THE USE OF WEATHER RADAR IN MODELLING THE MANCHESTER EXPERIENCE

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1.0 Introduction

This paper covers the use of weather radar for modelling as part of the Manchester Trunk Sewers Hydraulic Strategy Project, which was a project to define a high level strategy for controlling flows in the Davyhulme Wastewater Treatment Works catchment. This is the largest in the North West serving a population of 675,000 people in a catchment area of 195 square kilometres.

The majority of the catchment is served by a combined system of drainage. At points in the system excess flows are spilled to watercourses at combined sewer overflows (CSOs). There are approximately 250 CSOs in the catchment of which 160 are considered unsatisfactory for various reasons.

It was considered during the early days of the study that spatial variability of rainfall over such a large catchment would be important. Also for verification purposes to adequately cover the catchment using raingauges over 50 would be required at considerable cost and with severe logistical problems in finding adequate sites.

NWW in conjunction with University of Salford Water Resources Group had carried out research into the use of Weather Radar in the Bolton catchment as part of the North West Urban Radar Project. The conclusion was that provided the weather radar data was calibrated against available raingauge data the use of weather radar was sufficiently accurate to use in Urban situations.

It was therefore decided to use weather radar as a source of spatially varied rainfall for the hydraulic computer modelling of the Davyhulme catchment.

2.0 The Approach to Radar Rainfall in Manchester

2.1 Availability of Data

Processed radar data, in the form of rainfall intensities on a 5km grid at 15 minute time intervals is available throughout the UK and is provided by weather stations operated by the Meteorological Office. Radar data at finer resolutions, in the form of 2km grid at 5 minute intervals is available within 75km of each of these stations. The Davyhulme Drainage Area is located approximately 30km South of the North West Weather Radar Station at Hameldon Hill and the finer resolution data is available for the area.

It is possible to obtain historical weather radar data from archive and this form of information was used in the study.

2.2 Selection of Events

There were three distinct occasions during the study when weather radar data was used. These were a) for assessment of the performance of the network under extreme events, b) for the provision of rainfall information for validation of the Wallrus hydraulic computer model in conjunction with a sewer flow survey, and c) the provision of rainfall information for a water quality sampling survey in conjunction with in sewer quality monitoring.

2.2.1 Extreme Event Analysis

At the time of commencement of the study flow data was available from a Depth monitor situated in one of the Main Outfall Sewers upstream of a major overflow. Also available were daily figures from various raingauge sites around Manchester together with Wind Direction figures from Manchester Airport. This data was assessed and six events were chosen from a dataset between May 1990 and July 1991. In the end one set of data was unavailable as the rainfall information had not been archived by the Meteorological Office and five events were obtained.

The raw Met Office data was amended by Salford University by first stripping out the existing calibration and recalibrating against six raingauges within or immediately adjacent to the catchment. After recalibration the data was manually assessed for brightband, a band of supposed extreme rainfall caused by the radar signal reading ice drops as rain. If the data was acceptable after calibration it was converted to the format required for the Wallrus hydraulic computer model. This procedure was standard for all the uses of radar data.

The real events were assessed for return period by the use of a computer programme developed by Salford University based on both Bilham and Flood Studies Report techniques and a return period assigned to the storms. The data was then factored to give five events each of a nominal once per year return period.

2.2.2 Validation of Wallrus model

The hydraulic computer model of the Davyhulme catchment had been constructed using existing models and where these were not available new models had to be built. Some of these had been verified using flow surveys. There were significant areas that had not been verified and therefore the accuracy of the computer model had to be assessed. This was done by carrying out a limited flow survey exercise linked to rainfall obtained from weather radar.

2.2.3 Water Quality Sampling

In order to evaluate the strengths of effluent being spilled from combined sewer overflows it was considered necessary to carry out a wet weather sampling exercise. This data was linked to rainfall from weather radar to enable the wet weather sampling to be used to validate a water quality computer model of the network.

Five events were used for sampling. However when the data was requested for the events it was found that data was not available for three of the events due to a failure in the archive facilities at Hameldon Hill. Data was retrieved for the other two events and converted to Wallrus data files as previously.

3.0 Assessment of Results

3.1 Accuracy of Results

Comparisons were made during the model validation stage of radar rainfall against rain gauges set up as part of the flow survey. These raingauges were not used for calibration purposes.

In general the radar derived data tended to be less peaked than the rain gauge data. The radar rainfall represented the relative intensity of the rainfall against time accurately.

Radar rainfall data was obtained for three events over a 2000 hectare area in South Manchester, known as the Mersey South Drainage Area, for the same period as a flow survey had been carried out using raingauges. One of these was the same event as one of the real events used for design purposes on the whole catchment.

The Mersey South model was run using radar data and raingauge data as rainfall inputs and the results compared. The flow results obtained from the model runs were a good fit. This confirmed that the use of radar information was not detrimental to the verification of the model.

This also confirmed work carried out on the Bolton catchment as part of the North West Urban Radar Project were in some circumstances radar derived rainfall inputs gave better response than raingauge derived inputs.

3.2 Comparison of Spatially Varied and Point Rainfall.

As has been previously stated five real rainfall events were selected for use with the Wallrus modelling package. This was distributed rainfall over 56 2 kilometre square rainfall grids, with each rainfall hyetograph being assigned to the wastewater network in the particular grid. At the time this necessitated development of a special version of Wallrus which allowed greater than 9 different rainfall inputs.

The use of spatially varied rainfall produced difficulties both from a hydrological and a logistical viewpoint. The largest problem from a hydrological viewpoint is placing a return period on the event.

Because of the variable nature of the rainfall it is possible for each individual grid to have a different return period. Hence it may be possible to have return period event on a lumped basis but have return period event in parts of the catchment and very little rainfall in others. This in fact did happen as the results from using the spatially varied rainfall inputs showed.

Due to the problem with return period assessment on the real spatially varied events a decision was taken to use the annual time series events for the checking of network performance and design of required improvements. The real 'design' events were used as check on the results of improvements to ensure compliance at the downstream end of the catchment.

In order to test further the requirement for spatially varied rainfall inputs, a comparison was made of flow and spill volumes using the fully spatially varied 56 rainfall inputs, together with single rainfall inputs using grid 21 at Davyhulme WWTW and grid 31 in the centre of the total catchment. The fits were almost identical for flows at the WWTW.

Similar results were obtained using Event 5. This is significant as Event 5 is more of showery event than Event 1 and spatial variation would be expected to be larger in event 5.

The conclusion reached is the flows at the downstream of the catchment are not greatly affected by spatial variation across the catchment and the use of a point rainfall source at the centre of catchment is suitable for design work. In the upstream parts of the catchment this is not the case, and there is considerable spatial variation, with same point rainfall for the design of works in these areas is also proposed.

The situation is not the same if an element of control is added to the system, either local or globally. Then there will be a requirement to handle variations in flow from spatially varied rainfall actually happening, rather than statistically determined rainfall, and spatially varied rainfall will be required.

4.0 Conclusions and Recommendations

1. The use of radar rainfall data as a supplement or replacement of rain gauge data is a viable approach as long as the radar rainfall data is calibrated against rain gauges.

2. Due to the problems of setting a return period to spatially varied rainfall, if this is to be used for design purposes a long rainfall time series of events is required to enable return periods to be assigned.

3. The requirement to use spatially varied data for design in the Davyhulme catchment is not proved, and the use of point rainfall should be adequate for design of upgrading works unless real time control is proposed.

4. The use of the WRc annual time series rainfall is inadequate in the Davyhulme catchment due to the limited durations of rainfall, and an actual or statistically generated long rainfall time series should be used in the design of upgrading work.

THE FUTURE Chairman Wayne Earp STW

The Use of Weather Radar in Modelling . The Manchester Experience
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Question David Powell Wessex Water
What are the costs for weather radar data ?
Answer
Expensive for one off data cheaper per event for a lot of events. Approximately £1,000 per event.