Bristol City Surface Water Management Plan – Development and Application
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City of Bristol

- Bristol city, population of over 433,000 incorporating an urbanised area of over 150 square kilometres. Currently the sixth largest city in England, although until the industrial revolution it was regarded one of the top four.

- Has been an important centre of trade since the 12th century due to its port and land based transport links that date back to Roman times.

- Significant growth in the 19th century following an expansion of new industry and commerce, which was supported by the new Great Western Railway from Bristol to London.

- The continuing urbanisation within the area has had some negative results, one of which is more frequent flooding of the city.
City of Bristol

- Bristol has a long history of flooding from various sources and there are records of some major events dating back hundreds of years.

- The image on the right is from a wood carving of the ‘great flood’ of 1607 that was reported as being responsible for the loss of 2,000 lives.

- Starting from the 1483 flood till the 1999 event the chronology bar above shows the increasing frequency of flooding in Bristol.

- DEFRA identified Bristol as one of the 10 highest risk areas susceptible to surface water flooding in the UK.
Integrated Urban Drainage (IUD) pilots

- 15 pilot studies around England commissioned by DEFRA in Jan 2007
- Significant issues with getting all the stakeholders ‘on board’
- Organisational issues reduced time available for actual modelling studies
- Pilots highlighted ‘fragmented’ responsibilities within UK Water Industry

Extracts from the Pilot Summary

- “An assumption of nearly all the modelling approaches was that surface water flooding comes from surcharged sewers, overloaded beyond their conveyance capacity. Direct surface runoff resulting in pluvial flooding as a result of inadequate drainage systems was not represented because the modelling software used to represent the sewer systems does not readily represent flow generation and routing above ground.”

- “An argument can be made for ignoring the operation of the underground drainage system altogether by assuming that an extreme event has completely filled it at an early stage and most runoff remains on the surface. The approach can be modelled by applying rainfall inputs directly to 2D models of the urban area which formula to generate runoff across the surface.”
Surface Water Management Plan (SWMP) pilots

- 6 pilot studies around England commissioned by DEFRA in Jan 2009
- Aim was to test the methodology within the ‘new’ SWMP manual
- Organisational issues again reduced time available for actual modelling studies
- Majority of SWMPs opted to simplify catchments being considered
- Various methods have been created in an attempt to make allowance for underground systems
- One common method was to deduct between 5 to 15mm per hr from the rainfall
- Most simplification methods assume that underground system is redundant during extreme events
- Bristol City Council opted to push the boundaries and create a high level IUD model
Bristol Surface Water Management Plan

- The Bristol model incorporates the whole catchment at a 4m resolution or better
- All the buildings are represented within the model to give a better picture of flow routes
- All the water courses and rivers are represented within the model
- The sewerage system pipe network is represented within the model
- All CSOs and sewerage pumping stations are represented within the model
- Water can flow between all the elements of the model without manual coupling, which assumes all flow paths are known
- A ‘Superstorm’ methodology was applied to give critical results across entire catchment
- The 2D model incorporates a variable Manning’s roughness to better represent effects at both shallow and deep flows
- 2D surface was originally 250km² but only 150km² actually contributed to final model
Bristol SWMP

• 68 million 3 dimensional data points
• 15,000 Ha 2D surface
• 86 hydraulically independent watersheds
• 33,000 sewers
• Largest fully interactive IUD model created to date
• Over 300 simulations run in one 2 week period of the study
• 28 copies of the software running simultaneously
This plot shows a small part of the Bristol study (about 15km$^2$)

It is a comparison of flood depths with and without sewers

Red is increased flood depth, Blue is reduced flood depth

Adding the sewers to the model decreased flood depth by up to 4m at the top of the catchment, whilst increasing the flood depth by up to 5m at the bottom of the catchment
Bristol SWMP

- The sub-catchment boundary is shown in magenta
- The principle sewers are added in black
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- Surface water flow transference
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- Static Surface water flood maps

  - Standard flood maps show the worst case everywhere simultaneously
  - They almost always over estimate the ‘real’ effects
  - They give no indication of spatial or temporal progression
  - They are of little ‘practical’ use in contingency planning
  - They are open to misuse and misinterpretation
Bristol Surface Water Management Plan

- Surface water management in practice
Bristol Surface Water Management Plan
• Surface water management in practice

Diagram showing flow over time for Urban and Rural steam.
In two recent studies undertaken by separate consultants, the flow characteristics of two significantly different urbanised catchments both appeared to follow the simplified graph shown below.
Why?
Why?
Why?
Why?
Why?
Why?
Why?
Comments on model limitations

• Fluvial flood risk models are good at the macro level but are too coarse for SWMPs

• Simplified pluvial flood risk models can omit or mask critical flow mechanisms and should only be used as screening tools

• IUD flood risk models are complex and require a much broader range of knowledge and experience than conventional approaches

• Good data is essential, which ever method is used.
Summary

- Underground systems can transfer huge amounts of water
- Hazards move around the catchment
- Static flood maps are of limited use
- Real events tend to be spatially and temporally transitional
- Urban catchments appear to have capacities.
- We can represent complex IUD’s even at the City Scale.

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- And Finally......