MODELLING THE IMPACTS OF CLIMATE CHANGE ON INTERMITTENT DISCHARGES INTO RIVERS FOR URBAN POLLUTION MANAGEMENT

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The pollution of rivers from intermittent discharges from combined sewer overflows (CSOs) and storm overflows is a growing concern as climate change places freshwater resources under increasing threat. An Urban Pollution Management (UPM) assessment was undertaken to identify the environmental impacts of CSO spills on receiving water quality. Through an integrated modelling approach this study identifies the impacts of current and projected spills on receiving water quality for current and future UKCP09 emissions scenarios.

Introduction
CSO discharges occur when the design capacity of the sewer system is exceeded, typically following heavy rainfall. These discharges have varying polluting effects on the receiving water quality (Even et al., 2007), the most significant being reductions in dissolved oxygen (DO) levels (Engelhard et al., 2008), due to high levels of biological oxygen demand (BOD) in the untreated effluent. This is worsened by reducing flows and increasing temperatures as a result of climate change. Sufficient levels of DO are essential for all higher aquatic life. There is increasing pressure to maintain good water quality from the EU Water Framework Directive (WFD) (2000).

The Urban Pollution Management (UPM) Manual (FWR, 1998) gives guidance on the design criteria for CSOs in the UK, in the absence of EU legislation. It provides appropriate standards for CSO discharges (Clifford & Crabtree, 2002). The UPM manual identifies two approaches to monitor the effects of wet-weather discharges on water quality: Fundamental Intermitent Standards (FIS) and percentile standards.

Methodology
CSO spills were modelled using a pre-built InfoworksCS network model, using a baseline rainfall profile. Climate change factors were developed from medium and high UKCP09 emissions scenarios and applied to the baseline rainfall profile, which was then run through Infoworks to obtain CSO spill data for future climates.

Water quality of the receiving river was modelled using a pre-built ISIS Quality model. Spill data was entered into the model, which was run with known flow conditions and subsequently with flows updated with UKCP09 climate change factors to assess the climate change impact in terms of dilution capacity and sensitivity of the river.

Levels of in-river DO, BOD and ammoniacal nitrogen levels were compared with FIS and percentile standards (for River Ecosystem class 2) using SIMCON, a simplified urban pollution modelling spreadsheet.

Results
All profiles were predicted to experience a decrease in summer rainfall and an increase in winter. Mean monthly flows generally decrease across the year, as do DO levels. Increasing summer temperatures make summer seasons especially sensitive to spills.

There is a reduction in spill events across all scenarios, with no spills occurring during the summer months, as a result of reduced summer rainfall. Although the number of spill events decreases, spill flow rate increases.

The levels of dissolved oxygen in the river mirror the flow regime, with higher levels of DO present at times of high flows. High flows cause increased water velocities, which improve aeration in the river; increasing the oxygen reactivity coefficient (kL)
(Minikou et al., 2000). DO results for all scenarios are summarised in Figure 2.

The UPM manual indicates that the FIS threshold for DO should be 4.0mg/l. This is clearly breached during the year. However, SIMCON did not find either BOD or ammoniacal nitrogen loads to be in breach of the percentile standards, suggesting over the year spill effects are negligible (Table 1).

Conclusions and Further Work
Changes to the river flow regime as a result of climate change appear to have significant effects on DO levels and the river’s response to CSO spills.

Integration of individually modelled components of the drainage system as encouraged by the UPM manual is shown to provide a holistic representation of the system, however this study identified incompatibilities between models as a hindrance to this approach.

Although SIMCON provides a useful tool for assessing compliance with regulatory standards, its best estimate value for the year limits details of within-year behaviour.

Further research could be undertaken into the impact of land use change on river water quality or population growth on number of spills. Quantification of diffuse pollution entering the system may provide a more holistic approach at the catchment scale into effects of climate change on river water quality.

Key References
UKCP09, Online Climate Change Projections Report Version 2 UKCP09 http://ukclimateprojections.defra.gov.uk/content/view/834/500/ [accessed online 28/08/11]