WaPUG Autumn Meeting 2001

Implementing the NoSWA CSO Programme

Summary

The paper provides an early review of experience gained from the North of Scotland Water Authority (NoSWA) Programme for Combined Sewer Overflow (CSO) Improvements. NoSWA awarded the contract in late 1999 to two contractors to undertake the necessary improvements over a 5 year period. The two design and construct groups are the Miller Babtie Alliance and the M.J.Gleeson MWH Consortia. The paper covers the work of the latter consortia. Early in 2000 we received details of the first 13 unsatisfactory CSOs to be addressed, these being based in the Tayside area around Dundee. All the design and the majority of the construction works for these particular schemes are now completed and feedback on the first few months of operation is becoming available. Many of the solutions use relatively untried technology and the real performance of these solutions provide contractors and designers with vital information for future work.

Contractual Arrangement

The key aspects of the contract are:

New Engineering Contract target cost with pain/gain share.	This allows for the design and construction of the project to be completed to an agreed target cost. This offers better cost management for the Client while providing an incentive to the Contractor to deliver solutions quickly. There is a further incentive to innovate by offering a share of any cost savings achieved. Costing information and target costs are refined throughout the programme as experience is gained. The contractor is required to continually improve efficiency.
Design Build Consortia	The CSO programme is shared between two Design and Construction Consortia. One is The Miller Babtie Alliance, the other M.J.Gleeson/ Montgomery Watson Harza. The performance of the two consortia is tested against key performance indicators. There is a system of knowledge sharing between Consortia to develop best practice and encourage innovation.
Steering Group	A small group of senior NoSWA and Consortia Managers meet quarterly to agree strategy.
Standardisation Group	Meetings between SEPA, NoSWA Operational and Technical Staff and the two delivery teams are held regularly to review progress and agree programme standards.
Delivery Teams	The Delivery Team are a mixture of NoSWA and Consortia Staff and where possible is based in a single office location. Project Scoping is carried out by the delivery team prior to the agreement of the target cost for design and construction. The delivery team's task is to develop and implement necessary improvements to unsatisfactory combined sewer overflows. NoSWA Programme and Project Manager Staff who are supported by external cost consultants, both technically and economically closely monitor its performance.

Team Approach

The challenge the contract offered was to successfully design and construct CSO improvements in large numbers within a short timescale. The team approach is acknowledged to be vital to the successful delivery of the programme. One of its key attributes is improved communication, as many aspects of the decision making process as possible are concentrated in the operating team. The delivery team has regular contact with NoSWA operational staff so that current operational problems are identified and future maintenance issues are addressed within the solutions implemented.

The volume of information necessary to implement the programme is large and diverse. As an individual project develops the information grows and changes on a daily basis. The management of this information, ensuring that it is upto date and available to the right individuals is key to the successful completion of the project. Due to the nature of all large projects it is inevitable that mistakes will be made. Any inefficiency in the communication system increases the risk of mistakes. These weaknesses are sometimes technical but are more often between individuals. The team approach has so far succeeded and encouraged individuals to work well together. The mistakes to date have been few and great efforts are expended to avoid a blame culture. There is an open and honest airing of problems and whilst there is no shortage of healthy criticism, this tends to be good humoured.

The Regulator

The regulatory arrangement in Scotland is somewhat different to that in England and Wales. There are currently three Water Authorities in Scotland; these are public bodies whose performance is monitored by a regulator similar in some respects to OFWAT. The three Water Authorities are currently being merged into a single Water Authority for Scotland.

Environmental standards are enforced by the Scottish Environment Protection Agency (SEPA). The standards are set by the Scottish Legislature and introduced to comply with the European Wastewater Directive. This programme is similar in many respects to the Asset Management Plans (AMP 3) put forward by the privatised water companies in England and Wales, however the term AMP3 is not relevant to the Scottish Authorities. The programme addresses agglomerations with populations greater than 2000 where the unsatisfactory intermittent sewage discharges must be improved to revised consent standards by the end of 2005.

The requirements SEPA places in the consent standards have differences from those introduced by the Environment Agency in England and Wales. Although the basis of the legislation is the same, interpretation in some areas is different. As in England and Wales the guidance on the Urban Waste Water Treatment (Scotland) Regulations 1994 suggests that 80% of the spill volume from the annual time series should achieve the removal of a significant quantity of 6mm solids (6mm mesh equivalent). The remainder of the spill, upto a 5 year storm, is subject to 10mm separation (10mm bar equivalent). It is common practice to simplify these requirements and adopt a single screen achieving the 6mm standard for the full 5 year flow.

In high amenity areas due to the sensitive nature of the discharge, SEPA requires the Water Authority to screen all flows discharged from the CSO to the 6mm standard. This should be all flows that can be reasonably expected to arrive at the CSO. In practice this is often taken as the 1 in 30 year design flow. Only if it proved unreasonably expensive to provide this screening would SEPA consider relaxing this requirement.

A value management process is used by the delivery teams to develop a preferred option with representatives invited from SEPA. To date there have been few instances where the scheme selected to provided for a 1 in 30 year storm screen has been significantly more expensive than one to achieve the 1 in 5 year requirement. This tends to happen only when space is limited and the 5 year screen can be retrofitted while the 30 year screen cannot. However this rarely happens and usually the larger screen can be included for a modest increase in cost.

In high amenity areas SEPA also require the Water Authorities to provide spill volume and event monitoring. This is to ensure that consented spill frequencies are not exceeded and also that the consented flow is passed forward for treatment before a spill occurs. Again this is only enforced where the additional cost is deemed reasonable.

Selection of the preferred solution

The solution to be adopted for a particular project is determined within a Value Management Process from options developed by the delivery team. The solution does not always involve the provision of a 6mm mesh equivalent screen. The full network requirements are considered and where a particular unsatisfactory CSO can be abandoned or rationalised this is considered. To date it has been possible to remove completely around 30 –35% of the unsatisfactory discharges by making modifications to the network.

Whilst the programme is by no means just about screens, many of the particular problems revolve around the uncertainty over the performance of screens in the sewer network. Where a screen is required there is an approved list of types and suppliers. If however particular circumstance occurs and it can be proven that another screen will offer advantages to the programme the Standardisation Group can permit its use. NoSWA acknowledge the importance of encouraging innovation and is currently implementing trial installations of unproven screening technology. It is hoped that this information can be made available to the industry on its completion.

There is a range of different types of screen, each being best suited to different sites. The following figure attempts to demonstrate the different parameters and how they may affect the choice of screen. The screens are divided into two main types, the manual cleaned screen and the self-cleaning type. The manual cleaned type includes disposable mesh sacks and static screens which require manual jetting, the self-cleaned type include those with an external power source and those which employ energy from the flow. Ultimately the choice of screen is chosen using whole life costs so that a balance can be made between capital cost and operational cost together with an acceptable level of risk.

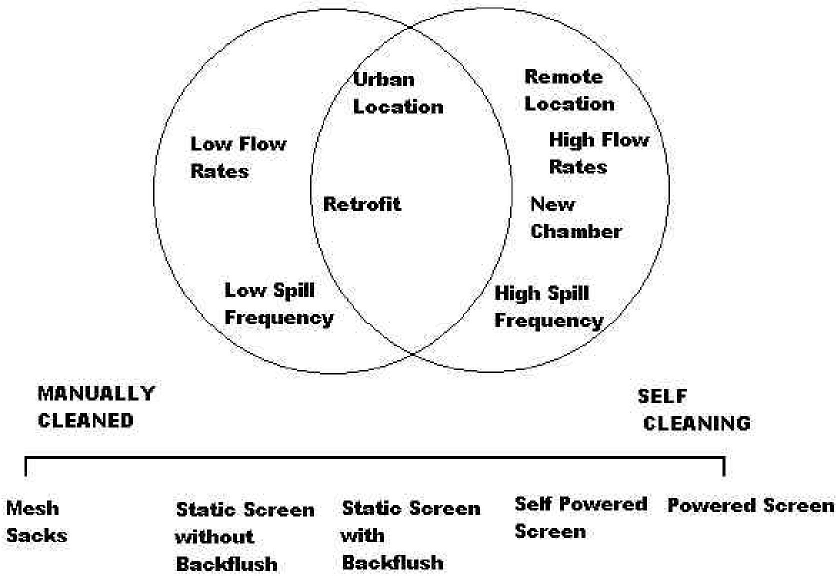

Figure 1
Screen Selection

Work completed to date

The early screens in the programme have now been commissioned and feedback on there performance is just becoming available. Some of the typical types of installations are discussed here

Huber Rotamat – Burnside Road

This scheme resulted in the installation of twin Huber Rotamat RoK 1 brushed auger screens within an existing CSO chamber. Each screen is 700mm diameter and 7.5m long with a combined flow capacity of over 6000l/s. This is the 1 in 30 year design spill flow for the CSO.

The screens are of a push auger type with screenings returned by gravity to the continuation flow. The chamber itself has five parallel channels, the central one carries flow to treatment, the remaining four are used in pairs either side of the central channel. The outer channel of each pair receives storm inflow, which is spilt over a dividing side weir into the outflow channel. This arrangement was retained from the original bar screen chamber.

The critical issue in the design was the means by which the screenings were to be returned to the continuation flow. Problems had been identified on previous installations where screenings had tended to bunch and fail to be passed forward. At Burnside Road CSO the existing weir levels were relatively low, this was a due to a height restriction affecting the scraping arm of the original mechanically cleaned bar screen. It was possible to raise the weir level without compromising the upstream catchment and thereby increase the level difference between the screen and the water level in the continuation channel. This allowed the screenings to be returned together with some washwater by gravity. This had the advantage of simplicity and it was hoped reliability.

Another factor affecting the auger brush screen is the presence of grit or other foreign objects within the screen basket. These can cause rapid wear of the brush tips and in severe cases damage to the mesh basket itself. The key means of preventing this is to manage the velocities in the chamber, high velocities are undesirable and result in heavy objects such as grit from being carried over the weir. The checks recommended in the WaPUG Guide for CSO Chambers for chamber velocities were used to check for subcritical flow. In this respect raising the weir levels was beneficial to reduce flow velocities.

Another means of reducing the quantity of damaging material passed over the weir is by the installation of baffles. Unfortunately due to the slope present on the outer channels there was insufficient height below the weir to install conventional side weir baffles. Transverse baffles on the entry to the channels themselves have been considered, however these would cause significant upstream surcharge at peak flows while crucially being relatively ineffectual for the first flush.

The installation has recently been commissioned and has already been severely tested. Numerous spills have been dealt with without problem and a severe storm with return period in excess of 1 in 20 years has occurred in the last couple of days. The initial indication is that the screen has operated successfully but it has been reported that small collections of screenings have accumulated on the downstream side of the screen. There is no indication of a problem at the outfall. It should be noted that the tissue passed through a 6mm mesh can snag and collect at certain points and appear as a papier-mâché. This can give the appearance of solids greater than 6mm in two directions. Telemetry recording of flow depths during the storm are to be interrogated to determine whether these solids arise from this cause or whether the screen has been overtopped.

Also the system to prevent damage of the screen is an issue. If the power demand of the electric motor rises above a safe level, as it would if the screen became jammed, the power to an electronic trip switch cuts off the motor. Due to the relatively long screen the torque required for cleaning in normal operation is high. While the electric motor is designed to trip out if a foreign object becomes jammed, this high torque requirement increases the risk of damage to the screen before this trip can occur. In this aspect it would have been beneficial to use four shorter screens with a reduced torque, however for reasons of limited space in the existing chamber this was not practical. To date there has been no evidence of an actual problem, however experience will tell.

Copa Cross Wave – Grange Road

Grange CSO is typical of many of the existing combined sewer overflows in NoSWA coastal areas; it discharges twelve times per year as derived by the time series rainfall. Also the existing chamber is of the stilling pond overflow and this means the chamber itself is relatively large These factors of low spill frequency and a large chamber lend themselves to a retrofitted static screen solution.

Advantages- Simple, no moving parts therefore reliable.
Indent low capital cost as a retrofit solution.

Disadvantages- Requires manual cleaning, increasing operating cost
Requires a large plan area, high capital cost if a new chamber was required.

The area of static screen required is derived from the design spill flow and the permitted static screen loading rate. The screen is designed to progressively blind through the storm; a sufficiently large area of screen is required to prevent complete blinding.

Retrofitting a screen to an existing chamber invariably offers a low capital cost solution. For this reason it is often the first to be consider. It may be tempting to accept compromises in the design to allow a screen to be shoehorned into an existing chamber. If a compromise is accepted, say a reduced screen area is chosen there is a risk that operating problems will result. In a climate of projected reductions in operating budgets the higher maintenance costs this could involve risk being unsustainable. In cases of stilling pond chambers it has generally been found however that the existing chambers are large enough to accommodate the desired screen area.

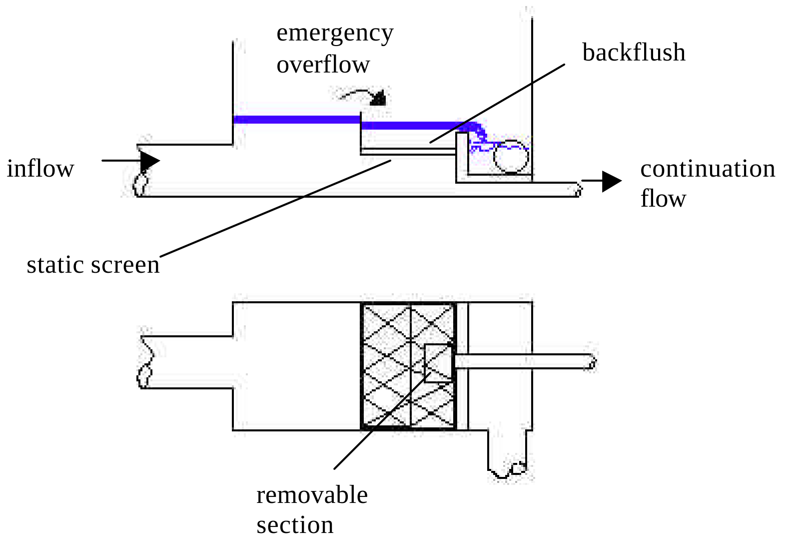

Figure 2

Layout of static screen within stilling pond overflow

The main issue to be addressed when using a static screen is the potential high operational cost of manual cleaning. The design adopted various strategies to minimise this requirement including: -

- Maximise the hydraulic settlement in the chamber to reduce the screen loading and thereby the rate of blinding.
- Provide a backflush by placing the screen below the weir level. Once the event is over the flow captured between the screen and the weir is flushed back through the screen helping to remove retained screenings. Unfortunately this flush is not as dramatic as might be imagined as it is hampered by the relatively slow drain down in the sewer system.
- Providing a sufficiently large access opening to allow the whole of the screen to be easily viewed and cleaned from the surface. This is important to avoid the need for confined space entry for cleaning which is not only hazardous but also time consuming and expensive.
- Ensuring the access covers themselves are easily lifted by a single operative while also being durable, safe and secure from potential vandalism.
- Provide safe vehicular access to the site, while avoiding highway locations. Large access openings in the highway can be hazardous. Expensive traffic management would be required to allow safe working. Vehicles regularly parking over the chamber can make maintenance difficult and such sites should be avoided.
- Provide means for the safe removal of debris too large to pass through the continuation orifice and which would become trapped below the screen. This is often referred to as the road cone test, i.e. how would a road cone be removed. This has been achieved by a removable section of screen above the control orifice.
- Telemetry is installed to provide centralised information on the CSO performance and allow maintenance to be carried out only when required. This is a consequence of SEPA requirements for spill volume and event information and is not required at every location.
- A high level emergency bypass is provided in the event the screen blinds during a storm. A high level alarm would be activated for such an emergency.

The installation at Grange CSO has been operational for some months. Its performance has been very good. Inspections after events have indicated very little evidence of material retained below the screen and little requirement for cleaning. One problem is the deposition of a film of particles of fine material on top of the screen, this settles out as the chamber drains down. There is a concern that this material may dry and solidify rather than be washed off by the next event. The residues from the initial storms were manually washed off. It has now been decided to leave the residue and discover if overtime it does increase and cause a problem.

Longwood Stormguard - Burgh Yard

This scheme required the provision of off-line storage to limit spill frequency and a 6mm screen. A 450m^3 storage shaft has been constructed and the new CSO chamber is currently being completed. This was the first CSO in our programme which required a new chamber rather than modification to an existing. This may be because the initial schemes were not the typical hole in the wall type overflows.

The new CSO chamber was designed to an early draft of the WaPUG Guide to accommodate a Longwood Stormguard Screen. The screen is located upstream of the off-line storage with the continuation flow passing to an existing submersible pumping station. Storm flows in excess of the storage volume are also pumped through the sea outfall, but only during high tide conditions.

It has been necessary to raise the weir level in the new CSO in comparison with the old. The original overflow was a simple relief pipe set below half pipe of the continuation sewer. In cases such as these it appears unlikely that the existing weir level can ever continue to be used.

Some of the reasons are: -

- The physical depth of the screen and the clearance required around and below the screen. The continuation channel must be benched to the sides of the chamber at 1 in 8 to prevent sedimentation.

- A clearance between the top of the benching and the screen is important to avoid the trapping of screenings and sediment.

- As chambers tend to be wider than the minimum of 1.4 D to allow safe working, the slope of the benching on these wider chambers increases the height of the weir further.

- The requirements to control inlet velocities and avoid a hydraulic jump forming at the weir. The velocities can be controlled in the inlet sewer before the CSO chamber or by raising the weir. Increasing the size of the incoming sewer for a distance of 25 diameters would include a crossing beneath the main East Coast rail line. To avoid the time delay and to save several trees, which would be sacrificed to the paperwork, it was quickly agreed that this was not the best option. The alternative way to control energy levels is to raise the weir level.

When modelling work is carried out for optioneering it is often necessary to assume that existing weir level and continuation flows are to be retained. This is important to both avoid making existing flooding problems worse or creating new ones. It is never fully clear whether the model contains the lowest point in the catchment, that private gully connection hidden in a cellar haunts us all. In this case and many others I believe, it is not be possible to keep the same weir level. The ultimate surcharge level in a 30 year storm can be retained by providing a longer weir however the risk of flooding cannot be removed completely.

The new CSO is to be completed shortly and it will be interesting to see how well it performs.

Conclusion

The work on other CSO schemes is progressing, the feedback on the first to be constructed is generally positive, however it is perhaps it is too early to say. There will inevitably be further problems, hopefully of the minor variety. It can already be seen that improvements to the procedures in the programme are bearing fruit, the steep learning curve is beginning to flatten and solutions to problems are easier to visualise. Team members have a better understanding of each other and how their work integrates with that of others.