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Inter-relationships between rivers and sewers in flood alleviation

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Introduction

This paper discusses some of the common technical interests between river and sewer engineers in the assessment and alleviation of urban flooding. These include urban runoff modelling, hydraulic modelling, levels of service, methods of flood alleviation, flood warning, maintenance, the effect of urban development, and water quality. The presentation (although not the text for reasons of space) includes reference to examples of flood alleviation studies.

Watercourses and sewers

A 'watercourse' has a natural source, and includes all rivers etc through which water flows except public sewers. The functions of a public sewer include the drainage of buildings, and public sewers are vested in a sewerage undertaker who is responsible for maintenance. Culverts may be classed as a watercourse whatever their physical appearance, or the legislation under which they were built.

The National Rivers Authority (NRA) exercises 'a general supervision over all matters relating to flood defence'. It has permissive powers for maintenance, improvement works, and construction on watercourses termed 'main rivers'. Non-main rivers are generally supervised by Local Authorities. Riparian owners have rights and obligations under common law, as well as statutory responsibilities.

There is thus an important difference between statutory undertakers which both own and maintain public sewers, and the NRA, which has permissive powers over watercourses owned by others.

Urban Runoff

Derivation of reliable urban runoff hydrographs for river models, particulary for the rare events of design conditions, remains difficult. This arises partly because of the paucity of calibration flow information on small urban catchments, and partly because of the complexity of urban runoff and the uniqueness of every sewered catchment.

There are clear similarities in the generation of runoff into rivers and sewers. However, there are differences in flow pathways, in scale, and in the longer time duration of river hydrographs. In some cases, the flood hydrograph input to a river model might be the excess rainfall which did **not** enter a WALLRUS model of the same land area.

Unlike WALLRUS, the river modelling programs do not necessarily include a standard methodology to derive inflow hydrographs, but these are normally derived separately and then input as data to the hydraulic model at selected locations, rather than for each reach length, as is more common in sewer models.

In order to derive flood hydrographs, the urban river modeller may decide to use a modified 'rural catchment' method, such as the Flood Studies Report (FSR), or some more complicated method based on the urban sewerage network. The latter approach may involve considerably more work, and requires the co-operation of the water plcs and their agents. A number of studies carried out for NRA North West have shown the advantages of both methods under different conditions.

Hydraulic modelling

Hydraulic river modelling is mainly concerned with deriving water levels for particular flow conditions. Backwater calculations are suitable for studies of short lengths of river where a constant discharge can be applied. Hydrologic routing methods are relatively little used because water levels are not an integral part of the calculations. Hydro-dynamic models based on the one-dimensional Saint Venant equations of unsteady flow have become increasingly used in the last five to ten years, and normally incorporate the ability to model looped systems. In comparison with sewer models, WALLRUS-HYD may be regarded as a hydrologic routing method, and SPIDA as the nearest Wallingford sewer equivalent to hydro-dynamic river models.

The step procedures of building and using sewer models are similar to those used in river models - collection and input of data, model building, calibration and verification, assessment of levels of service, and investigation of improvement options. However, in river model studies the hydraulic and hydrologic aspects tend to be split to a greater extent than in sewer studies, and the two aspects may be calibrated separately.

Many of the problems in building river and sewer models are similar. Particular problems arise in river models because of the variability of channel roughness and cross-section, because many river structures have uncertain hydraulic behaviour, and because verification of a river model can be more complicated due to the rarity of flood events. Modelling culvert flow with hydro-dynamic river models can be difficult, particulary in steep culverts, and where the type of control (eg. inlet, culvert, or outlet control) changes with change in discharge. On the other hand, culvert/sewer siltation may be less of a problem in river than in sewer models.

Hydro-dynamic models are not generally used in the NRA to form the equivalent of a 'Drainage Area Plan', although it is possible that in the future the need for such models may be identified in the preparation of a multi-functional 'Catchment Management Plan'.

Levels of service for flood alleviation

The design standard for flood defences from river flooding is generally higher than from public sewers. Target standards for river flooding have been between once in fifty and once in a hundred years, depending on the level of urbanisation, but under present MAFF rules the actual design level of service will vary so as to derive the most cost beneficial design for each scheme. Events of return period higher than the design standard may be applied in order to assess the cost savings of the reduced damages once the scheme has been built. These levels compare with typical sewer flooding trigger levels for occupied premises of ten years and target levels for upgrading systems of thirty years.

Design flows for river models are normally derived from FSR standard design rainfalls (defined in terms of return period, duration, rainfall depth, and symmetrical storm profile), and an equivalent to the 'time series rainfalls' of sewer modelling is not generally applied.

Methods of flood alleviation

The possible methods of alleviation of flooding from rivers and sewers are similar, and include re-sectioning or regrading of the conveyance, on-line or off-line storage, pumping, provision of a by-pass conveyance, diversion of flow into another conveyance, and improvement of local constrictions to flow (such as bridge openings in the case of rivers). The river engineer also has the sometimes simple solution of raising walls or embankments, and the sewer engineer has the additional possibility of improving the separation between surface and foul systems.

The practical options to alleviate river flooding may be severely restricted by the need for public consultation, the effects of land ownership, and environmental aspects - river works are visible to the public. On the other hand, there is generally less disruption to roads and services than in sewer works. Compared with sewer storage schemes, storage solutions for large rivers may involve flooding of extensive washlands, features such as automatic operation of gates and other structures, and incorporation into the flood warning network.

The same rainfall event may cause flooding from both rivers and public sewers, and this may complicate the assessment of solutions. In these situations close discussion between sewer and river engineers in necessary, and it is preferable if the results of any river and sewer hydraulic model studies are available together.

Examples of where solutions to river flooding may be restricted by their effect on the sewer network would include situations where raising riverbanks may increase the downstream head on a sewer outfall, thereby increasing the surcharge in the sewer, or where the prescence of drain pipes along a river bank allows river water to flood through the pipes, and negate the effect of wall raising.

The effect of improvements to sewer networks on river flooding may be less significant, partly because the volume of water in the sewers may be only a small part of the river flow, and partly because of the common intention to reduce the frequency and amount of spillage from combined storm overflows (CSOs). However, where spillage does occur, works which increase the attenuation may delay the peak flow so that it occurs nearer to the peak of the river flow.

The benefits from alleviation of river flooding are normally assessed using methods set out by the Flood Hazard Research Centre at Middlesex University.

Flood Warning

The longer lead times of river flooding enables flood warning systems to be operated effectively, both for operational matters within the NRA, such as flood basin and pumping station operation, and for the dissemination of flood warnings to outside agencies for defined flood risk zones. However, flows capable of causing fairly extensive flooding may be generated (for example, in the Pennine Hills) before any warnings could be issued and disseminated.

Maintenance and Operation

Compared with sewers, rivers may have considerable debris, of a wide range of size and type. A particular operational requirement preceding and during an event is the cleaning of trash screens. In some rivers the first large flood of winter brings down an exceptional amount of rural and urban debris, possibly analogous to a 'first foul flush' in sewers. Main-river culverts may be cleaned out on a regular basis, and NRA North West has a permanent man-entry team for this purpose.

Urban development

The NRA is concerned that future urban development is located outside the floodplain, and that the cumulative effect of development does not reduce the standard of protection against flooding downstream. This is done principally through the position of the NRA as a statutory consultee when submissions for development are made to Planning Authorities. The object from the NRA's point of view is one of 'prevention rather than cure'.

If it is considered that a proposed development will aggravate surface water flooding, the developer might be advised to carry out :
- improvement to the watercourse downstream
- on-site works for retention or infiltration
- works to convey the flow into an existing sewer

The long-term maintenance of such works, and who would be responsible, would need to be considered. Improvement to the watercourse downstream might be effected by including the watercourse within the planning application, or by a formal agreement between the developer and the downstream land owner.

When a hydraulic river model has already been built it may be used as part of the process by which the NRA evaluates the proposal for development.

Water Quality

A considerable part of the Urban Pollution Management (UPM) programme is involved with the management of combined sewer overflows, and the methodology developed includes both simple procedures and full modelling. Full modelling of transient pollution events will involve a number of models working together - WALLRUS, MOSQITO, STOAT, and the Mike11 hydrodynamic river model to assess river impacts. There is thus a potential overlap between this modelling and existing river models for flood defence, whether or not they were built using Mike11.

The EC Directive on urban wastewater will have a considerable impact on the practice of wastewater treatment and disposal. In some cases where it is also proposed to improve flood defence standards the assessment of options may require close liaison between the two schemes.

Technical Session 3 Chairman Nick Orman WRc

Interrelationships Between Rivers and Sewers to Control Flooding
Peter Spencer NRA North West Region

Question David Searby Wessex Water

Are river models used for development control purposes, i.e. to refuse permission to develop areas where this would increase flooding?

Answer

Where hydro-dynamic river models have already been built they have been used to assess the effect of development. The costs of building such a model are such that it is not normally justified solely for this purpose.

Question Martin Osborne Wallingford Software Ltd

What do you think about using alternative river models for studies under the Urban Pollution Management programme? I believe these should be allowed.

Answer

Yes I agree.

Question Camylyn Rainey Wallingford Software Ltd

To what extent dose the river modeller need to look at sewers ? What return periods to use? What are the implications of RTC?

Answer

The extent to which a river modeller needs to include the effect of sewers on the runoff entering the river is a complicated subject. The answer depends on the purpose of the study, the required accuracy, and the degree of the modification of the drainage with urbanisation. Perhaps the Flood Studies Report "urban" term is best applied to "sub-urban" areas?