SPRINT PROJECT SP.226

REAL TIME CONTROL OF URBAN DRAINAGE AND SEWAGE SYSTEMS BOLTON TOWN CENTRE TELEMETRY CONTROL SYSTEM

Brian J.Sharman and Robert G.Tidswell

Wastewater Network Planning, North West Water, Chadwick House, Warrington Road, Risley, Warrington, England

ABSTRACT

SPRINT stands for the Specific PRojects for Intra-Community INnovations and Technology transfer and 's a European Community programme which has been set up to promote innovations and technology transfer, achieved through specific projects. Each project involves the transfer of technology already in existence in one sector of the Community to another where the technologies are not yet in use.

The Bolton Town Centre Attenuation Strategy was chosen by North West Water (NWW) as being the most appropriate location for the development of a "Real Time Control System". Some 28,000 cu.m of storage has been provided by a capital investment of £ 20 million to alleviate pollution of watercourses and flooding within the town centre. The development of an integrated control system to ensure effective use of the network and receiving treatment works is required and a Control and integrated telemetry system is currently being provided within the two year 1993 -1995 Sprint programme.

The completion of the installation works in March 1994 will enable NWW to gather system performance data to simulate the reaction of the sewer network to actual storms experienced in Bolton. This will enable the optimisation of control decisions to be developed prior to becoming operational in the summer of 1994.

The attenuation of flow in the network will, as a result of the increase in knowledge of the system 'erformance and the benefits of active control result in a reduced need for further capital investment in the treatment works catchment.

KEYWORDS

Real Time Control, Sewerage, Urban Drainage, Detention Tank, Storage, Pollution, SCADA, Overflows, Flooding.

INTRODUCTION

Bolton is a large town located to the north of Manchester in the North West of England. The town is located on the Rivers Croal and Irwell, rivers which emanate from the Pennine Hills to the east of the town. The location was ideal for the development of the textile industry as the local watercourses were used to power the mills. The settlement grew as people congregated in the workhouses attached to the mills during the industrial revolution in the 19th century. At this time sanitation was not recognised as a problem and where pipe systems were constructed, following a Public Health Act in 1870, these generally discharged to the watercourses.

EXISTING SYSTEM

The existing Bolton Town Centre Sewer System now serves a population of 90,000 in an area of some 4,500 Ha, this being approximately one third of the total Bolton population. The network is comprised largely of brick sewers which were constructed between 1870 - 1930 to take both foul and surface water sewage. The Croal Valley/Middlebrook Trunk sewer was initially constructed in the 1930's to intercept the direct discharges and thus reduce pollution of the Middlebrook and River Croal. However to minimise the size and cost of this sewer numerous overflows were retained to restrict the flows passed to the newly constructed sewer.

Following development of Bolton as a town, with a population rising from approximately 30,000 up to 250,000, the problem of pollution has increased and the pipe system has become more and more hydraulically inadequate. This has resulted in foul flooding frequently occurring on the production floor of a shoe factory in the North Eastern area of the commercial town centre, together with flooding being experienced in the Market Hall. Further incidents of foul flooding have been experienced by 24 residential properties in the catchment and a school canteen. The pollution of the River Croal caused by the 42 crude overflows has gradually worsened with the population growth and conditions have deteriorated to an unacceptable level.

IDENTIFICATION OF INVESTMENT REQUIREMENTS

The Bolton Town Centre's Sewerage problems of pollution of the local watercourses and of flooding both in the residential areas but more significantly in the commercial town centre were highlighted in a Drainage Area Study report completed in 1986. This Study was used as a pilot for the Water Research Centre's document "Sewerage Rehabilitation Manual", now generally accepted as the UK's national guidance document for the rehabilitation of sewer networks.

An Options Report was produced the following year identifying several possible solutions to rationalise the number of overflows in the catchment and significantly reduce the pollution to the Rivers Croal and Irwell, and to alleviate the flooding caused by hydraulic incapacity. The various options were modelled using the Wallingford Storm Sewer Package (WASSP) software. Two main options were defined.

i). The Flow Attenuation Option
). The Western Interceptor Option

A detailed Planning Note was developed in 1988 which considered the above options in more detail, provided detailed cost breakdown and considered the individual sub catchments works that would integrate with the trunk sewer strategy. Following the comparison of the benefits and costs of each option the Flow Attenuation Option was approved as the preferred investment strategy.

CONSTRUCTION PROGRAMME

Work commenced on site in April 1990 on the Spa Road Retention Tank. This tank is an off-line tank, some 25 metres in diameter and 29 metres in depth, providing storage for up to 9,000 cu.m of sewage prior to pumping back into the Middlebrook Trunk sewer following storms. A second similar tank was commenced at Ladybridge, upstream of the Spa Road Tank. This tank provides storage of up to 2,000 cu.m of sewage.

The two tanks were completed in 1992, Spa Road was operational in May 1992, whilst the Ladybridge Tank became operational in July 1992. These tanks work remotely of each other, although both facilities return lows to the same trunk sewer. The pumping regime being activated following consideration of three factors :-

i). a volume of sewage recognised in the wet well.
ii). sewage not being overflowed into the tank.
iii). sufficient capacity being available in the downstream sewer to accommodate the pumped return flow.

A third tank was commenced in April 1992 at Springfield, the tank being an on-line oversized gravity sewer, constructed in tunnel. The tank has a capacity of 1,250 cu.m and restricts the rate of discharge from a large subcatchment into the main trunk sewer. A fourth tank was commenced in October 1992 at Water Street. This tank, like the earlier Spa Road and Ladybridge Tanks, being an off-line sump style tank. The volume of the storage of the tank is 10,000 cu.m and pump returns the sewage on cessation of the storm. This tank is the furthest downstream on the Middlebrook trunk sewer. The rate of return from this tank, along with the pass forward flow from the controlling overflow is the major control of flows from the Town Centre catchment.

SPRINT - WHY BOLTON?

In October 1991, WRc invited North West Water (NWW) to act as end user partner in the "Definition" phase of a Sprint Project on the development of "Real Time Control of Urban Drainage". In accepting WRc's invite, North West Water (NWW) considered three possible locations.

Fylde Coast - Ongoing works in providing a long interceptor sewer which removed several sea outfalls and provided retention of sewage previously spilled through unsatisfactory overflows. Unfortunately the work on site did not fit in with the January 1993 - December 1994 Sprint Programme.

Liverpool - The Mersey Estuary Pollution Alleviation Scheme (MEPAS) is similar to the Fylde Coast in its strategy. The Interceptor sewer, intercepting numerous direct outfalls to the River Mersey. In the case of MEPAS, the construction work has been completed by 1993, however a catchment wide Drainage Area Study , had not been completed and a hydraulic model of the network was not available.

The Bolton Town Centre Attenuation Strategy was chosen as the most appropriate location for development of a "Real Time Control System." The on-going construction of both on-line and off-line tanks, providing some 28,000 cu.m of storage, required an integrated control system incorporating the tanks, sewer throttles, overflows and treatment facility, to ensure the most effective use of the £20 million construction investment. The two year Sprint Project commenced in January 1993 and the programme for implementation links in well with the construction programme. As identified four of the seven tanks are to be completed by December 1993.

The ongoing construction work has been designed to alleviate the flooding and provide sufficient capacity to enable the development of schemes in the sub catchments which will alleviate both the flooding and pollution. However the current operation of the tanks do not consider the following factors prior to returning or releasing flow :-

The flow must be accommodated in the downstream sewers.
There must be no downstream flooding present.
There must be no spillage at downstream overflows.
The receiving Treatment Works must be able to treat the additional hydraulic load.

Additional factors also need to be considered in terms of quality of the sewage:-

Sewage cannot be passed from tank to tank.
Sewage cannot stand in any one tank for more than 24 hours.

It was considered that these factors were important to the overall integrated control of sewage within the network and at the treatment works.

PROPOSED SYSTEM

The Bolton Town Centre Control System, costing £475,000 will involve the adaption of existing telemetry equipment which currently collects data on a daily basis from ten raingauges located around the Bolton Metropolitan area, together with sewer depth monitors, major overflows and the treatment works. This will link to a second system which currently provides the Local Council with "alarm data" required for reactive maintenance of small pumping stations. More importantly the alarm data from the two completed off-line storage tanks at Ladybridge and Spa Road also report on this telemetry system.

Further monitors will be essential to the project located at remote pinch points on the trunk sewer, notably in the vicinity of the town centre where flooding has previously occurred and at the treatment works to monitor the status of the storm tanks.

The project will incorporate monitors being installed at all further storage tanks for local control and will collate the data at a single System Control And Data Acquisition (SCADA) Masterstation based at the receiving treatment works. The Control software computer will sit adjacent to the SCADA and will interface with the computer to extract relevant data for simulation. Simulation and Optimisation of the system in real time will be undertaken using MOUSE ON-LINE and control decisions will be sent back to the SCADA system to enable activation on site.

The close monitoring of the frequency of spills of the key overflows on the network and at treatment overflows which discharge into the Rivers Croal and Irwell respectively will provide evidence of the benefits of the Project.

MODEL BASED CONTROL

The control of a sewer system relies on the level of information available. The basic idea of model based control is to introduce a numerical model in the control loop to improve the quantity and quality of the information available. By having a model running which, based on the on-line information from a SCADA system, simulates a forecast, information from other than the monitored points is available together with information about the expected situation. Another advantage of having a model is that it is possible to analyze the effect of control actions in advance.

MOUSE ON-LINE provides such an environment, see Nielson, Lindberg & Harremoes (1993). MOUSE ON-LINE interfaces to the SCADA system from which it receives the on-line measurements and sends the selected control actions to the SCADA system.

MOUSE ON-LINE is based on a modular design with two blackboards, an external one where information is exchanged between MOUSE ON-LINE and the SCADA system and an internal one where information is exchanged between the modules constituting MOUSE ON-LINE.

The main modules in MOUSE ON-LINE are:-

The rain forecasting module:

based on on-line rain measurements and a description of a growth and decay time profile for the rain, a rain forecast is computed.

The runoff forecasting module:

based on the rain forecast and a description of the network topography a forecast of the sewer load is computed.

The control module:

based on the forecasted sewer load a control strategy is selected and the corresponding control actions selected.

The runnoff and sewer load modules are based on the MOUSE system, which means that the file format is identical to the MOUSE format.

The execution of the different modules depend on the mode of MOUSE ON-LINE. It works in three modes, monitoring, forecasting and controlling. A set of criteria, which are specific for the individual applications, specify when the mode is changed. The change from monitoring to forecasting is needed when the current situation in the sewer indicates that information about the expected situation is necessary. This could be the case eg. when the intensity of the rain or the inflow to the treatment plant exceed the biological capacity or levels in overflow structures exceed the biological capacity it changes back to monitoring. The criteria are implemented in a knowledge based system which performs the analysis of the current and expected situation. The knowledge based system also controls the execution of the individual modules.

The selection of the control strategy is also handled by the knowledge based system. Four different main strategies can be selected:-

Dry Weather strategy:-	the default strategy applied when the load of the system is small.
Expecting a high load:-	applied when a high load is expected, for example to empty the system.
During a high load:-	applied when the system has a high load, for example to retain water upstream in the system.
After a high load:-	applied when a high load has passed and the retailed water should be released.

Within each of these strategies sub strategies can be defined eg. depending on the spacial distribution of the high load etc. Corresponding to the control strategies there is a set of control actions which are specified together with the control strategy. When a strategy and a set of control actions has been selected of the new forecast is simulated in order to evaluate the effect of the control strategy. The control actions are then sent to the SCADA system.

MOUSE ON-LINE is also equipped with a user interface which can be tailored based on user defined requirements. The main functionality of the user interface is to present the following information:-

an overview of the system, showing sensors and regulators

the current situation in form of of-line measurements received from the SCADA system

the expected situation in the form of the simulated forecasts

the selected control actions.

CONSEQUENCES OF THE DEVELOPMENT

The objective of the Control System will be to maximise the use of the storage facilities during storm events to eliminate flooding, to minimise pollution to local rivers and to optimise the use of the treatment works.

The active control of the system will require a change in the consents conditions currently applied to the overflows, and will require close monitoring in both the performance of tanks, treatment works and network overflows to provide archive data of the implications of various storms and control actions.

The alleviation of pollution will naturally bring about an increase in the flows arriving at the treatment works. As a consequence of the extension in duration of flow to full treatment, the treatment works will need to consider the impact on the three stages of treatment. An additional consideration on the network is that further storage facilities are planned for the other two contributing Bolton Catchments. The attenuation of flow in the network will, as a result of the increase in knowledge of the system performance and the benefits of active control, result in a reduced need for capital investment.

In order to develop the project a multi-disciplined task group, incorporating Treatment, Network and Water Quality personnel, has been formed to identify how ultimately the project will operate. It is recognised that the implementation of the Bolton Control System will significantly alter the approach to the sewerage problems within Bolton and the North West Water (NWW) area.

THE EUROPEAN PARTNERSHIP

The European Partners in the project representing Denmark, U.K, Italy and Spain are Copenhagen and the Danish Hydraulic Institute; North West Water (NWW) and the Water Research Centre; Mantova and Societa Generale di Ingegneria; Vitoria and the Angisa AN Group.

The partners will share their experiences in the development of individual projects, and will disseminate their knowledge throughout Europe with the assistance of a specialist Project Advisory Group.

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Technical Session 2 Chairman Gareth Catterson Integrated Hydro Systems

Bolton RTC SPRINT
Brian Sharman North West Water
Robert Tidswell North West Water

Question Andrew Taylor Sir William Halcrow and Partners

The implementation of an RTC system with such large tanks will affect flows and loads at the STW, are there any conclusions as to what may need doing at the STW?

Answer

Data acquisition is still going on and not all the SCADA is in place, we do not envisage being able to make much comment until then.

Question David Wright Consultant

Why did you use MOUSE?

Answer

At the project definition stage Mouse On-Line was available and DHI were the project partners. The system is modular and the model can be unplugged and a different one plugged in.