An Overseas Application of the Wallingford Procedure

D C Beale - Howard Humphreys

In 1986 Howard Humphreys was appointed by the Environmental Protection Agency of Hong Kong to prepare a Master Plan for the sewerage of East Kowloon. The study, the first of its kind in Hong Kong, was to identify both the quantity and the quality of foul sewage flowing untreated into Victoria Harbour and to design appropriate treatment facilities. The methodology and techniques used were to be applicable throughout the colony as the problems were typical of conditions prevailing elsewhere in the territory.

For historic reasons the majority of industrial wasteflows are discharged into one of the thirteen stormwater drains crossing the study area. In addition the existing foul sewer system was known to be extensively overloaded. Approximately half of the urbanised area is founded on land reclaimed from the sea. Sewer gradients within this landfill area are negligible resulting in tidally affected flows, frequent surcharge and extensive silt deposition within the sewers. The storm drains, designed to cope with the run-off from extreme rainfall occurring during typhoons, are particularly affected by sediment deposition and do not achieve self-cleansing velocities. It was known that impermeability factors of nearly 100% were prevalent in the highly urbanised areas. The high population densitites and widespread industry resulted in large dry weather flows to the foul sewers.

The very slack gradient, large diameter sewers and extensive sediment deposits were principal criteria in the selection of the WALLRUS model as it was our experience that these factors would lead to severe problems in the operation of a WASSP model.

The modelling study was in two phases, a dry weather flow study to assist in determining the pollutant load in both the foul and surface water sewers and a conventional wet weather flow study in the foul system only.

The procedure adopted for the dry weather flow study was to undertake short-term monitoring of the flows in both the storm drains and the foul sewers at over 50 locations and to compare the results with longer period measurements at selected locations. A concurrent study used these data to correlate the land use with the flows observed in the sewers. Estimates of the total dry weather flows throughout the sewer systems were then prepared using a proprietary data base. A conjunctive water quality sampling exercise enabled the total pollution loads to be estimated. The range of flows equating to the peak and multiples of peak dry weather flows were then routed through the foul sewer system to assess its hydraulic performance. The very slack gradients, especially during periods of high tide, meant that the backwater flow modelling capability of the WALLRUS model was fully utilised. The effect of the extensive sedimentation was also investigated by comparing the results of model runs including and excluding the sediment.

The Foul Sewer System models were then verified using the results from a wet weather flow survey and the total stormwater inflows into the two systems were assessed. Sample areas were analysed to provide a best estimate of inflows into the foul and surface water sewers.

As this was the first use of the Wallingford Procedure in Hong Kong it was necessary to use data from sample areas to calibrate the WALLRUS model. The WALLRUS model uses a linear reservoir to route storm rainfalls, allows the direct input of percentage run-offs and enables the user to adjust parameters to suit local conditions. For example, it was found that as a consequence of modelling only foul sewers greater than 450mm in diameter, the model as initially constructed under-predicted the routing effect of the sewer system and the routing coefficient was therefore subsequently modified.

It was found that 10% of the paved area drained to the foul sewers with the remainder draining to the storm drains. Percentage runoffs from paved and roof areas ranged from 95-100% after allowing for depression storage. Runoff from unpaved areas was effectively nil.

Owing to the limited timescale of the project the surface water drainage system was not verified.

Modelling problems were mainly due to software deficiencies as WALLRUS still under development. It was found that the selection of backwater flow analysis substantially increased total run times.

The study demonstrated the following advantages of the WALLRUS model:-

1. Ability to model extensive backwater flows.

2. Inclusion of sediment.

3. Ability to model large (greater than 3m square) culverts.

4. Facilities to calibrate model based on local conditions.

5. Ability to interrupt simulation runs to review results.

DISCUSSION NOTES

Technical Session 2
Paper 2.1 Discussion

D.Wall ; Wessex Water

The WASSP hydrology model is not applicable overseas - was this overcome with WALLRUS ?

D.Beale ; Howard Humphries

Yes, we changed the linear-reservoir coefficients to fit the measured results.

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N.Simmonds ; Consultant

Can you summarise the main benefits of WALLRUS ?

D.Beale

The ability to model backwater and sediment in the very flat sewers.

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R.Dew ; Yorkshire Water

What size were your models, and what computers did you use ?

D.Beale

There were 20 models in all, ranging from 50-200 pipes after simplification. Two IBM-ATs + maths co-processors were used.

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D.Wright ; Applied research

I am concerned that you changed the linear-reservoir model co-efficients, could this not be considered as "force-fitting"

D.Beale

There were 20 models, each verified individually. The linear-reservoir coefficients were altered globally, so I don't consider this to be "force-fitting".

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D.Williams ; WRc

You had very high rainfall during verification, was the run-off from the pervious area nil ?

D.Beale

One of the calibration areas was unpaved and only 1% run-off was measured.

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J.Packman ; IH

Where were the rain-gauges sited ? Was there any ground-level information ?

D.Beale

Three were located on tops of buildings. There were another eight permanent gauges also used to help predict against land-slips. There was considerable spatial variation, and we used that aspect of WALLRUS. There was some ground-level information.

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A.Taylor ; WRc

Did tidal effects cause any problems ?

D.Beale

Not really, but there *were* substantial backwater effects. Again, WALLRUS was needed in this respect.