REPORT BY THE FOUNDATION FOR WATER RESEARCH

WASTEWATER RESEARCH & INDUSTRY SUPPORT FORUM

ON

THE URBAN FLOOD ROUTE PREDICTION - CAN WE DO IT?

A WORKSHOP HELD

26TH SEPTEMBER 2002

AT

RENEWAL CONFERENCE CENTRE, SOLIHULL

SPONSORED BY FWR AND WAPUG

FWR (Foundation for Water Research) is an independent charity dedicated to education and information exchange. Its subjects are the science, engineering and management of water resources, water supply, wastewater disposal and the water environment in general. FWR brings together and disseminates knowledge and makes this available widely.

WaPUG (Wastewater Planning Users Group) is a not-for-profit organisation established over fifteen years ago to promote best practice in the wastewater industry. Its terms of reference are to:

- Provide a forum for discussion between practitioners
- Facilitate the exchange of information between relevant organisations
- Identify areas for improvement or modifications to and associated research and development of wastewater planning models
- Identify education and training needs and encourage the necessary education and training.
- Promote relevant research.

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1 Executive summary

It is predicted that climate change will mean that severe weather events will become more frequent. The ability to predict the route of floodwaters in urban areas is important for its financial and quality-of-life implications. Work commissioned by DEFRA (Purnell, 2002) estimated that assets worth £215bn are at risk from floodwater in England and Wales alone, and yet the EA does not list flood route planning amongst its principal sectors (Harman et al. 2002). The purpose of the workshop was to answer the question do we have the tools to do it?

It was expected that the solution will be a combination of terrain modelling, fluid mechanics, hydrology, urban drainage, open channel hydraulics, computational fluid dynamics, data capture by remote sensing and meteorology. Accordingly lead experts were selected and invited who could contribute information on these aspects together with potential funders and "customers". FWR and WaPUG sponsored the meeting at the Renewal Conference Centre, Solihull so that it was free of charge to invitees, 23 of whom participated. Those who were unable to attend asked to be kept informed of proceedings. Attendees said that it was a very worthwhile day and indicated that there might be successors in the future.

It was agreed that it is inevitable that under extreme rainfall (intensity or duration) the capacities of sewers and covered watercourses will be exceeded on occasions. This is because it is not economic to build underground conveyance large enough for the most extreme events and because the flow of surface water is sometimes so great that some of it cannot enter the drainage system. The streets and other above-ground areas will then become the primary drainage routes.

Land management in non-urban and peri-urban areas can attenuate flows to the rivers and run-off into urban areas. Management of non-paved areas can influence infiltration and thus the amount of surface water. These measures could lessen the frequency but cannot eliminate flooding. Roads can be designed as drainage routes, apparently the Romans did this in Pompeii by constructing high curbs, and it is commonly practised in S.E. Asia today.

The UK's climate change model is second to none in the world. Therefore the ability to predict the precipitation for which solutions should be designed is probably good.

One-dimensional hydraulic modelling of watercourses (including sewers) as linear systems is well developed. This was considered to be another area where the UK leads. They are modelled as a succession of elements of defined capacities that can be combined and divided as necessary. Modelling problems start when the capacity of this confined (and defined) conveyance is exceeded. Roads, highways and other elements can be modelled very simplistically as 1-D elements by making assumptions about widths and curb heights etc. but this neglects roughness and slope effects. Knowledge of the extra dimensions (width, depth, etc.) is sparse and the computational power required for 2-D or 3-D modelling increases enormously compared with 1-D modelling. It was agreed that Moore's Law means that it is only a matter of time before this computational power becomes available and affordable. However data acquisition and validation for the additional dimensions will remain a major task and therefore resources will have to be targeted to the areas of highest priority in any catchment. A decision support package that includes the uncertainty of the information and the consequences of the decision (called CMAM Condition Monitoring and Asset Management) could be the tool to direct this tiered prioritisation of resources and activity to the areas that are most critical for each urban area.

Participants agreed that planning roads and other features for water conveyance needs to be (re)applied in the UK (and the rest of Europe) but recognised that many agencies are involved, some (but not all) of these are the responsibility of DEFRA in the UK. When sewers are remodelled it would be sensible to combine the exercise with data capture for the flood routes as part of the exercise, but there needs to be a remit and funding for the water, roads, highways and other agencies to work together.

2 Recommendations

The workshop identified work (and investment) that could be made in R&D, surveying and engineering. Given the inevitable resource constraints it is important to adopt a systematic and tiered approach to investigations as detailed below. Liabilities regarding damage to property and quality of life as a consequence of flooding are changing. The public is demanding that flooding be managed. The following recommendations have been drawn from the multi-disciplinary workshop:

1) Acknowledge that it is unrealistic to expect that underground drainage routes can be constructed with capacities large enough for every circumstance, and that therefore alternative routes are necessary for the situations (which will occur inevitably) that there is drainage water above ground.
   1.1) The consequence of accepting this will be the conclusion that flood routes have to be planned in order to minimise damage to property and to the quality of life.
   1.2) This does not absolve the importance of minimising the amount of surface water by maximising the opportunity for infiltration and minimising the risk of run-off, which are additional essential measures.
2) Acknowledge that when surface water volumes and flow-velocities are extreme a proportion of that flow might not be able to get into the underground drainage system.
   2.1) Better modelling tools for points of access could improve this situation and enable designs that will conduct more of the surface water underground.
   2.2) Design and install improved points of access at critical locations where there are likely to be the largest volumes or flow-velocities in order to increase the capture of surface flows and divert them underground where this is deemed appropriate (see below).
   2.3) However increasing the capture of surface water by the sewerage network (carrying foul drainage) increases the likelihood that the capacity to carry this combined drainage will be exceeded and the combined flow will become surface flow somewhere further down the catchment.
   2.4) Even if all of the combined flow were to be conveyed to a (non-coastal) wastewater treatment plant, its (finite) capacity will be exceed in extreme events and its partially treated discharge would then contribute if there were fluvial flooding further down the catchment.
3) Acknowledge that roads and highways are the least undesirable routes for surplus drainage water (whether clean or combined) and therefore implement a process of (re)designing them in association with the underground drainage so that they are effective and predictable flood routes.
4) Require agencies (sewerage, roads, highways, planning) to co-operate and to
   4.1) Designate flood-routes.
   4.2) Co-ordinate the design of sewerage, drainage and flood-routes.
   4.3) This may require new legal powers and responsibilities.

4.4) Consider drainage catchments systematically to decide the points where the risk that there will be drainage water at the surface is greatest and decide for each whether the best solution is to increase the underground capacity or whether it is to plan and construct the surface flood-route.

4.5) Apply a tiered approach to the catchment, including an allowance for the uncertainty of the information, in order that resources and solutions can be applied to the most critical points first.

4.6) Designate the required roads and highways as flood-routes and reconstruct them as necessary and appropriate to obtain appropriate hydraulic capacity. Parking restrictions would need to be imposed during flood-flow on these designated routes such that the flow of floodwater was not impeded during periods when there is flood-flow.

4.7) Remove road humps, tables, chicanes and other ‘traffic claming’ constructions that would obstruct water flow (and induce sediment deposition) on roads that are planned and designated as flood-routes.

4.8) Design and modelling work is needed for road junctions in order that the integrity of the designated flood route is maintained and flow does not escape to a non-desired route.

5) Reconsider planning guidance that encourages the construction of streets with curbs and with level thresholds in the vicinity of designated flood-routes because these structures are essential to contain the hydraulic flow and they need to be of an appropriate height.

6) Develop techniques and start to capture (and analyse) data about the heights of curbs and roughness and slopes of roads and highways in order that flood routes can be modelled using the existing 1-D modelling tools. These will include ground-based and aerial techniques.

7) Develop techniques and start to capture data about features in the urban and suburban landscape that will affect flood flow in order that flood routes can be predicted for the situations when the capacities of roads and highways are exceeded.

8) Encourage further development of modelling tools in order that flows can be modelled outside defined channels. This task is complicated by the factors of roughness (of vertical as well as horizontal surfaces) sediment capture and deposition and permeability of some features, especially hedges and fences. However it has to be recognised that application of these tools will not be possible on a wide scale until greater computing power has developed, as it inevitably will.

9) Hold further inter-disciplinary workshops on this subject and develop, refine and review these recommendations.

Mail contribution from Auckland, New Zealand

The following contribution was received from Brian Sharman after the workshop (brian.sharman@metrowater.co.nz).

I heard that as a result of the widespread flooding in 2000 they (FWR/WaPUG) are now looking at modelling overland flow as part of the simulations. This has been done in New Zealand for some years and especially here in Auckland. The stormwater pipes themselves are only designed for a 1 in 10 year storm so they use managed overland flow paths for the extreme 1 in 20, 1 in 50 and 1 in 100 year events. Flood hazard maps are produced which go on the public records and new residential development is not allowed to take place in these areas. The values of existing properties that lie in these areas are affected. When projects are constructed that remove flooding, new flood hazard maps are produced and the values of properties recover. As all new development or re-development requires a consent from both the Council and Metrowater this is carefully managed. WaPUG/FWR could develop some standards pretty quickly rather than trying to re-invent the wheel when we already have one, which could be tailored to suit the UK situation quite easily.

List of contacts involved with the workshop

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A copy of the full paper can be viewed on the WaPUG web site.

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