WATER QUALITY MODELLING (CASE STUDY)
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## Synopsis

This paper outlines the procedures and process used in building a verified water quality model for the Kingston-upon-Hull catchment, with particular emphasis being put on the verification of the water quality model and the sampling techniques used and the theory behind them.

## Background

The sewerage system is divided into two totally separate catchments, East and West Hull with the River Hull being the boundary between the two. Much of both East and West hull sewer system were constructed prior to World War 2 and comprise of large diameter sewers laid at flat gradients and discharging by tidal flapped outfall to the Humber during low tide. During high tide conditions the system backed up and the volume within the oversized sewers used as storage. Subsequently, interceptor sewers were constructed at low level to conduct the sewerage to the new East and West Hull pumping stations for pumped discharge to the Humber and the old outfalls abandoned.

## Purpose of the Study

The model was required as part of the commitment by Yorkshire Water Services (YWS) to improving the environment and investing in new sewerage infrastructure. As part of this (YWS) are currently in the process of evaluating the effects of the Hull sewerage system on the Humber Estuary. The exercise is to ensure that YWS complies with EC Legislation and as a consequence the water quality model was required to produce the following information :

1. Peak dry weather flows
2. Quality and pollutant loadings of first flush
3. The spare storage capacity in the existing sewerage system
4. Pollutant loadings and number of spills at the East and West Hull pumping stations

## Hydraulic Model Building

Prior to attempting to construct a new model an investigation took place to see whether a model constructed in the mid 1970's by Watson and Hawksley and verified by WRc would be suitable. It was found that the existing model did not go into enough detail and the pipe lengths were far too simplified to provide a model that would satisfy the needs of MOSQITO, therefore it was decided to construct a totally new model. Before the Hydraulic model building began, all the existing drainage data for the whole catchment was merged into one STC25 database and the accuracy of this data brought up to an acceptable standard.

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4 Flow Conditions
Avoid slow, steady, stale sites as segregation of the sediment may cause an unrepresentative sample to be taken. Turbulent sites should also be avoided as this can cause unreliable triggering of sample runs.

Methodology of Sampling Programme

The sampling work was separated into two phases which were intermixed depending upon Met. Office forecasts, Dry Weather Sampling and Storm Sampling.

1 D.W.F.
Samplers were set up to commence sampling at a predetermined time when dry weather was expected and programmed to take one sample per hour over 24 hours. At set up, the sample carousel was filled with ice to preserve sampling integrity as much as possible. Samples were recovered 23 hours after sampling commenced.

2 Storm Sampling
The methodology adopted for collecting storm samples relied on two main elements :
- installation of intelligent flow monitors to trigger sampler at a predetermined flow rate.
- selection of one key site which was telemetered back to a base station.

Equipment was set up for 'Storm Sampling' in response to Met. Office forecasts and this also allowed 'retrieval' and laboratory staff to be alerted to the likelihood of samples being taken.

**Telemetry Link**
This allows the equipment to send a warning to the appropriate person once sampling has been triggered. Four and one half hours after triggering the sample runs was completed, and the crews from ERSTU were on site ready to remove carousels for analysis.

**Triggering Samplers**
As all the sites were relatively close to the terminal Pumping Station, it was vital that samplers triggered from an increase in flow rate (not depth) as the sites could and were affected by backwater.

**Sampling Rate**
Samplers were programmed to collect at 6 minute intervals over the first hour and at 14 minutes thereafter. This provides more data points for the first flush when loadings in the flow change more frequently.

**Analysis of Samples**
Before the costly exercise of having samples analysed, the Engineer had to check that the following criteria were achieved

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Also, in extreme cases of this, the package was prone to crash, resulting in loss of results data. These problems were attributed to the following factors :-

1 Instabilities caused by changes in pipe length, gradient and silt levels, which did not caused any problems while running the models through WALLRUS, became apparent, once the water quality verification was started.

2 Any alteration of the default values within the .DWP file and the sed.PRS file magnified any instability problems. Linked to this, any reduction of the sediment particle density below 1100 kg/m3 caused the model to crash.

3 Due to the maximum number of computational points, per pipe length, being far greater in MOSQITO than in WALLRUS, it was necessary to keep modelled lengths less than 600m. This problem was overcome, to a degree, by increasing the model step time to 60 seconds.

Verification of Water Quality Model

The methodology behind the verification of the water quality model starts with comparing the results of the predicted 24 hour diurnal dry weather data, with the observed sampler results. When a good comparison is achieved for the dry weather data, the water quality model is run for a storm event, and the predicted is compared with the observed data.

Dry Weather Verification

The East and West Hull models were verified on four separate pollutants, BOD , COD , Suspended Solids and Ammonia. With the exception of ammonia, the other pollutants are partially reliant on the concentration of the suspended solids. The reason being that both the total BOD and COD are built up of two separate parts ; one is the dissolved part (the .hbd and .hcd files) and two, is the part attached to the suspended solid particles (.hbl aand .hcl files). For this reason, suspended solids is the first pollutant to be verified. The problems encountered and the assumptions made to give a reasonable verification to the dry weather flow pollutant concentrations were as follows :

1 Standard default values in the .DWP and sed.PRS files were used, but they produced higher concentrations than the observed sampler data for suspended solids, throughout the whole of the sample. Therefore, the density and size of the sediment particles was reduced to 1100 kg/m3 and 0.24mm respectively. This produced a better comparison for predicted, against observed solids.

2 The predicted values for both BOD and COD were higher than the observed results, for all the sampler points. Therefore, the potency factors relating to these pollutants in the .DWP file were reduced, in order to improve the comparison.