YorkshireWater

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Spreading Best Practice in CSO Design and Maintenance

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Summary
This paper details the findings of a Post Project Appraisal Study undertaken by Ewan Group plc, together with Yorkshire Water. These are presented in the hope of spreading the knowledge gained during the design, construction, and 'early life' maintenance, of AMP3 upgraded CSOs so that future projects can capitalize on the improvements and innovations and be more efficient in CAPEX and OPEX costs, without detriment to their performance.

Introduction & Background

As an industry we have delivered several thousand UID schemes during AMP3 with indications that a significant number will be delivered during AMP4. The work involves installing both screens and storage within the sewer network to protect the receiving waters. Yorkshire Water (YW) has delivered 450 outputs and these have been split approximately 37% static, 60% powered and 3% self-cleansing.

Ewan Group plc (EGP) together with YW undertook a post project appraisal (PPA) review of 15 combined sewer overflows upgraded during year 3 of the AMP3 program as part of the continuous improvement of the YW design matrix and subsequent maintenance. The PPA had a number of aims and this paper focuses on the final one, namely:

> •*To provide feedback into the design process on design, construction standards and maintenance issues.*

Appraisal Findings

Screen Type and Screen type Selection

There are three main groups of screen types from which designers may choose. In ascending order of complexity and cost of the screens themselves these are

1. static screens,
2. self cleansing screens
3. powered screens.

The selection of screen type has always been dictated by the flow to be screened, spill frequency and the amenity value of the receiving watercourse. The selection of a static screen has historically been seen as the base option, with the more expensive self-cleaning and powered options being specified if unavoidable. However, there are two good economic reasons why the static is not always the best solution in both short and long term. Firstly, the size of the chamber represents a significant part of the total cost of upgrading a CSO and the installation of a static screen with its lower loading rate means a screened area of up to seven times the size and a proportionate increase in chamber size. Secondly, when whole life costs are considered the cost of the more frequent inspection and maintenance of a static screen may mean that a powered unit could be of the same order. This is not to say that static screens are not still a useful option, but their selection is normally considered by YW for low amenity sites, where space for construction and future access for maintenance is unconstrained, and where flow and spill frequency is relatively low.

In the assessment of amenity value the visibility of the outfall pipe is significant. Even if the receiving watercourse is nothing more than a minor watercourse filled with non-sewage-related litter, an even slightly ragged outfall pipe visible from a road or worse still a property is likely to draw customer complaints. Use of a powered screen in these cases will improve confidence in the ability of the chamber to contain all screenings; not being dependent on maintenance to control blinding and prevent reduction in screen performance.

Re-application of solids

During an event a typical CSO chamber may spill around five times the rate of flow and several times the volume that it is passing forward. An effectively operating screen will trap all the screenings within the chamber to continue with the pass forward flow. In many networks this situation works well. However, restrictions downstream can reduce the pass-forward flow with a consequent reduction in the quantity of screenings going forward. This increases the proportion of solids being stored in the chamber until the pass-forward flow returns to normal. In these cases the same pieces represent to the screen multiple times during the event. Although some powered screens are designed with the screening return downstream of the control, this build up of screenings would still occur where there is reverse flow. During a long spill event this will temporarily reduce the efficiency of the screen and cause an increase in depth due to a reduction in screen capacity.

In a number of cases the modelling had identified the issue at the design stage and the screen size had been increased accordingly. Further investigation is required into the detailed impact of increased solids concentration and the required reduction in loading rate.

In other cases however the problem had not been anticipated but was found to occur after the screen had been installed. In these cases further operational solutions are required. These might include the provision of a baffle to prevent floating solids from reaching the screen and changes to the run cycles of the screens to prevent the build up within certain sections of the chamber. Investigation into the effectiveness of this is ongoing.

Screen performance

As part of the study a detailed 6-month flow survey around a number of CSOs was undertaken. This involved flow monitoring for spill volumes, flow balances across the CSO and depth monitors within the chamber. Raingauges were installed within the CSO catchments.

Analysis of the data collected allowed for detailed investigation of the performance of each chamber and screen over the longer term (trends, deterioration and maintenance planning) and also during individual events (performance against design and ability to self cleanse).

Long term performance

Figure 1 shows the profile of rainfall on the static screen CSO catchment, and the corresponding flow, depth and velocity at the entrance to the chamber recorded during the 6-month survey period. The two zones circled are either side of the routine maintenance screen cleaning undertaken on 26th February 2004. The rainfall experienced in each zone is comparable.

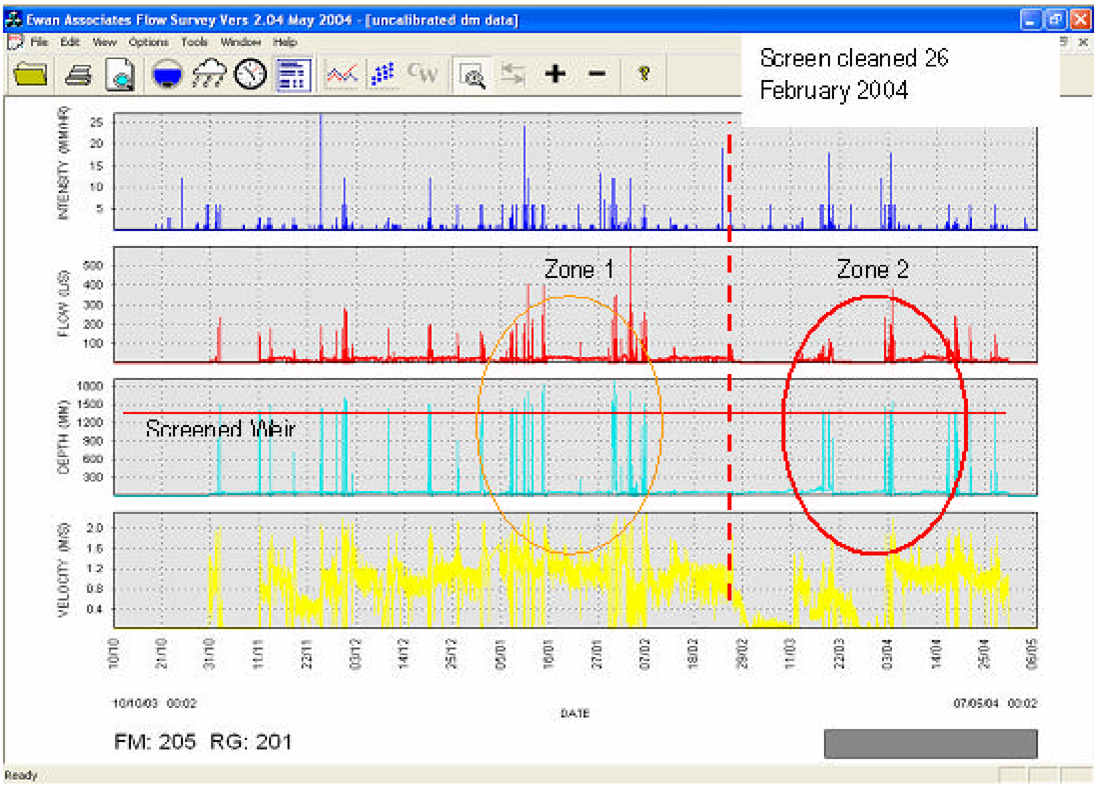

Figure 1

Figure 2 shows the flow discharge relationship for each zone together with the screen headloss reduced to an equivalent weir co-efficient in each case. As can be seen the clean screen has a value close to a 'typical' design figure however the partially blinded pre-cleansed screens value is considerable lower than any design figure.

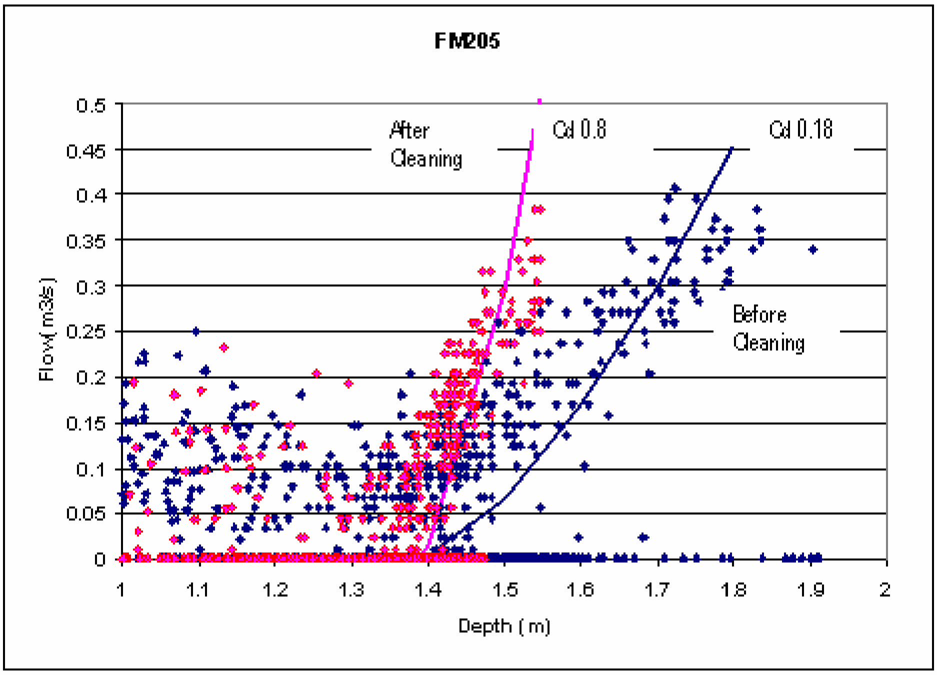

Figure 2

This identifies the need for more frequent maintenance at this site to prevent the reduction in flow through the screen and corresponding undesirable increase in depth within the chamber. This highlights the positive impact of timely maintenance and these results are being used in the development of future maintenance strategies.

Individual Event Performance

Figure 3 shows a similar plot to that of figure 1 for a powered screen. The performance of the screen during a single event can be seen in figure 4.

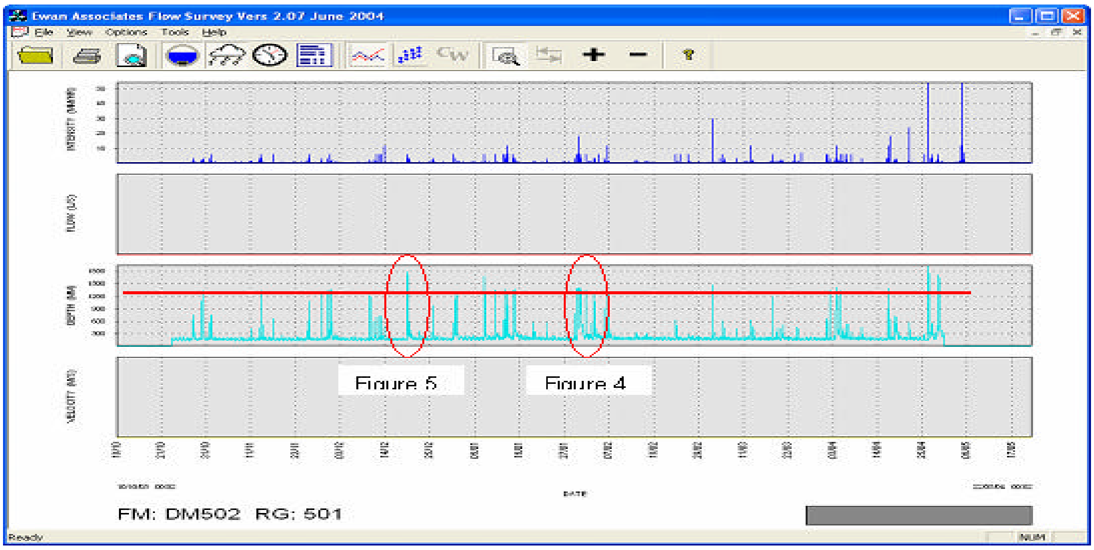

Figure 3

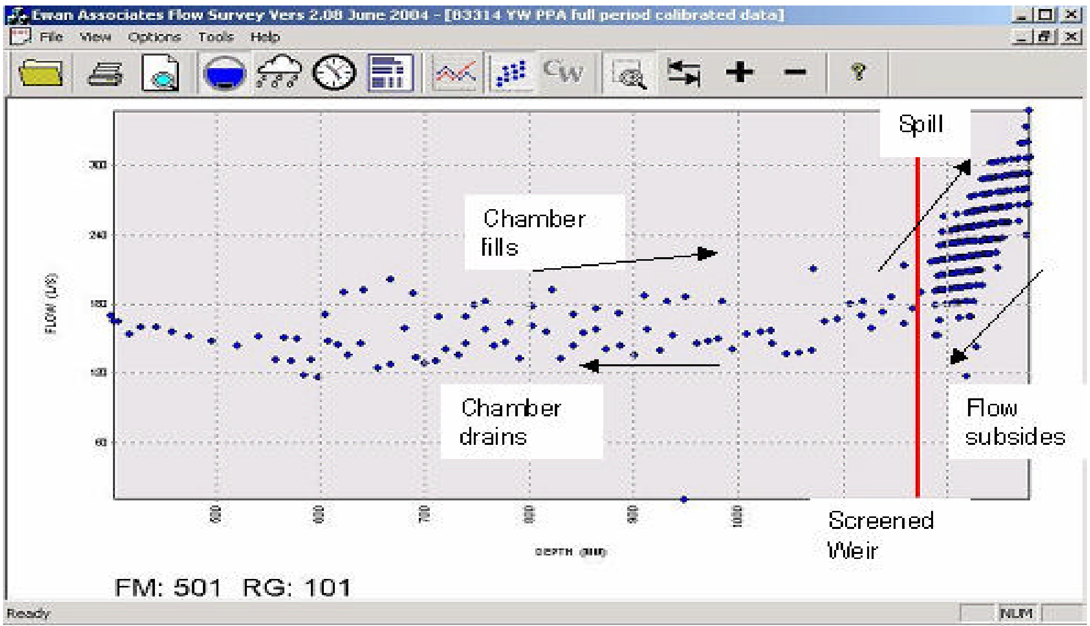

Figure 4

The flow entering the chamber builds up and the depth increases as the chamber fills. Once the screened weir is reached the flow increases without a significant increase in depth. Once the event finishes the depth reduces as the spill finishes and the chamber drains. This is normal operation for the chamber.

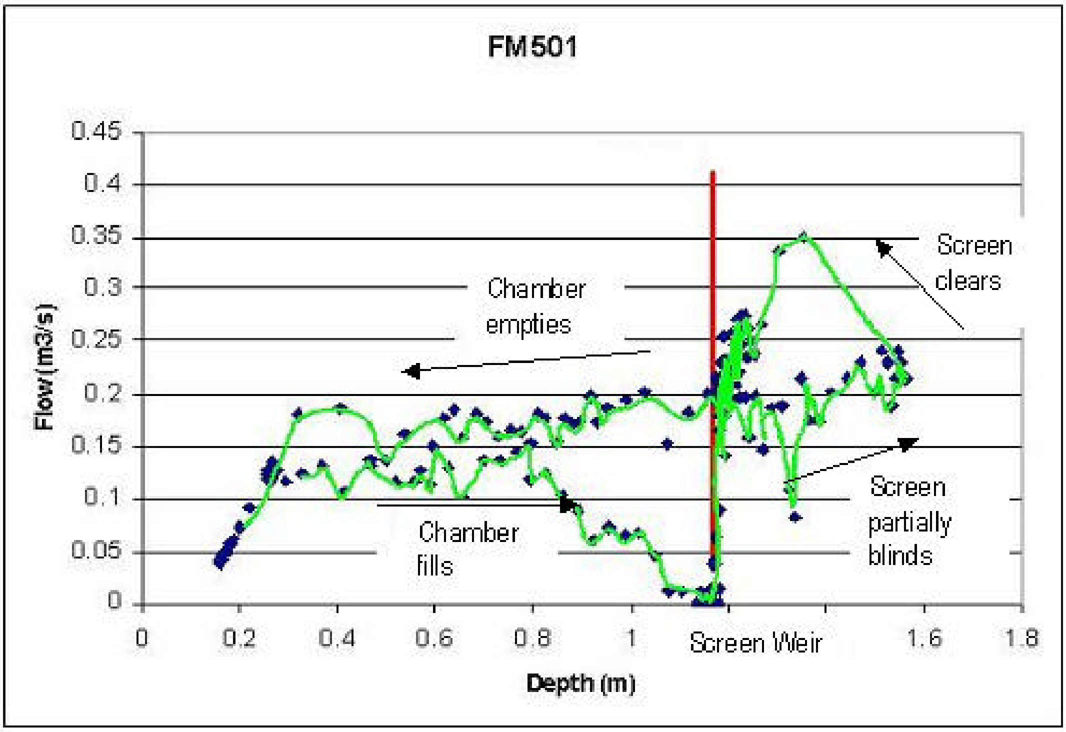

Figure 5

Figure 5 show the same initial increase in level and screened spill however the screen fails to maintain a sufficiently clear surface and the depth increases without a significant increase in flow. This continues until the screen can be seen to clean itself and depth decreases significantly whilst the flow remains high. In this case the screen failed to self cleanse during the early stages of the event and this resulted in the increase in depth. This data can be used to refine the control for the screen motor runtimes. Operationally this will reduce the likelihood of a repeat occurrence. In light of these findings and other performance data the use of variable speed motors is being investigated to improve cleaning during the higher concentrations of solids during the first flush.

Modelling

The modelling carried out by the designers was reviewed during the PPA. Particular attention was paid to the way the CSO and screens had been modelled to ensure that this matched the detailed designs provided. In some cases the designers had used cut-down versions of larger models and the implication of this on results was considered.

The representation of headloss through the screen was checked. If headloss is higher, the levels within the chamber are also likely to be higher than anticipated. Common practice was to aggregate the openings in the screen into a single orifice of equal area, and then use a typical orifice coefficient to represent the losses. Analysis of the flow survey showed that this method could significantly underestimate the headloss. Later designs used the results from field testing and this proved to be more realistic.

Loading rates

Originally the design loading rates were established through a series of rig tests. The design loadings used by Yorkshire Water are generally less than recommended by screen manufacturers and used by other companies, and the results of the PPA confirmed that this had been a correct decision. The flow survey data was used to assess the loading rates being experienced by screens that are in operation. These were well within design standards, as would be expected during a 6 month flow survey in which the events trapped were all well below the design threshold.

Screen Cleaning

As shown above the ability to self cleanse was variable within events for the powered screens. Overall the screens were able to remove the build up of solids and maintain their capacity for spill flow, but temporary performance reduction could occur during a single event or series of events.

The situation with static screens is more complex. The provision of cleaning is via fixed or mobile Breaconcherry spray units. These were found to be very effective, but only when used correctly. The positioning of the unit, the depth within the chamber, the pressure applied and duration all govern the effectiveness. The former two points need to be designed in and it is clear that this has improved already; the latter two require skilled staff who understand their equipment and its operation with each CSO requiring its own optimized settings. This again has now been established for each CSO.

Detailing

Survey of the CSOs during the PPA study found that good overall design and operation was let down on a number of occasions by poor attention to detail. This was in both the design detailing and the construction. Simple steps such as sealing the screen against the weir or chamber wall to prevent the escape of unscreened solids and the omission of minor alterations to a chamber reduce the level of protection to the watercourse.

Provision of safe and easy to use inspection and access covers is an area where the PPA highlighted a number of shortcomings. The ability to be able to inspect the condition of a screen without having to enter the chamber makes the maintenance significantly easier. This has again been dealt with by the evolution of the matrix.

Conclusions

The understanding of CSO design and operation has moved forward considerably during this AMP period. However, through further studies including the PPA carried out as part of Yorkshire Water's policy of continual improvement, it is clear that there are still areas that can be and are being improved on. A number of the issues raised in the PPA were revised out of the design matrix and do not occur/appear in year 4 projects. The continuing research and development into CSO design and operation will benefit designs for future projects into AMP4.

References

Screen designers
Ewan Group reports

Acknowledgement

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Disclaimer

The views in this paper are those of the authors and do not necessarily represent the views of Ewan Group plc or Yorkshire Water.