Cowdenbeath Wetlands

a sustainable wetland has provides Scottish Water with an asset that treats stormwater overflows and provides a habitat for a wide variety of wildlife

Cowdenbeath (population 11,000) is a former mining town situated within west Fife, close to Dunfermline. The Cowdenbeath area is serviced by a combined sewer network which connects to the Cowdenbeath Wastewater Pumping Station (WwPS) and storm tanks before being transported for treatment at the Levenmouth WwTW further downstream. Several combined sewer overflows (CSO) exist within the network and two of these CSOs are the focus of this overflow treatment project, namely Selkirk Avenue CSO and Cowdenbeath WwPS CSO. The improved discharge quality at these overflows is part of a larger programme that aims to improve the water quality in a number of watercourses in the Cowdenbeath area, in particular the Lochgelly Burn. The Lochgelly Burn is the main watercourse in Cowdenbeath and flows to Loch Gelly, which is considered to be a sensitive waterbody.

Recently installed reeds in the Forced Bed Aeration™ Wetlands - Courtesy of Scottish Water

Background

Currently, in times of heavy rainfall, the excess wastewater spills through a screened outlet directly into the burn which the Scottish Environmental Protection Agency (SEPA) has classified as Class D - seriously polluted under their River Classifications Scheme. The project will allow this excess wastewater to be stored and treated to a significantly higher standard before allowing it to flow back into the natural environment. SEPA's aspirations are that the standard is raised to classification A2 and to the following levels:

BOD (ATU) = 9.0mg/l
Total Ammonia = 1.5mg N/l
Un-ionised Ammonia = 0.04mg N/l

The solution

The solution was determined after extensive modelling work of the Cowdenbeath sewerage system to assess the performance of the CSOs and the interaction of the overall waste water network. Global engineering consultants Atkins carried out this extensive modelling work as well as creating the detailed design for the overall solution.

A full range of "conventional" options were assessed to address the Water Quality failures of the Lochgelly Burn; however, a viable option was not found.

The difficulties encountered in developing options for the Cowdenbeath catchment were primarily due to three factors:

1. The watercourses within the Cowdenbeath catchment are very small with 95 % of flows less than 1.6l/s for all receiving burns. The level of dilution offered to the CSO discharges is therefore minimal and, as a consequence, the burns are failing the water quality parameters almost as soon as the CSOs start spilling.
2. There is believed to be a significant level of slow response flows in the catchment. The flow survey undertaken during the verification of the model showed that during winter months, slow response flows in excess of 100l/s had been evident for over 24 hours after a storm event finished. This significantly reduces the available flow capacity within the sewerage network and at the Cowdenbeath WwPS. In particular, for options that involve storage, this has a major impact on the ability of the storage tanks to be drained down within a reasonable period of time.
3. Flows downstream of Cowdenbeath are being significantly limited by the Cardenden WwTW and the waste water network downstream of the works. The WwTW includes a flume and weir control structure that was designed to limit pass forward flows to 300l/s. However, the model predicts that due to incapacities downstream, a maximum of approximately 230l/s is being passed forward before the storm tanks at the treatment works start filling up.

The combined effect of the above three issues is that 'conventional' solution development was not able to identify a viable option to resolve the water quality needs for the catchment.

The selected solution based on the design information *(see Table 1 on the next page)* was to install a wetland facility constructed on predominantly Scottish Water owned land that lies adjacent to the existing Cowdenbeath WwPS. The solution includes the provision of a 3,000m^3 storage tank and an Forced Bed Aeration^{TM} (FBA^{TM}) aerated wetland scheme that will provide sufficient treatment to allow flows to be discharged back to the burn without causing failure of the relevant water quality parameters. The completed scheme has the ability to treat approximately 230,000m^3 of water per annum.

With agreement from SEPA, Scottish Water approached the wetlands scheme in two phases. The first phase involved the construction of the wetland and an associated storage tank. The phased approach was undertaken as the network modelling and River Impact Optimisation Tool analysis (RIOT) which analyses model results to provide cost-effective solutions to water quality problems, predicted that 9,500m^3 of storage would be required to meet all three of the water quality standards set by SEPA.

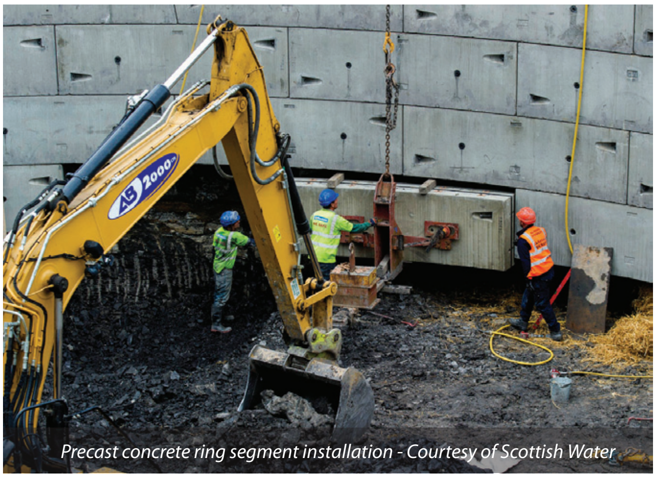
The 3,000m^3 storage was sufficient to achieve two of the three standards. At this size the wetland meets the 9.0 mg/l BOD limit for 79% of the CSO events (95% overall compliance). This same wetland would meet the 1.5 mg/l ammonia-nitrogen limit essentially 100% of the time. To achieve 100% compliance would require an approximate tripling of the size of the system as noted above.

Therefore it was agreed that Scottish Water undertook a period of water quality monitoring before and after construction of Phase 1 to determine whether a second phase of construction to install the remaining 6,500m^3 of storage was required. Monitoring will continue until late 2014; however early indications show that the treated flows are satisfactory and it is unlikely that a second phase of storage will be required.

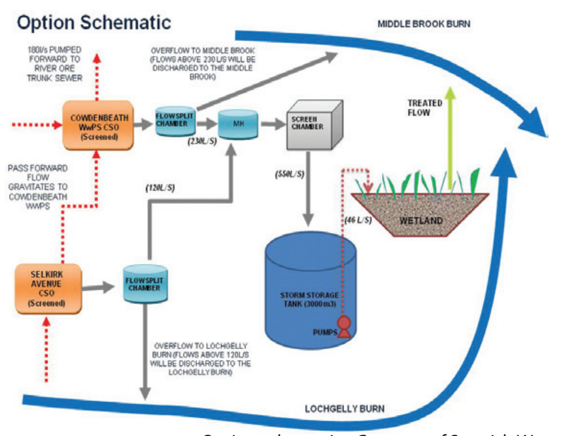
The maximum flow to be diverted to the storage tank will be 350l/s and of this 120l/s will be diverted from Selkirk Avenue CSO which is 1.2km to the west of the wetlands. This will pass through a 900mm diameter check-mate valve retrofitted into an existing pipe to regulate the flow, and the remainder will be made up from the Cowdenbeath WwPS overflow. The wetlands will need the capability

Ground remediation underway by Ground Developments Ltd
Courtesy of Scottish Water

3000m^3 storage tank underway by Barhale
Courtesy of Scottish Water



Precast concrete ring segment installation - Courtesy of Scottish Water



Option schematic - Courtesy of Scottish Water of treating flows up to 46l/s at any one time. Flows exceeding this will be held in the 3,000m³ storage tank prior to being treated by the wetlands. A pumping station and valve chamber has been built to achieve a wetlands design flow rate of 46 l/s.

Table 1: Design information

1	Cowdenbeath has a population of 11,000 and an average trade flow of 10l/s.
2	Dry weather flow (DWF) to the CSO is approximately 40l/s.
3	Flow to the wetlands would be hydraulically limited to a maximum of 350l/s for all storm events.
4	Original model predicted 65 (No.) spill events to the wetland per annum.
5	Original model predicted 480 hours spill duration to the wetland per annum.
6	The originally predicted annual spill volume was 229,700m³.
7	Estimated total BOD load to wetland from typical annual rainfall series: 16,429kg total BOD per annum.
8	Estimated total ammonia load to wetland from typical annual rainfall series: 652kg total NH_4 per annum.
9	Estimated total sediment load to wetland from typical annual rainfall series: 37,376kg total sediment per annum.
10	Estimated peak BOD concentration to wetland from typical annual rainfall series: 0.151kg/s BOD.
11	Estimated peak ammonia concentration to wetland from typical annual rainfall series: 0.0033kg/s NH_4.
12	Estimated peak sediment concentration to wetland from typical annual rainfall series: 0.305kg/s sediment.

Preparing the ground - site investigation

Extensive site investigation work was undertaken on the wetlands site prior to construction. Both geotechnical and geochemical testing was carried out to assess ground conditions and composition.

The site of the wetlands is on a former treatment works and was used as a local dumping ground so had significant contaminated land issues up to a depth of 12.5m. There are several types of contaminants present on site namely colliery spoil, domestic waste, general waste, sewage sludge and demolition rubble from the old Cowdenbeath High School.

Ground investigation was carried out by Terra Tek Limited, part of the Raeburn Group. 33 (No.) samples of soil, 3 (No.) of groundwater and 4 (No.) of surface water were carried out to test for chemical contamination. A number of contaminants were found that were deemed to be harmful to human health. Therefore they were given a hazardous classification and required removal from site. The principal contaminants of concern are heavy metals, organic and inorganic compounds with the additional possibility of asbestos.

Ground stabilisation

There were also concerns over ground stability as there are shallow mine workings and mine entries within the site and surrounding area. Forkers Ltd was commissioned to locate and stabilise the mineworkings under the footprint of the site. A total of (No.) 2,033 boreholes were drilled on a rectangular shaped grid across the site with boreholes spaced 1.5m apart around the perimeter of the grid and 3.0m within.

A total of 5,250 tonnes of grout was injected into the mineworkings which were encountered at depths as shallow as 14.5m below ground level. This work was carried out prior to any remediation works on the site.

Ground remediation

Given the depth of contamination, the variability of materials and large area covered it was not financially viable to remediate the whole site or to remove the contaminated materials off site to landfill due to the taxes applied.

Aerial of storage tank construction - Courtesy of Scottish Water

Barhale, the principal contractor, appointed Ground Developments Ltd (an earthworks and soil stabilisation specialist working with Scottish Water), Atkins (consulting engineers and designers) and SEPA to create an alternative on-site remediation strategy that would work both in a geotechnical and environmental capacity.

The remediation solution involved screening, sorting and classifying the excavated materials from the storage tank. Plastics, metals and timber were removed and sent to landfill. Specialist solidification techniques were then used on 16,000m^3 of soil to lock-in the contaminants by combining the soil with a pulverised fuel ash (PFA) and cement binder, which is a by-product from the nearby Longannet Power Station, thus rendering them immobile.

The treated material was then used to create the embankments which form the sides of the 2.5m high perimeter wetland bund to form a totally impermeable material to contain the wetlands.

All of the soft formation under the base of the wetlands was also solidified to create an impermeable capping layer across the wetland by utilising a deep soil mixing system which was a first for Scottish Water, having opted for more traditional systems of contaminated land remediation in the past.

7,000m^3 of ground was treated to an average depth of 1.5m using the deep soil mixing technique. A large mechanical mixer arm operated from a 20 tonne excavator was positioned vertically into the soil.

The bottom of the arm has rotating 'teeth' and the pulverised fuel ash/cement mixture was pumped to the bottom of the mixer as it was moved up and down, enabling the mixture to be distributed evenly and penetrate further into the soil. The mixer was then removed and the whole process was repeated across a grid system over the base the wetland.

The columns are self compacting and able to withstand shear loadings and therefore create a stable, solid base spread across the columns which will reduce any potential differential settlement. The resulting platform is also impermeable, reducing the risk of surface water migrating through the contaminated soil and towards a groundwater source.

Once the soil had been solidified and compacted it achieved a California Bearing Ratio (CBR) value in excess of 30%, a permeability of 10-7 and a phi angle of 35º. This technique was also used to stabilise the formation level of the retaining wall.

This solution was found to be the most cost-effective approach which also delivered programme savings compared to other options the team considered. The approach saved the disposal of circa 16,000m^3 of contaminated soil to landfill and the importation of the equivalent volume of granular material.

As well as the environmental and economic benefits, the solution avoided 3,200 truck movements through the neighbouring housing estate saving a significant amount of customer disruption.

Forced Bed Aeration™ wetlands

Creating an FBA™ wetland is another first for Scottish Water. FBA™ increases the amount of oxygen in the water by delivering air from blower units, located several metres from the reed bed on their own concrete plinth, through an aeration manifold and series of aeration tubes that lie under the gravel at the base of the reed bed.

The project involved the construction of a single reed bed, designed and built by reed bed specialists ARM Reed Beds (ARM). The reed bed is a 2m deep, saturated vertical flow system with a surface area of 4,000m^2. It is fitted with FBA™ designed to remove organics (BOD) and ammonia. 15,000 tonnes of gravel was imported to fill the base of the wetland bund.

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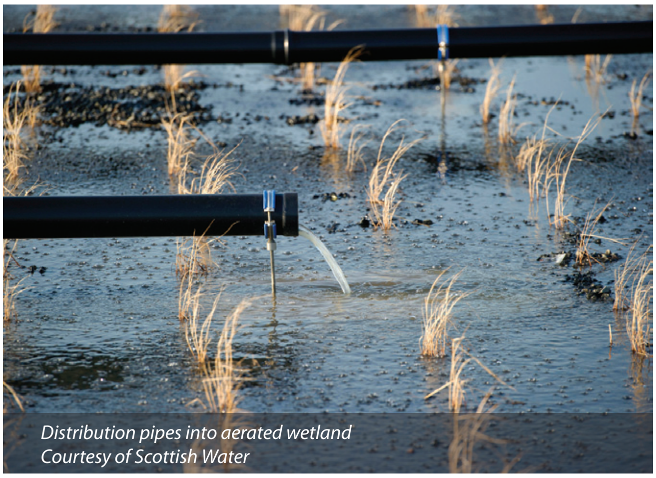
Final wetlands with developing reeds - Courtesy of Scottish Water

Final storage tank and wetland bund - Courtesy of Scottish Water



Distribution pipes into aerated wetland
Courtesy of Scottish Water

Before and after of incoming flow and treated discharge
Courtesy of Scottish Water

Once construction was complete, the nitrifying biomass within the system would take up to 6 weeks to develop within the system before the required treatment levels were achieved. The new system will provide sufficient treatment to allow storm waters to flow back into the watercourses via a decanting chamber and gravity sewer without compromising water quality.

Although the reed bed is fitted with FBA™, it may only need to be switched on to treat flows during storm events. The entire system is only 'expecting' 65 spill events per year which equates to 480 hours spill duration per annum, which means there will be about 300 days per year where no fluid will enter the wetland.

During the 'dry days' the reed bed will be aerated for at least an hour each day to maintain aerobic conditions within and avoid it becoming septic.

This is an ideal solution as the aeration element can be turned on during storm events. The effluent from storm water is variable but all of it needs to be treated before re-entering the watercourse.

An FBA™ wetland treatment system is an ideal solution for Cowdenbeath and they are fast becoming a more popular alternative method of water treatment due to their low-energy requirement, sustainability, habitat creation and versatility. Aerated wetlands are up to 15 times more effective at providing treatment over traditional reed beds.

The storage tank

The open storage tank itself has a volume of 3,000m^3, is 25m in diameter and 10m deep. The tank, constructed by Barhale, took only four weeks and was constructed from precast concrete ring segments, which were bolted and grouted together. The bolts are required only during the construction period. Once constructed, the tank is self supporting.

The first two complete rings were built one on top of the other on the surface. Around this ring, at intervals, sheet piles were driven and these were incorporated into a cast in situ concrete ring beam, which effectively holds the top two rings in place. The remaining ring segments were then placed using 'under-reamed' construction techniques from 'inside the tank'.

Each 'segment void' was excavated out and the ring segment was lowered into place and bolted to the one above and to the one beside it. This process continued until a complete ring was made. Grout was then pumped into the annular space behind the segment and the sides of the excavation. After the grout had set, work commenced on the next ring using the same techniques.

After the last ring was placed the base was excavated out, lined with steel reinforcement and filled with concrete. Ground anchors were also drilled into the base, on a grid system, to prevent uplift of the entire tank from groundwater pressures.

To ensure the health & safety of site staff, gas monitoring was carried out throughout the construction of the tank to detect any potentially explosive or harmful gases or substances. No gases were detected and the construction proceeded without incident.

The project began initial operations in December 2013 and gained SEPA approval in March 2014. This has been a successful project, not only improving the water quality in the burn but leaving a site that is cleaner, visually more attractive and environmentally friendly for the people of West Fife.

The Editor & Publishers would like to thank Scottish Water, Barhale plc, Atkins and ARM ltd, for providing the above article for publication.