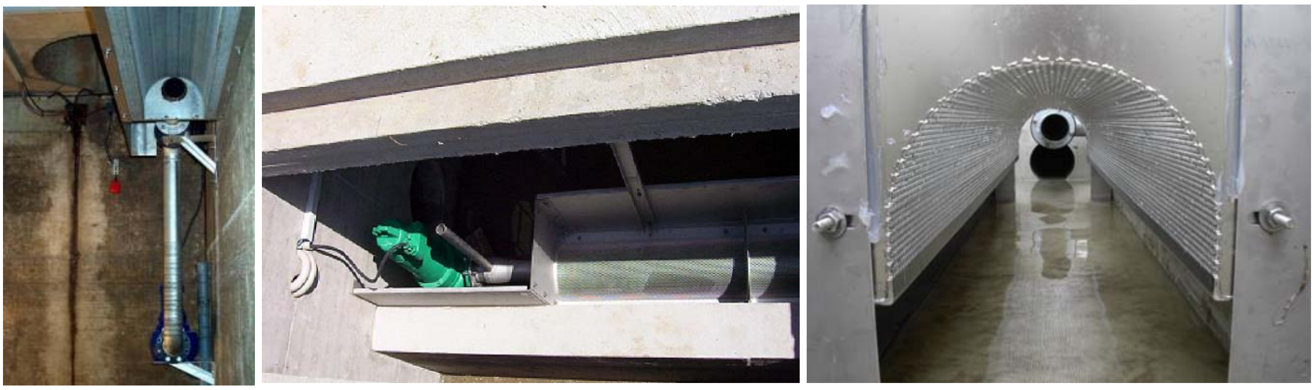


Figure 19 Three views of Pump Action Screens (left to right) from below within the chamber; from above with the weir foreground; along the length looking at the ejector pump.

Figure 19 illustrates the PAS (Pump Action Screen) which is described as simple and low cost. It is a 6mm perforated stainless steel sheet with an approximate open surface area of 40% which is preformed into a semi cylinder. Because there are no moving parts to the screen it is robust. The scouring system consists of a pump linked to an ejector and a venturi to induce air into the flow. Introduction of air reduces the oxygen demand of the spill and the pass forward flow. The pump is connected to the screen by means of a flange system. The pump can utilise either unscreened storm water (left) or screened (centre) as the water source. The PAS has no moving parts and consequently low maintenance requirements, the pump can be guide rail mounted, there is no confined space entry requirement and there are no screenings traps. Screenings are passed to the end of screen so they cannot re-present. PAS was tested at the National CSO Test Centre at Wigan in April 2003 (Test report No TRPM-REP094) it had a Solids Retention Value SRV of 58% which was one of the highest results achieved.

11 CSO screens: a supplier's view – Steve Skowron, The Longwood Engineering Co. Ltd.

We would really benefit from some design standardisation, at present water companies have their own standard or "signature" solution, the chamber design is probably to WaPUG recommendations but they have differing control philosophies, differing access arrangements and the devolved administrations of the UK do not even agree on the ATEX requirements[4]; Scottish Water classifies CSO chambers as Zone 1, United Utilities classifies them as Zone 2 and Severn Trent does not classify them as ATEX environments.

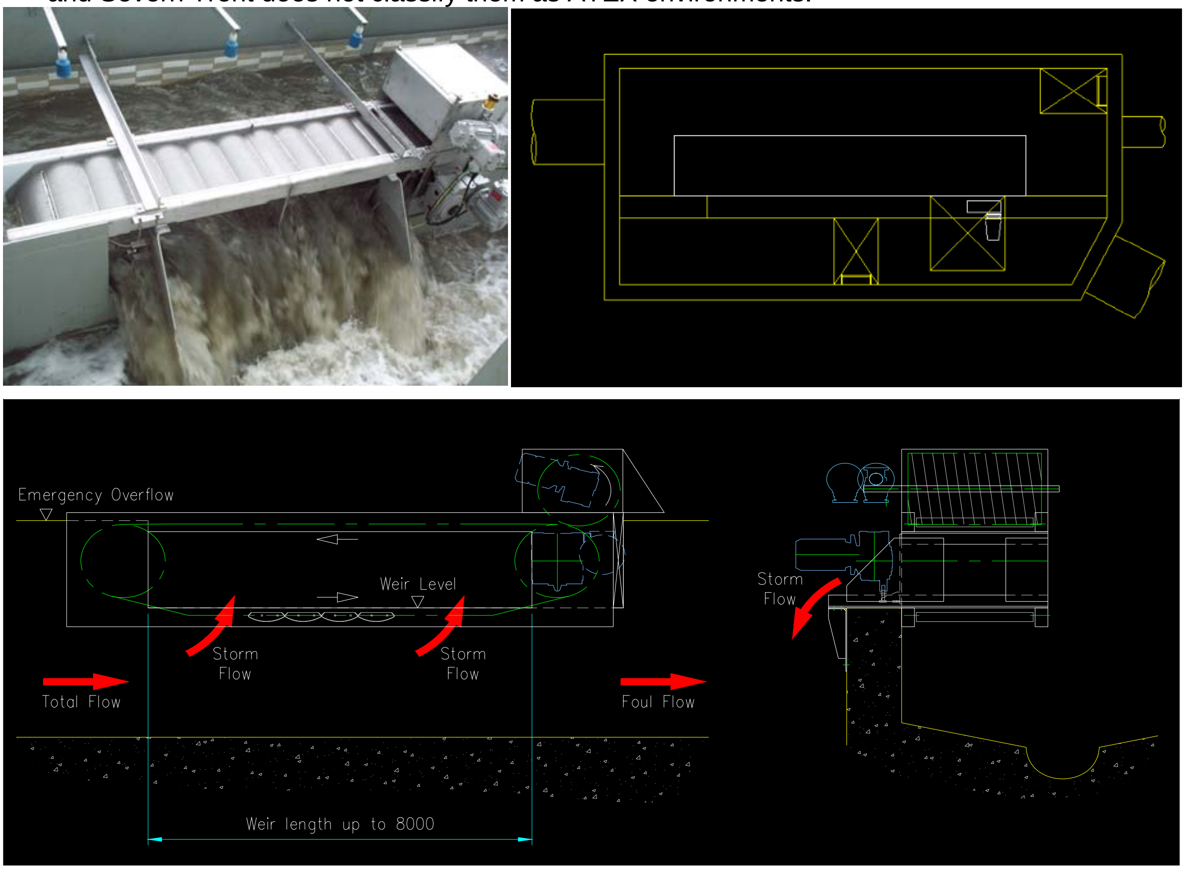


Figure 20 Illustration of a moving screen CSO screen (the Longwood Stormguard) at the Warrington test facility and plan (top right) and side and end elevation.

The features of the screen illustrated in Figure 20 are that most items are accessible from the dry side but access is required at both ends of the screen, which on a few installations may necessitate a hinged platform if the height to weir is too great; small screens (up to 150 l/sec) can be guide rail mounted for removal as a whole. Grease lines are extended for ease of maintenance. Over 500 screens have been sold but there has not been much feedback, either that is because they are performing faultlessly or because they are "out of sight, out of mind". Many of these installations have telemetry. There was frequently a lack of design information; quite commonly no more information is given than the flow. Longwood Engineering uses a 50% blinding factor as a conservative assumption but for 'end of line' chambers a blinding factor of 75% would be more appropriate, because of the accumulation of carried forward screenings. It might seem obvious but it is important to get the outlet pipe level correct otherwise the weir can be surcharged. Relief weirs should be positioned upstream of the screen as screenings tend to congregate at the downstream end of the chamber. The screen supplier should be contacted at an early stage of the design. Modular construction screens are available for existing chambers with limited access.

[4] Equipment and Protective Systems intended for use in Potentially Explosive Atmospheres derived from ATEX Manufacturers Directive 94/9/EC and ATEX User Directive 99/92/EC

12 **Choosing the Right Screen for the Framework?** - Peter Myerscough,

Yorkshire Water

Yorkshire Water's dilemma was that it felt that the published data did not differentiate enough between screens. It wanted a Framework contract with three manufacturers selected on the basis of confidence in their screens' overall performance, their abilities to deliver cost effective solutions and to drive efficiencies through the process.

To provide the answers YW decided to set up a testing facility at Knostrop WwTW that would replicate reality for flows in the range 40 l/s to 260 l/s assessed by the depth measured at three locations. The facility should also be capable of subjecting screens to a range of loads from average loading up to thirty times average loading when the screens were clean and when they had been blinded to controlled extents. It was decided tests should be continuous and carried over a 48hr period and they would include assessment of how well the cleaning mechanisms work.

Figure 21 General views of the CSO evaluation facility at Knostrop

The facility and the testing work cost £100,000, it yielded valuable results and gave an objective basis for the company to establish its policy, which has changed and will continue to change as a result of the information gathered.

Figure 22 shows the purchase prices of powered screens from different manufacturers as a function of their wetted area; five were very similar, two followed a different trend and one was a completely different magnitude from the rest, although interestingly the slope of its relationship was similar to the five. However purchase price is not the only criterion as other authors have discussed and the whole life cost gave greater differentiation.

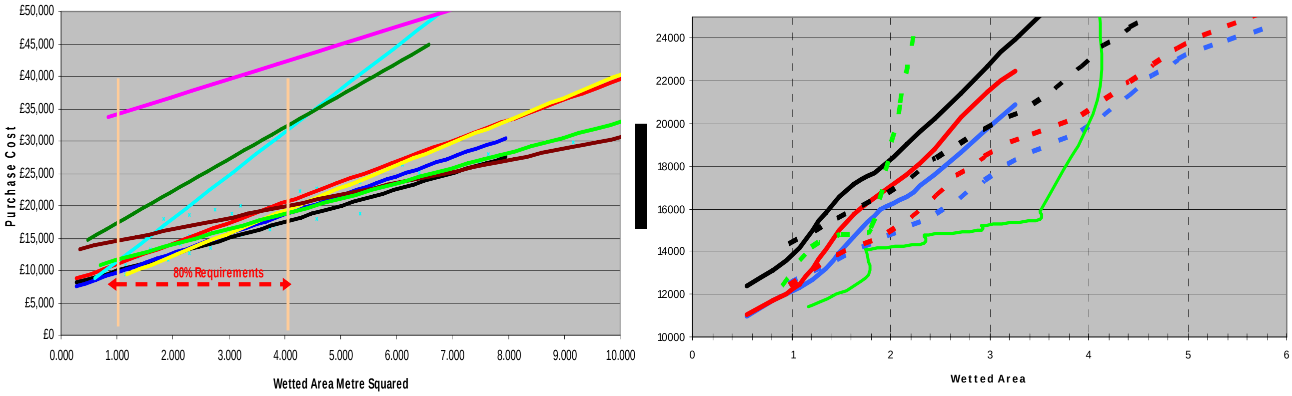


Figure 22 Results for powered screens: left, comparison of purchase price vs wetted area and right, "whole life cost" vs wetted area for different manufacturers

Yorkshire Water considered the following features in addition to cost: guarantees and warranties, lead times from ordering to delivery, design freeze, construction time, consignment stock, a company's approach to innovation and ideas for future developments, the potential to gain share, adherence to the new NEC form of contract, spare parts price list and lead times, adherence to supply chain specification and whole life costs. YW constructed contract management databases. It also held regular (monthly) workshops/clinics with manufacturers and designers to share and exchange information. Initially there was hesitancy to share information and risk competitive advantage but in practice the adage that if 5 participants each contribute one piece of information, everybody leaves the meeting with 4 pieces of information they did not know at the start of the meeting; these workshops have proved very productive.

12.1 Scottish Water Solutions' post meeting contribution - Brian Dalton

Scottish Water Solutions[5]

Key members of Scottish Water Solutions' CSO team have discussed the report and they agree it is pretty comprehensive and covers most points. Rather than comment on individual remarks or observations in the report, I list below the key issues that Solutions have dealt with in delivering their screen installation programme.

1. Rubbish in means rubbish out. The most important point is the information gathering and quality of information. The CSOs need to be part of a full catchment survey - a Drainage Area Study with a hydraulic model produced. Surveys of the chambers and chamber locations need to be carried out to verify the accuracy of the representation of the CSO in the model. Datum points require to be confirmed and upstream and downstream manhole levels checked and CCTV surveys carried out. Only then can the design begin.

2. The use of a "Signature solution" or standard design to accommodate the range of screens proposed is helpful. The main feature of this is the access requirement to the screen and level sensors which should be detailed on these drawings. The Signature solution should comprise of standard detail drawings and a flow chart selection matrix to select the screen type required based on number of spills and peak spill rate. Solutions specify a powered screen for spill instances above 400 L/s and more than 24 spills per year

3. Use of Frameworks to standardise the equipment provided. Solutions are using Longwood for powered screens and Hydrok for static. The suppliers are involved early on in the process

[5] Scottish Water Solutions was formed in September 2003 by Scottish Water to manage and deliver 70% of its Quality & Standards II Investment Programme. There are more than 2,300 projects in the £1.4bn Programme. There are eight companies in this unique joint venture, making it one of the biggest partnering agreements in the world.

and have access to drawings through Solutions on-line Document Management System (Internet based "Build on Line")

4. The WaPUG guide for CSO design is helpful and most of the detail is incorporated into the Signature solution. A solution can be proposed by hand calculation for weir height and length (to suit screen) and then trialled and refined by running the model with the screen represented to simulate headloss by adjusting the weir co-efficient. The solution should not create flooding or worsen existing flooding. Generally it is best to have double sided weirs to reduce the head over the weir to minimise upstream impact on water levels. Outlet flow control, if required, can be provided by Orifice plate penstocks with a minimum opening diameter of 200mm. These can be opened in the event of chokages and are more effective than penstocks and less likely to block than "Hydrobrake" type controls.

5. In partnerships like Solutions, the work is carried out by in-house Contactors and associated Contractors. Designers' input to the construction phase is required by CDM regulation and designers should be encouraged to visit sites and should be checking that due attention is given to critical dimensions (weir height, length etc.)

6. A comprehensive sign-off process must be adhered to. In Solutions a "Beneficial in Use" process which must be complete before the investment output can be claimed by Solutions. This involves checking all hand over documents (Operating manuals, Drawings etc.) and a site visit by the Ops & Commissioning section of Solutions and a health and safety Inspection with Scottish Water in attendance.

13 Discussion session 2

Steve Dempsey – Frank Evans had made a very good point when he said it was a pity there are no contractors at the meeting. Also there is only one representative of front-line operators– the bottom line is that operators take over the issues and their presence would have been valuable.

Frank Evans - The cost of building a chamber could be £¼ million for constructing the civils and only £15k for the screen and ancillary works.

Steve Dempsey – This raises a series of 12-15 questions – all about how you operate and control the screens. 4 signatures are necessary for sign off a scheme. WaPUG is a planning group which now seems to be changing focus, possibly too late. Today is a good event, if we continue the momentum.

Bruce Adams - I think it is particularly worthy of note to mention Post Project Appraisals and when they are conducted. I don't think it is right to conduct these PPAs during the construction period. There were some examples of this today. PPA should be X months after handover when the screen has been in operation for a while. That would be an example of how it performed in practice. It would have to be dealt with by the contractor. PPA timing is important. It is associated with the screen test, difficult to get an understanding for the next periodic review – there are very few data available.

Peter Myerscough – Yorkshire Water's PPA was 6 months after handover. We want to get feedback into our file as well. Our programme covers 3, 4 and 5.

Bruce Adams - Something that Frank picked up about CSOs, was whether they are signed off before the screens are complete. It is the regulatory output. All that was done was to make sure the chamber was constructed, the screen was in place and the telemetry was working. The Environment Agency (EA) could then come and inspect it and give it its regulatory "tick" before the roof is on.

Frank Evans - We have had examples of regulatory ticks for where power screens that require cleaning are in place, but can't be cleaned because there is no power supply. When the power is not connected until two months into operation you have to go into commissioning with a live sewer and risk assessment is then needed to get in there and clean it and commission it.

Bruce Adams - That goes back to programming and it goes back to the "bean counters".

David Balmforth - Some things we have influence over and others we don't. This is now the 4th AMP; this time we are supposed to be better prepared.

Tim Evans - Why does the EA sign off things that haven't been proved to work?

Phil Hulme – The Agency will do an annual return to OFWAT to say the scheme is consented to meet the AMP objectives and has been informed by the water company that it is constructed and operational, the EA is one part of the team.

Tim Evans - How is it operational when there is no power?

Unidentified contributor - Post Project Appraisals have two elements: a) technical aspects and performance review and design and b) construction and commissioning process review. We carried out several PPAs during the mid to late 90s and identified the problems with the process review. What it suggests is that organisations should have the appraisal clearly as part of their culture, throughout their organisation. I think it is important for all organisations to look at how they are going about it.

Steve Dempsey - We are talking about guidelines, templates, stuff like that. We have got problems at the end of the construction period. Knowledge management, what do we do with that knowledge? We have to keep asking the questions, why, how, where?

Peter Myerscough - We have a knowledge transfer group, four contractors on a monthly basis, pass on information. Good communication.

Steve Dempsey – It should be possible to do the things that are required can be done with the CSO Research Group at Wigan. However the UKWIR research was woefully underfunded. At Yorkshire Water measured the depths to estimate the capacities and the loading rates. Peter Myerscough has a good relationship with the regulator. Appropriate organisations have to get together.

David Gordon - Yes, we can all learn from each other, but I do agree with the point that Mark was making. We need to get the knowledge out there. There have been a lot of new people getting into the Industry. Guidelines do at least outline the issues that need to be addressed and are a good starting point.

Tim Evans - I find a lot of this quite surprising. Much of it sounds like the benefits and method of working of Partnering. The best exponent of this that I have seen has been BAA with Terminal 5, perhaps not surprising since Sir John Egan's ODPM committee recommended it. Everybody gives the impression of being in the same team with the same objective irrespective of who their employer is and where their pay cheque comes from. The best exponent in the water industry that I have seen is Thames Water. I thought the water industry had adopted Partnering. Is that wrong?

Peter Myerscough - What we have done over the last six months will be out in the industry within the next six months.

Andy Eadon - We are the publishers. This is a workshop of specialist people. We haven't got to the researchers and regulators. What more information do we need? It needs to be directed at a political level, in my view. I have been talking to politicians at all levels and they think that we have fixed everything at AMP2! This is an opportunity to generate more views.

Tim Evans - Do these things work? It would be interesting to know. On the subject of maintenance, Peter Forster does a lot of work on European standards and he says he thinks our proactive work on sewers is woefully deficient. He says he's sad to admit the France and Germany do a lot more proactive work. On one of his company's completed CSO schemes he was told it was spilling frequently, which he could not understand on the basis of his knowledge of that section of sewers. When he looked down the sewers he found debris from the construction work was causing a blockage. Now that it has been cleared the CSO never spills. Was this £¼ million scheme really necessary or would it have been avoided by proactive maintenance? Do you think, as a nation, we do not do enough maintenance?

David Balmforth - CSOs are upgraded out of capital but maintenance is an operating cost, i.e. it comes out of profit. One of the things to pull out is “nuggets”. It would be nice to record some of the key points that are being made. Understand what we need to do to improve the processes:-

1 the value of integrated teams and good co-location - Partnering
2 knowledge sharing within and between companies – how do we do that better?
3 guidance is limited – we need to understand & develop this
4 succession planning – how do we transfer the knowledge and pass on the baton?

14 **The Yorkshire Water CSO & Screen Test Programme** – John Blanksby[6]

The University of Sheffield, Pennine Water Group

The aim of the facility was to establish the hydraulic capacity of the screens for different screenings loading rates and validate YWS Ltd.’s precautionary reduction in screen loading rates was appropriate. Specifically the objectives were to assess objectively the impact of blinding on screen performance how screen cleaning mechanisms work, the effect of prolonged operation at variable flow rates on visiting frequency and to investigate the effect of changing chamber geometry. Eight screens were tested: 2 static (operator cleaned), 1 self powered (hydraulically cleaned) and 5 powered (electrically driven cleaning mechanisms).

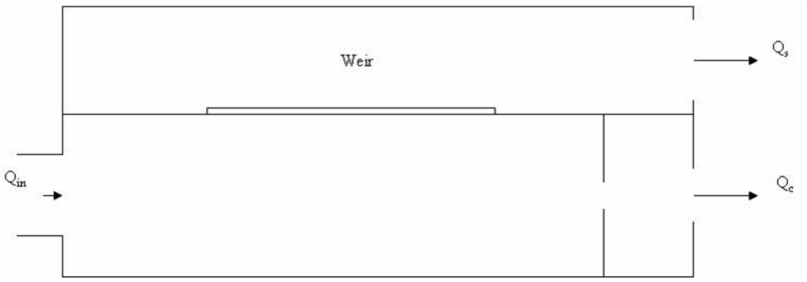


Figure 23 Plan of the test rig (see also Figure 22)

The dry weather flow load per person (DWF load) was determined from field work; this was used to calculate the nominal population served by the test screens from their design flows (5 year return period peak flow). Tests were carried out at different multiples of DWF load to represent the impact of flushing deposited material during wet weather. Flows in the test rig were dosed with screenings to achieve multiples of DWF load (Figure 24).

Figure 24 Weighing out the solids/screenings (left) and the dosing column (right)

[6] This presentation was co-authored by John Blanksby, Adrian Saul, Dennis Dring and Peter Myerscough

Flow was measured using an externally mounted ultrasonic Doppler transducer mounted on inlet manifold. This was calibrated against the depth of flow over the weir and through control which was determined by laboratory testing.

Depth was measured by using ultrasonic depth transducers located at different locations within the chamber; these were backed up by rulers (measuring rods) fixed to chamber walls that were read visually.

Solids were collected to confirm the loading rates, the solids retention efficiencies and the associate solids load with depth discharge relationship for each screen at different degrees of screen blinding (determined from controlled blinding tests in laboratory). Solids were collected from the continuation flow, the spill flow, the chamber after test and the screen after test.

The tests screens were fixed within the chamber as if they were being located within a real CSO; the chamber dimensions matched those of the UK standard side weir chamber (FR0488). They were assessed under steady flow conditions and under continuous flow tests over an extended period of time (Figure 25). The screen was tested for different periods of time at flow rates representative of a typical year. As a consequence the majority of the test was carried out at relatively low flow rates.

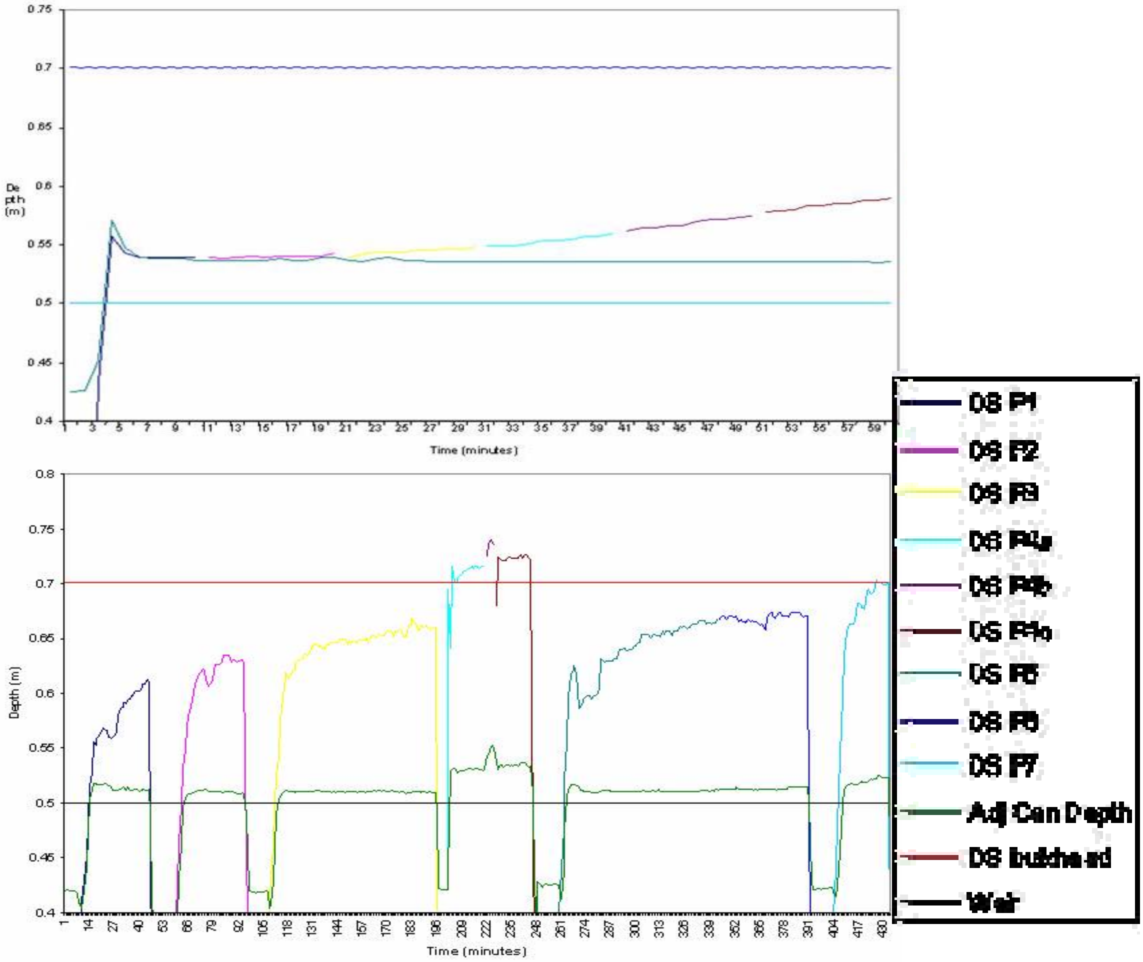


Figure 25 Result of testing a static screen under steady flow conditions (above) and data from day 3 of continuous flow (below)

Depth discharge relationship was checked to compare actual performance with manufacturers' claims and checked against controlled blinding tests in the laboratory to establish percentage blinding.

The impact of chamber dimensions was assessed by carrying out tests at different flow rates with varying weir height, chamber width, stilling length and inlet pipe diameter and also under the continuation flow regime with and without baffles to represent screen in-flow.

Conclusions:

- The tests justified the decision of YWS Ltd. to amend the screen design flow rates in its design matrix
- The results of the tests for each type of screen, are being included in the Yorkshire Water CSO design matrix
- Methodologies have been developed for determining:
  - the size of powered screens and
  - the cleaning frequency of static screens
- The tests provided a valuable insight into the operational performance of screens in the field and resulted in improvements to screen design
- The tests have demonstrated that chamber dimensions are critical and recommendations have been made with regard to minimum size

15 Discussion session 3

Tim Evans - Do you perceive that the character of screenings is changing over time, or is it the same as say 10 years ago?

John Blanksby – I don't know whether the nature and quality of screenings has changed over the years but they do change along the length of the sewer. At the top end they are mainly faecal and tissue whereas at the bottom these have disintegrated and plastic and sanitary products dominate.

Jeff Pierson - Did you do any calculations based on when the maximum loading hits the screen?

John Blanksby - The maximum load of screenings hits before the maximum flow. We had variable speed motors on the screen and carried out a series of tests including flow loading rate.

J Pierson – If the maximum loading hits before the maximum flow, how do the CSOs impact on this? Does it impact further down the system? It is very difficult to design the screen for maximum screen load.

David Balmforth – The amount of solids conveyed down the system to the treatment works has increased as a consequence of CSOs; this is a treatment works issue.

David Balmforth - At the start of AMP4 what new technology available to use to understand maintenance? We need to understand the potential and how we might interpret the results.

David Hanson - However, as an Industry we have been talking about the last twenty years.

D Balmforth - We need real time maintenance and real time control. This is a question to the regulator. Do they feel that the screens in AMP3 have actually achieved the objective of controlling aesthetic pollution?

Phil Hulme - We haven't got the resources to visit them all. Risk based regulation means we don't go looking for environmental problems, unless we are leading up to the next AMP. If the new consents which secure the improvements are complied with by the discharger the risk to the environment will be low. Isn't it up to the discharger to ensure they comply with the consents they have applied for / accepted to achieve AMP sign-off?

16 Group Sessions and Feedback

The delegates were assigned to four groups and asked to consider the following topics for discussion:

- Whole Life Cost
- Role of Monitoring in Maintenance Management
- Handover
- Project Proposal Appraisal
- Communication/Partnering
- Knowledge Management
- Do they work?
- Proactive Sewer Maintenance
- R&D requirements

16.1 Group A

PRESENTATION GROUP A
❖ **Whole Life Cost, Monitoring, Maintenance, Communication, Knowledge** ❖ Attitudes to maintenance changing – more sensible approaches – different companies at different stages ❖ Not all screens needed - evidence of no operation – need for regulatory challenge ❖ Current maintenance interval scheduled – intervals adjusted on experience ❖ Telemetry now going in. Telemetry driven maintenance expected ❖ Maintenance focussed on blockages & cleaning rather than M & E ❖ Screen suppliers not selling the spares they might have anticipated ❖ Screens still “low maintenance” due to infrequent operation – hence low impact on whole life costs ❖ **Mixed evidence of feedback from Post Project Appraisals – need for better knowledge sharing and communication** ❖ **Current data on maintenance not being used to drive improved processes – need for more knowledge sharing**

16.1.1 Group A Presentation & Commentary

Identify key elements of whole life cost – for the screen is maintenance the key in the long term

PPAs are very valuable but there is a problem in that there is no direct funding, unless it has been written in as part of the capital scheme, which would be a very good idea. PPA could start at a basic inexpensive level of complexity and increase as necessary and as telemetry data and rainfall data become available. Snagging should be picked up as a routine part of the capital scheme, it is not PPA and it is not an add-on. There is too little supervision of site work; it is inhibited by Health & Safety rules.

Handover - As an Industry we have not done nearly as well as we could do. Better communication is needed. Often it is no more than a check list. At the outset we should know what we are trying to achieve. Are we able to maintain it in the way that we hope to? Is there a cultural problem in what we are trying to do?

Knowledge Management – There is an issue on how we work and who is going to pay for it, if we want to share the knowledge? New graduates starting – time to learn and to build on experience.

Proactive Sewer Maintenance - Telemetry to pick up spills when there has been virtually no rainfall, which would indicate that there is a problem. Make sure maintenance schedules are correct and ensure they are effective.

Possible future areas of research - drivers are future policy changes, and climate change related rainfall changes. Do we look at other ways of dealing with rainfall induced flows?

16.2 Group B

PRESENTATION GROUP B

- **Whole Life Cost**
  - If WSP wants to do it, it will do it! –perceived to be valuable
  - Identify the key components
- **PPA – Funding**
  - Generally cheap and cheerful
  - Telemetry – [there have been locations that have spilled following 4 weeks without rain], it could start simple and then get more complex if necessary
  - Each WSP has UK wide report
  - Not a substitute for snagging
- **Handover**
  - Not as good as it should be
  - Checklist for achieving compliance – and what WSP expects (maintenance etc.)
  - Is there a cultural problem in sewerage?
  - Is the promoter being too nice?
  - REs should be hands on and do snagging as work progresses
  - However – adverse impact on cost

16.2.1 Group B Presentation & Commentary

Maintenance Issue:- The water companies are getting better and smarter about maintenance. Monitoring, communication, knowledge management, and PPAs are all part of ensuring CSO screens give good service.

Consultants, water companies, contractors, screen suppliers all need to work together. Currently they all have a different perception of how much maintenance is going on. Water companies are now taking a much more proactive approach to maintenance and there seems to be quite a lot of use of technology in use for giving feedback from the data.

PPAs, - It has been found that some CSOs never spill; the screens are not required to operate. Why are we installing a screen if there is no requirement? Do we need Regulatory changes?

Current practise is often to derive maintenance intervals from an iterative approach. Telemetry is starting to go in and this will enable maintenance to be tailored to events and thus to need. In the USA the MWH telemetry system calls up the spares from the suppliers. M & E fairly long term approach. Contractors are actually questioning whether the level of maintenance expected is happening because sales of spares are not happening.

Whole life costs, some screens operate infrequently, influence on whole life cost.

Information on PPAs doesn't always get right back through the supply chain, back to the suppliers with whom it should be shared.

There would be value in sharing information on maintenance (including costs and frequency) between the companies; WaPUG is trying to do something on this.

16.3 Group C

PRESENTATION GROUP C

- **PPA**
  1. Advantages
     - a) Knowledge Capture
     - b) Identify issues/exposure to risk
     - c) Does Investment future/residual work?
  2. Disadvantages
     - a) Cost
     - b) Bureaucracy
     - c) Gaining interest from management/industry
     - d) Noted and Lost
  3. Who should be involved?
     - a) All Stakeholders? EA? PR?
     - b) Operators
     - c) Designers
     - d) Suppliers
     - e) Contractors
  4. Current Deficiencies
     - a) See results of Thompson RPM Presentation
     - b) Truly PPA – i.e. after construction and commissioning have been completed and following period of operation
  5. Input from WaPUG?
     - Site specific not appropriate but examples OK
     - Knowledge base: should be wide
     - Should feed into design guides/best practice guide
  6. Needs to be generic "No Blame"
  7. Conclusion: WaPUG Best Practice Guide

- **Proactive Sewer Maintenance**
  - Look at outfalls at least
  - Check Telemetry
  - Ensure incidents relating to CSOs are highlighted
  - Analyse the performance
  - Check telemetry against intended performance
  - Enact maintenance schedules and assess effectiveness
- **Adaptation of Current Assets to Future Drivers**
  - Understand movement of screenings

- **Knowledge Management**
  - Son of WIMES
  - But include info on Chambers
  - How do WSPs share info that they have funded themselves?
  - But include info on Chambers
  - How do WSPs share info that they have funded themselves?
  - Time for learning and experiencing

- **Do They Work?**

16.3.1 Group C Presentation & Commentary

Role of monitoring, maintenance, operator training and skills, performance of the CSO, physical survey, Knowledge Management – all these elements are part of the PPA.

Advantages of PPA – identifies: areas of weakness or for improvement, owner's and environment's exposure to risk

Disadvantages of PPA – who pays? It is costly and bureaucratic.

- There is mounting interest from management in the industry
- A lot of information is gathered, where does it go? Just put into a drawer or shared? If it's shared, how widely is it shared?
- Need to involve operators, designers, suppliers and contractors to look at current deficiencies in the PPA. Should the EA be involved?
- We need to have the investigations after the job has been finished and been operated by the client for say 6 months or a year. PPA should be "no blame".
- We are already into the next AMP period and want to get on building these things. Do we need to look at this now or do we risk repeating mistakes made in AMP3?

Most members of the general public don't know CSOs exist – do we need to involve PR?

WaPUG – there are a number of generic issues. Can we put in a design code or a Best Practice Code?

16.4 Group D

PRESENTATION GROUP D

- ❖ **Whole Life Cost**
  - What are they?
  - Bit like statistics – get the answer you want
  - Quality suffers due to capital savings
  - Minimalistic Design
  - Should be part of Solution Decision
  - WA must be able to determine the costs
- ❖ **Handover**
  - Who accepts sign over?
  - Different in Different Water Authorities?
  - Handover is always in dry conditions – Operator is 'exposed'
  - Savings could be made
- ❖ **Communication/Partnering**
  - Biggest problem is AMP length
  - Advantages in not communicating i.e. standard approach, get output
  - Does work
  - There are good systems out there not necessarily consistent or being used
- ❖ **Knowledge Management**
  - Guides need to have flexibility – give background data
  - It is needed
  - Who funds it?
  - How is it brought into being?
  - Need to remove competitive element (between WAs)
- ❖ **Do They Work (CSOs)**
  - What is acceptable?
  - Unsatisfactory is Public Complaint or Letter
  - PPA Surveys
  - Unknown as EA is under funded
  - NOT enough info to say they don't work – Yet, we are painting black picture?
  - Increased screenings at WwTW

16.4.1 Group D Presentation & Commentary

Whole Life Costs, how do your discount whole life costs? Does everybody have the same discount rules? Value engineering increases WLC. WLC should be part of the decision making process.

Water Companies must be able to determine the cost of their activities and processes; someone is being paid for doing the maintenance, so it must be determined in some way.

Handover - Who should accept the handover? This is done differently in different Water Companies. Different backgrounds, we have at least three different methods of getting handover at the end of the job. Handover is always done in dry conditions. Group D was aware of at least three CSOs that had been accepted (handed over) that had screens that had been put in the wrong way round. If handover was done right with all the relevant parties it could save money.

Pro-Active Sewer Maintenance – It improves performance. Mainly for aesthetic element of screens, to ensure flow is correct capacity and minimise spillages. If you do the maintenance, you know when the screen will start to fail. If you have to do a second job on the same site, you have the records of the previous jobs. If it is done right, it will prove cost efficient. Do we record pro-active maintenance outside of the reactive maintenance?

Do CSOs work? - What is acceptable? If 51% work – and 49% don't, is that acceptable?

PPAs – should be written into the capital scheme.

The EA is not funded to systematically review all CSOs. The improvements are secured through discharge consents, which the discharger must comply with. The EA has not quantified the benefits realised on the ground so does not really know whether the AMP3 investment has delivered in all cases, but if there were wholesale failings there would be complaints from the public that would make the EA aware of the situation. We know there are more screenings at the WwTW because they are being retained in the system. No other information at present to understand why they don't work?

Knowledge Management – There has been no great increase in flexibility, there is a bit more background knowledge for people to understand the subject better. Knowledge Management is needed – big question is who pays for it? Competitive element is there between design companies but there is no competitive edge between water companies so there should be no barrier to pooling knowledge.

Communication/Partnering – Partnering works. For the 5th AMP there would be benefit from an improved length. Get standard approaches, get CSOs the same. Following the standard, get the output.

Advantages in not doing communication.

Have systems out there, water companies have slightly different systems – WaPUG do something about this?

17 References

Egan (1998) Rethinking Construction: The Report of the Construction Task Force (Egan Report) Department for Transport Local Government and the Regions DTLR (formerly Department of the Environment, Transport and the Regions) July 1998 http://www.constructingexcellence.org.uk

FWR (1994) Guide to the Design of Combined Sewer Overflow Structures updated November 1994, FR0488. Foundation for Water Research. http://www.fwr.org/ [Publications] [FWR/WaPUG Workshops]

Sharpe D.E. and Kirkbride T.W. (1959) Storm-water overflows: The operation and design of a stilling pond, Proc. Instn Civ. Engrs, 13, pp 445

WaPUG (2001) WaPUG Guide - The Design of CSO Chambers to Incorporate Screens. Wastewater Planners Users Group, June 2001 http://www.wapug.org.uk/ [Publications] [Modelling guides]

WaPUG (2004) Autumn Conference No 20 http://www.wapug.org.uk/ [events] [past events]

WRC (1988) A guide to the design of storm overflows structures. Report ER304E. Water Research Centre, 1988

Appendix 1. Abbreviations and acronyms

CSO	combined sewer overflow
OFWAT	Office of Water Services
PPA	post project appraisal
SRD	Sewage Related Debris
UID	unsatisfactory intermittent discharge
UKWIR	UK Water Industry Research Ltd.
WIMES	Water Industry Mechanical and Electrical Specifications www.wimes.com

Appendix 2. Notes & Feedback

Each delegate was given a workbook for recording feedback on the different sessions; the following is a compilation of all the responses.

A Background View – David Balmforth

Name	Topics/Points I agree with
Jonathan Cutting	Head losses need to be considered – underestimates were common early in AMPs. Screening return and reverse flow is a major issue but and solids loading does need further research.
Chris Day	Better understanding of screenings loading required. Improved monitoring is required to assist maintenance.
Steve Skowron	Agree with content
Jo Haigh	Post project appraisal, maintenance and monitoring with the scale of the AMP3 programme.
Steve Dempsey	Screen technology must move forward. Screen blinding is generally less than 25% - however we tend to design to 50% blinding and screens are at their limits – so what is the missing “factor”?
Andy Eadon	Important functions, of CSOs are often overlooked i.e. controlling flooding and protecting treatment works. Reluctance to use screens – initial reliance on quiescent separation of solids. Storing first flush is a good principal. Not enough attention given to screens return.
	Topics/Points I do not agree with
Jonathan Cutting	A static screen is not better for reverse flow, blinding issues must be resolved.
Steve Dempsey	Storage retains solids due to 1^{st} flush before peak inflow – this is correct for a single overflow but if there are CSOs in series the loads gets spread out through the storm. Screens will give a head penalty – this may not happen if the existing CSO is too small or a hole in the wall and can be eliminated by good design – longer weirs etc.
John Blanskby	The Industry did not carry out any significant tests on screen performance prior to AMP 3
	Other Comments
Jonathan Cutting	For the water companies with lower standards has this had a worse impact on receiving water courses? Blinding during events varies so it is important to consider the worst case.
Steve Skowron	Well presented.
Jo Haigh	From EA point of view there has been a small decrease in the complaints from the public about CSOs. There is however a slight increase in soft blockages at CSOs.
Steve Dempsey	Good slides, pictures and diagrams not words.
John Blanskby	% blinding is a function of cleaning rate. It can be significantly more than 35%. However screens can be blinded to 60-70% before the depth/discharge relationship is significantly affected.

Owners/ Operators Views

	Topics/Points I agree with
Mike Foote	That maintenance schedules should be site specific and are essential to optimise performance. Agree with the use of first-flush baffles.
David Hanson	WLC critical to get most cost efficient solution. Getting power for sites has significant impact and puts water companies at risk.
Chris Day	Sluice Beach – stilling area should be reduced/removed.
Brian Butler	Need for design standards. Need for maintenance standards.
Jo Lambert	Operating/Maintenance checklist on site.
Steve Skowron	Baffle boards to keep solids away from screen concurs with our thoughts – good idea.
Ken Ball	Essential that flow controllers are maintained. As a 'hands on' engineer I have inspected screens and chambers myself and on a number of occasions screen performance was greatly affected by flow controllers blocking and poor design caused accumulation on solids in the CSO chamber.
Jo Haigh	Guidance documents. Maintenance programmes.
Steve Dempsey	Data sheets located @ CSO Very open presentation highlighting YWS failings in controlling design and construction.
John Blanskby	Provision of laminated sheets on site. Involvement and ownership of operators essential.
Andy Eadon	Frequency of maintenance is part of design What would it take to capture costs of maintenance?
	Topics/Points I do not agree with
Steve Dempsey	3 of the 4 points on the 'Future Consideration' slide were known about in AMP2 but ignored in AMP3 for 'cheaper' solutions. The 3 are; screen run-on, scum boards and the need for increased maintenance.
	Other Comments
Mike Foote	The selection of a static screen should not be based purely on flow rates. The percentage of suspended solids should be taken into account. This would ensure that the most economic solution can be considered.
David Hanson	All WC's should combine together with research funding to benefit the industry as a whole.
Jo Haigh	No account of risk of non-compliance of assets through OFWAT penalties is made in either design or maintenance programmes.
Angus Willis	Provide manufacturers with gross pollutant load and screens can then be sized correctly.
Steve Dempsey	Most of the problems identified seem to stem from lack of post installation training – this is the problem and some of the measures put in place appear to treat the symptoms not the problem. Good to see PPA being done and being honest. Brush failure on helical screens is an old issue – most failures are due to poor maintenance with re-fitting the brushes.
John Blanksby	Design weirs to direct flows to screen to maximise effect – tapered/sloping weirs. If screening removal is at downstream end, direct/move flow to upstream end to compensate for additional screenings at downstream end.
Andy Eadon	How much is spent on screens' maintenance? The correct costs are difficult to capture.

Post Project Appraisals – Barry Thompson

	Topics/Points I agree with
Jonathan Cutting	Access issues are important. Outfall clearing @ commissioning.
Mike Foote	Access should be improved to ensure proper maintenance. Site specific training is required.
Chris Day	Outfall must be cleaned at commissioning. More consideration to be given to access.
Alison Court	(Not an engineer) I am surprised that handover does not seem to pick up the basic checks highlighted by Barry's work. The simple cleaning up of debris before commissioning would seem an essential check on whether the scheme has delivered the required performance.
Jo Lambert	Highlighted issue that although CSO designed to meet standards, poor installation and maintenance will affect actual performance.
Steve Skowron	Interesting and useful presentation.
Jo Haigh	Use of post project appraisals. The majority of the points made were salient and should be part of industry standard expectation.
Steve Dempsey	Very good points for designers to take on board. Commissioning/Handover/Training needs to be improved. Easy to do it sectional completion is put in the contract with moneys held against these activities.
Christian Arias	Survey programmes should be implemented to monitor performance, provide design teams with feed-back and confirm that installation was suitable. This workshop and report highlight poor handover and QA procedures (bad installation – construction) in some sites and shows apathy by all parties. The workshop provided useful feedback like identifying major issues and shortfalls related to standards, screen selection, installation, handover and operation & maintenance. The development and implementation of Post Project Appraisal is necessary in the industry.
Andy Eadon	Post appraisal provides feedback for designers and operators. Location is a major problem for access for maintenance especially vehicle access. Guidelines need to be extended into this area.
	Topics/Points I do not agree with
Jonathan Cutting	How can it be established whether overtopping is for a 5 year storm or not from a single visit with no rainfall data?
Alison Court	Plenty of excuses and examples of shoddy workmanship – with potential to affect screen performance. No real excuse for this – should be identified in commissioning and handover.
Steve Skowron	Standard design guides are a useful tool in identifying the issues to be addressed when designing CSO's
Jo Haigh	Timing of PPA – some of the work was on design issues, these need to be addressed.
Steve Dempsey	Use of special MH cover lifting tools is a problem – Under the manual handling regulation these should be used for all M H covers and you can get tools that will open nearly all MH covers.
Christian Arias	Water companies within the industry have different standards and specifications. Sharing information and cooperating to unify and simplify guidance and specifications would help reduce confusion within the industry and provide more efficient and simplified information while cutting costs. The water companies should avoid providing parallel guidance.
Andy Eadon	Conducting post appraisals during construction.

	Other Comments
Jonathan Cutting	Chamber access is not good enough if not to both sides of the screen. Special tools have benefit of H&S + security but do also create issues for access by contractors etc.
David Hanson	Audits need to differentiate between 1 in 5yr storms and less so that the legality of the CSO can be evaluated.
Alison Court	Some WAPUG guidance on handover checks is a good idea.
Brian Butler	It would be interesting to hear how the 201 CSOs reviewed are after 2 years in service.
Ken Ball	Main issue appears to be poor or no commissioning/testing.
Jo Haigh	Much of the work should be incorporated into a guide.
Angus Willis	CSO manholes should be marked with "CSO", especially in highways, cast the CSO name into the cover. Contractors will cut corners to save money and compromise the CSO design. Emergency overflows in wrong position etc.
Steve Dempsey	Good access needs to be driven by ops from water companies.
John Blanskby	Essential to learn from mistakes and general practice.
Christian Arias	Other factors also affect CSO and drainage systems, which are not in the vicinity of the monitored structures such as downstream controls and conditions. We need to look at the bigger picture!
Andy Eadon	There is a grey area between contractors and operators at handover time.

Designer's Views

	Topics/Points I agree with
Jonathan Cutting	(DH) Outfall inspection is the key; the public perception is based on this alone. Operator training is also key. Maintenance is best designed in. (MS) Steep learning curve, time frame impacts on efficiency.
David Hanson	CFD useful for identifying where to position cleaning heads. Autowash has advantage of no grit/debris getting into pipe work.
Alison Court	Inefficient to deliver CSOs in same AMP as carrying out complex modelling work.
Brian Butler	Cleaning statics immediately after use.
Jo Lambert	Build on current knowledge to improve CSO design and operation. Share Knowledge.
Steve Dempsey	Most proprietary CSOs have very limited applicability. Power supply can be problematic – should use mobile generators.
Christian Arias	Design considerations are baffling for engineers Proprietary systems not as good as initially thought. Services and power are important considerations for design.
Andy Eadon	Powered screens should be arranged to run-on after an event. Call for standardisation.
	Topics/Points I do not agree with
Jonathan Cutting	(MS) Using CFD to reduce screen size + improve performance need to consider impact of first foul flush.
Christian Arias	CFD technology required. Good data on the properties of sewage is required to accurately represent site conditions. Cleaning systems connected to water mains are unsustainable, there must be better ways of cleaning a screen
	Other Comments
Jonathan Cutting	(DH) Again in-event binding is important and not fully understood or coped with. All guidelines need to be dynamic. Being overly prescriptive can prevent designers using ingenuity and only follow the production line approach.
Brian Butler	First slides indicate probable problems at any CSO screen would almost be submerged most of time and thus collecting screenings. Cleaned before storm event?
Ken Ball	Ensure they involve civil engineers and screen manufacturers with regard to install/access maintenance and actual operation. Ensure receiving waters can accept spill and does not back up into the CSO chamber.
Angus Willis	Get manufacturers in at start of design phase and most chamber designs can be optimised to provide most cost effective solutions.
Andy Eadon	Are YWS guidelines on self-cleansing acceptable to the industry? Is STW's design template acceptable to the industry?

Supplier's/Contractor's Views

	Topics/Points I agree with
Jonathan Cutting	(FE) Involving screen makers with designers. Civils detailing and tolerances need improving. (SS) Out of sight out of mine is a major issue as once finished 'we' all move on.
Mike Foote	Agree with poor civils – not to drawing. Involve manufacturers earlier.
David Hanson	Handover – critical to ensure that a satisfactory CSO is handed over for water companies. Snagging improvements will ensure quality. Involve screen manufacturers early. Design needs to take into account amount of blinding – 75% blinding needs to be taken account of when necessary. Standardised zoning across all water companies.
Chris Day	Lack of maintenance. Poor education of operators. Involve screen suppliers early in design.
Brian Butler	Early manufacturer involvement.
Jo Lambert	Communication between all parties involved. Maintenance requirements need to be passed on to relevant people. Involve suppliers at the earliest opportunity to try to avoid potential problems.
Ken Ball	Involve manufacturer at design stage for initial selection and inputting into proposal designs.
Jo Haigh	Low maintenance system.
Steve Dempsey	(FE) There were no construction contractors at this event.
Christian Arias	Standards are important. Building contractors should be present in these discussions. Designers need to consider Operation & Maintenance in designing confined spaces. Regular inspection and maintenance control should be well planned. Low maintenance options and designing out confined space entry must be prioritized. Operators must own equipment and operation, maintenance and H&S documents. Feedback to screen supplier. Do they get enough? Design should state solid content for blinding check.
Andy Eadon	Early contact essential Banana shaped weirs – construction to acceptable tolerances is required. Operators/maintainers are not on the scene. End-of-line situation is a design issue because of heavier solids concentrations.

	Topics/Points I do not agree with
Jonathan Cutting	(FE) Static screen checking after every event is too frequent for some CSOs. PAS – screen only need be removed if continuation flow.
David Hanson	Inspect regularly – better to maintain only when necessary.
Ken Ball	90% civils – caused most problems along with lack of proper commissioning. Civils tolerances have to be incorporated to match the design/installation.
Steve Dempsey	Suppliers are able to help at design stage – no all designers are knowledgeable enough and manufacturers are quite often not open enough or forceful enough – Too often they agree to supply to get the business without asking enough questions about the details. This is mainly applicable where supply frameworks don't exist.
Christian Arias	Access and installation should be the responsibility of the designer not the contractor only. Chamber size compromises the design of the screen. (Sometimes no option) Tolerances not good – suppliers must be more involved in design early on. Suppliers need more civil skills to foresee installation problems.
Andy Eadon	Contractors should have been invited.

	Other Comments
Jonathan Cutting	Maintenance management is not / doesn't have to be a problem. It is in Water Co, interest to resolve.
Mike Foote	The contractor has too much influence over screen selections.
Alison Court	Definite message regarding difference in build tolerances for civils vs. M&E work. How much consideration is given to changing design based on where the CSO is located within the sewerage system? e.g. Head of catchment vs. end of line!
Brian Butler	Commissioning should be part of "box-ticking" process.
Ken Ball	Question whether commissioning/testing is carried out correctly or at all. Handover is irregular and no specific guidelines are in place.
Jo Haigh	There seems to be very little communication with suppliers over programme/requirements.
Angus Willis	Sales Pitch – Not relevant to better CSO Designs O&M manuals need to get to the operators. Contractors need to work to programme as extra visits by screen manufacturers costs extra money.
Steve Dempsey	WaPUG is a planner group which has buried it head in the sand for too long over construction and operation issues. WaPUG needs to expand its vision.
John Blanksby	Most screens in current frameworks are proven to work well given appropriate chambers. There is no point in installing a screen where it won't work.
Christian Arias	It would be very useful to have modular section screens for retro-fitting into existing chambers with old small access openings with easy assembly. Designers must consult suppliers early on during design to avoid later changes/problems.
Andy Eadon	Auto – greasers are important.

Regulator’s and Researcher’s Views

	Topics/Points I agree with
Steve Skowron	A detailed discussion of YWS’s screen testing.
Andy Eadon	Screens are helping to clean up rivers. The nature of screening is not likely to change in the foreseeable future. Methodologies for the design of powered screens and for the cleaning frequency of static screens.
	Topics/Points I do not agree with
Angus Willis	Test procedures. Sewage is not the same as a storm event. During a typical storm event sewage is highly diluted. Solids are not retained in CSO events as long as they would be in an inlet work structure. Taking solids out of inlet works, mixing or stirring them will break them down in smaller particle sizes. Time of year will affect test results.
	Other Comments
Ken Ball	They do not appear to know whether schemes are actually in place and working Sign off seems to be if scheme is started.
John Blanksby	Use tapered/sloping weirs to direct flow where the designer wants it to go. Make sure the chamber and screen give the required performance.

ACTIONS AND PRIORITIES

	Topics/Points I agree with
Chris Day	Requirement for a best practice guide to PPA.
Christian Arias	All points discussed in general
Andy Eadon	Handover in dry conditions is questionable. Snagging – REs need to be more active. No direct funding for PPAs. (UKWIR report). Water companies do not share R+D knowledge. Water COs' maintenance is improving. Not sharing knowledge on maintenance.
	Topics/Points I do not agree with
Christian Arias	We all seem to know what needs to be done. We need to set actions, deliverables, task groups for implementation and set responsibilities, DRIVER??? WaPUG?? WaPUG PPA guide could be acted on now.
	Other Comments
David Hanson	Report – suggest that there is an executive summary incorporated.
John Blanskby	There is an evident need for sharing information. However, if this is to be between WSPs then there need to be the will. Who is the target? Who is the supplier? Who is the editor?
Christian Arias	Water companies must share information and set common targets, standards, guidance documents, etc. A partnering approach should be adopted in projects. Better communication between all parties is required. More data feedback to designers and suppliers would improve designs and reduce site problems.
Andy Eadon	R&D – Climate change effects. Whole-life costing – need guidelines as it can be whatever you want. Complaints about maintenance activity. Who funds knowledge management & PPA? Best practice guide. WaPUG to produce.

Appendix 3. List of delegates and invitees

Name	Group	Affiliation	Main Interest	E-Mail
David Gordon		Severn Trent Water	Design/Operation	david.gordon@severntrent.co.uk
Andy Eadon		Severn Trent Water	Design	aeadon@haswell.com
Peter Myerscough	B	Yorkshire Water	Design/Operation	peter.myerscough@yorkshirewater.co.uk
Tom White	A	Huber Technology	Manuf/Supply	tw@huber.co.uk
Jonathan Cutting	A	Ewan	Design	jonathan.cutting@ewan.co.uk
David Hanson	A	Yorkshire Water	Operation	david.hanson@yorkshirewater.co.uk
Barry Thompson	C	Thompson RPM	Research	barrythompson@thompsonrpm.com
Christian Arias		Hyder Consulting	Design	christian.arias@hyderconsulting.com
Dr Phil Hulme	D	Environment Agency	Regulation	Philip.hulme@environment-agency.gov.uk
Nadarasa Selvakumaran	D	Black & Veach	Design	selvakumarann@bv.com
Dr Tim Evans		FWR	Research	catchall@timevansenvironment.com
Alison Court	A	Severn Trent Water	Regulation	alison.court@severntrent.co.uk
Dr David Balmforth	B	MWH	Research	David.J.Balmforth@uk.mwhglobal.com
Gordon Moore	D	United Utilities	Operation	gordon.moore@uuplc.co.uk
Jo Haigh	C	Environment Agency	Regulation	jo.haigh@environment-agency.gov.uk
David Kinston		Ewan	Design	david.kinston@ewan.co.uk
Jo Lambert		WRc	Research	Lambert_J@wrcplc.co.uk
Frank Evans	C	CSO Technik	Manuf/Supply	frank@csotechnik.com
Chris Lee	D	CSO Technik	Manuf/Supply	chris@csotechnik.com
Richard Willis		Huber Technology	Manuf/Supply	rw@huber.co.uk
Chris Day		Hydro International	Manuf/Supply	Chris.day@hydro-international.co.uk
John Blanksby	A	Bradford University	Research	j.blanksby@sheffield.ac.uk
Mike Foote	D	Hydrok	Manuf/Supply	mfoote@hydrokuk.co.uk
Steve Skowron	B	Longwood Engineering	Manuf/Supply	sskowron@longwoodengineering.co.uk
Ken Ball	A	Mono Pumps	Manuf/Supply	kball@mono-pumps.com
Neil Scarlet	A	IETG	Manuf/Supply	neil.scarlett@ietg.co.uk
Alan Harle	A	Northumbrian Water	Design	Alan.harle@nwl.co.uk
Bruce Adams	C	Southern Water	Design	Bruce.adams@southernwater.co.uk
Brian Butler	B	Copa	Manuf/Supply	Brian.butler@copa.co.uk
Dave Leslie	C	United Utilities	Operation	dave.leslie@uuplc.co.uk
Angus Willis	D	MBR	Manuf/Supply	Angus.willis@mbrtech.com
Jeff Pierson	C	Longwood Engineering	Manuf/Supply	jpierson@longwoodengineering.co.uk
Mark Shimwell	A	Severn Trent Water	Design	Mark.shimwell@severntrent.co.uk
Wayne Ellis	D	Severn Trent Water	Design	Wayne.ellis@severntrent.co.uk
James Wallace	B	Severn Trent Water	Operation	james.wallace@severntrent.co.uk
Cliff Stanton		Anglian Water	Design	cstanton@anglianwater.co.uk
Alan McLean		Scottish Water	Design	Alan.mclean@scottishwater.co.uk
Steve Dempsey	D	MWH	Design	Steve.Dempsey@mwhglobal.com
Brian Dalton		Scottish Water Solutions	Design	brian.dalton@scottishwatersolutions.co.uk

Unable to attend				
Brian Powers		Jones & Attwood	Manuf/Supply	brianpowers@jones-attwood.com
Dave Middleton		Adams Three Star	Manuf/Supply	d.middleton@threestar.co.uk
Alastair Stewart		Anglian Water	Design	astewart@anglianwater.co.uk
Andy Bagworth		Anglian Water	Design	abagworth@anglianwater.co.uk
Shashi Deshpande		Pick Everard	Design	ShashiDeshpande@pickeverard.co.uk
Simon Whatley		Thames Water	Design	Simon.whatley@thameswater.co.uk
Rob Henderson		Wessex Water	Design	Rob.henderson@wessexwater.co.uk
Rob Whittaker		Environment Agency	Regulation	Rob.whittaker@environment-agency.gov.uk
John Piechota		Severn Trent Water	Operation	john.piechota@severntrent.co.uk
Peter Frome		Welsh Water	Design	Peter.frome@dwrcymru.com
Unable to accept invitation				
Mike Kinsey		South West Water	Design	mkinsey@southwestwater.co.uk
Ashley Ferguson		Northumbrian Water	Design	Ashley.ferguson@nwl.co.uk
Kieran Downey		Scottish Water	Design	Kieran.downey@scottishwater.co.uk
Simon Walster		OFWAT	Regulation	Simon.walster@ofwat.gsi.gov.uk
John Martin		Severn Trent Water	Regulation	john.martin@severntrent.co.uk
Dave Armstrong		Copa	Manuf/Supply	david.armstrong@copacw.co.uk
Richard Long		Ewan	Design	Richard.long@ewan.co.uk
Jonathan Adams		Pick Everard	Design	jonathanadams@pickeverard.co.uk

Appendix 4. Workshop programme

Objective - To review the design, installation and performance of CSO screens in sewerage systems and to produce a report that highlights problems and difficulties which need to be overcome.

Chairman	David Gordon, Severn Trent Water Ltd.	
Presenters	Dr David Balmforth Barry Thompson Delegates	
Publishing	Dr Tim Evans, FWR Andy Eadon, WaPUG	
PROGRAMME		
08.30 – 09.00	**Arrival and Coffee**	
09.00 – 09.15	Welcome, Introductions and Objectives	David Gordon
09.15 – 09.45	A Background View	David Balmforth
0945 – 10.15	Owner's/Operator's Views *Yorkshire Water Presentation*	Delegates *Peter Myerscough*
10.15 – 10.45	**Tea/Coffee**	
10.45 – 11.15	Post Project Appraisals	Barry Thompson
11.15 – 11.45	Designer's & Operator's Views *Yorkshire Water* *Severn Trent Water*	Delegates *David Hanson* *Mark Shimwell*
11.45 – 12.15	Supplier's/Contractor's Views *CSO Technik* *Longwood Engineering*	Delegates *Frank Evans* *Steve Skowron*
12.15 – 12.30	Resume and Discussion	David Gordon Tim Evans Andy Eadon
12.30 – 13.30	**Lunch**	
13.30 – 14.00	Regulator's and Researcher's Views *Pennine Water Group*	Delegates *John Blanksby*
14.00 – 15.00	Group Sessions - areas for improvement	All
15.00 – 15.15	**Tea/Coffee**	
15.15 – 15.45	Group Summaries	Reporters
15.45 – 16.00	Actions and Priorities	Tim Evans Andy Eadon
16.00 – 16.15	Summing up and Close	David Gordon