"Urban water quality modelling - the Lower Lea in East London"

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Introduction

The Lea Navigation is situated in East London, near Edmonton, and is just a few kilometres north of London's Olympic site. Flow in the system is dominated by Deephams STW, and the Navigation itself is a 3-4 km long canalised reach with a more or less constant water level controlled by a weir (at Lea Bridge). There are, however, other urban watercourses which contribute flows and loads to the Lea Navigation during wet weather events. At Lea Bridge, the majority of flows discharge into the tidal section of the Lea.

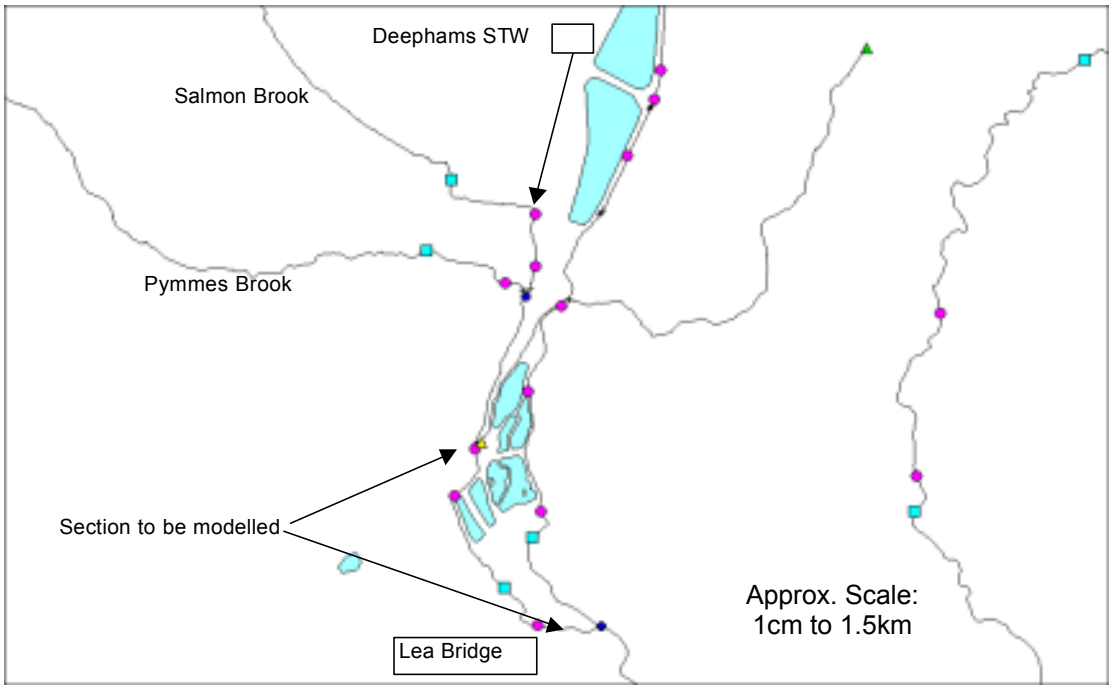

Figure 1 Study Area

The Lea Navigation is a Freshwater Fish Directive reach, but there are significant problems of Dissolved Oxygen in the Navigation, which can drop to zero during wet weather. There are several factors which serve to cause low DO levels in the Lea Navigation:

- Sediment Oxygen Demand;
- Loads from Deephams STW;
- High loads from urban runoff during wet weather events, possibly due to unconsented CSOs;
- Decline in algal activity in Pymmes and Salmon Brooks during wet weather events.

The key focus of this investigation was to adequately model the processes which contributed to DO levels in the Lea Navigation. With a model that appropriately represented these processes are far as possible, scenario work could be carried out to assess different strategic options to improve levels of DO in the Lea Navigation.

Methodology

WRc's in-house SIMPOL3 modelling package was used throughout the study. The SIMPOL3 model was suitable for this study for a number of reasons:

1. SIMPOL3 allows for rapid, continuous simulation of a given time period – for this investigation two years were modelled;
2. SIMPOL3 allows modelling of BOD, Ammonia and DO, all of which were important for this study;
3. SIMPOL3 accounts for the relevant in-river processes such as decay, reaeration, photosynthesis/respiration, and sediment oxygen demand (SOD).

The SIMPOL3 model is driven by input data, which was supplied by the Environment Agency. The data received was for a 2 year period (2005-2006), and included continuous flow, Ammonia and DO data at Deephams STW, Pymmes Brook and Salmon Brook.

Although data regarding the major inputs to the system were supplied, there were also a number of smaller urban watercourses, such as Stonebridge Brook, which contributed flows and loads to the system particularly during high flows. These additional inputs needed to be represented in SIMPOL3, and assumptions were made regarding flows and loads from these other urban watercourses.

The SIMPOL3 model conceptualisation is shown in Figure 2. The model was built by defining a number of SIMPOL3 river reach modules which represented the Lea Navigation, and some of the channels which feed into the Navigation itself. The various inputs which drive the model are conceptualised to bring flows and loads at the upstream boundary of the SIMPOL3 river reaches.

With inputs into model defined, the model was calibrated at various points along the Lea Navigation against observed flow, Ammonia and DO data.

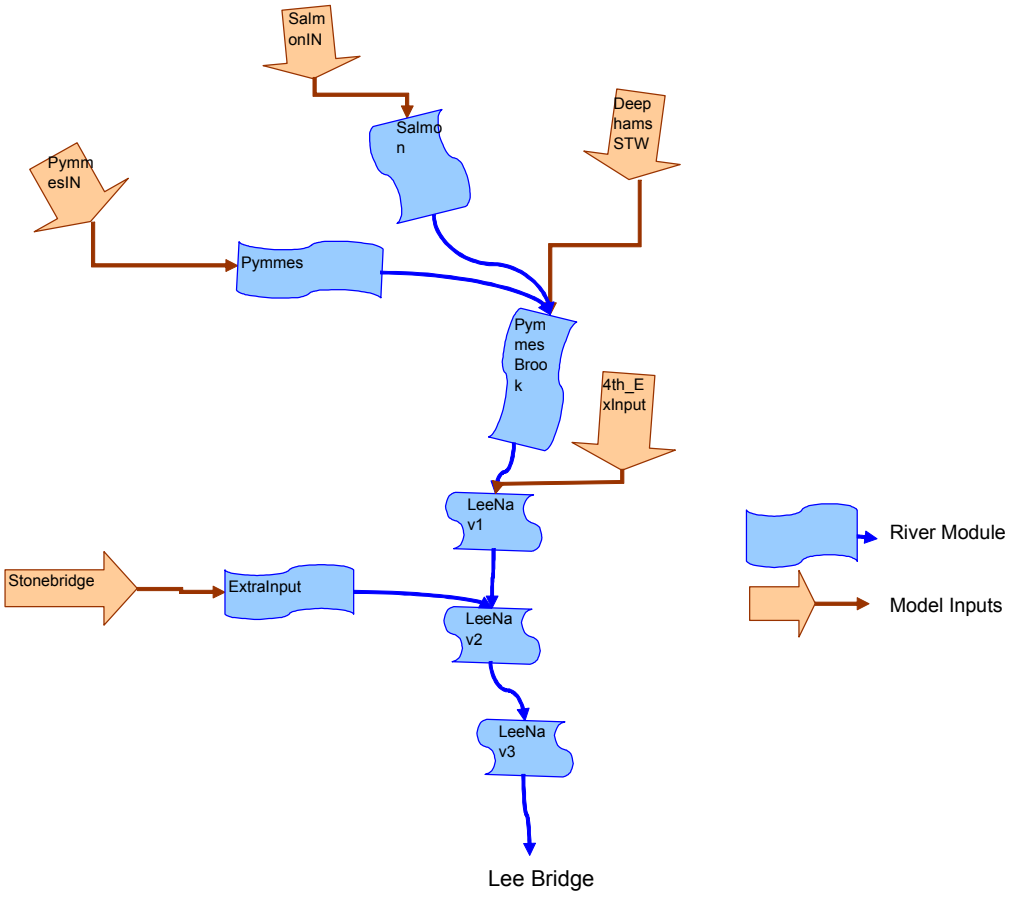

Figure 2 SIMPOL3 Conceptualisation of Lea Navigation

Modelling DO

When modelling the DO in the Lea Navigation there were two key challenges:

1. Matching the overall observed levels of DO in the Lea Navigation, and appropriately representing the diurnal pattern of DO;
2. Representing the response of DO after wet weather events.

To achieve this various process rates in SIMPOL3 were adjusted to give a good representation of the processes acting upon DO in the Lea Navigation.

Sediment Oxygen Demand (SOD)
Due to the drop in flow velocities at the point where Pymmes Brook enters the Lea Navigation there is considerable deposition of sediment in the Navigation, the source of which probably originates from higher up in the catchment. This sediment is believed to exert a considerable demand on oxygen in the Navigation, and a field study carried out in November 2006 confirmed this. SOD was added to the model based on the field measurements carried out.

BOD Loads during wet weather
The SIMPOL3 model was established with a constant dry weather profile, taken from routine sampling data. However sampling carried out by the Environment Agency during wet weather indicated very high BOD loads, particularly in Pymmes Brook. This was represented in SIMPOL3 as particulate BOD, which was inputted into the

system at a varying rate depending on flow. This particulate BOD was dispersed at a slower rate than the dissolved BOD. This helped the model to match the slow response of DO after wet weather events.

Algal Processes
Accurate modelling of algal processes was essential in this study due to the apparent interaction between algal activity in Pymmes Brook and DO in the Lea Navigation. There was a strong algal pattern in both Pymmes Brook and Salmon Brook. However there appears to be little, if any, algal processes in the Lea Navigation itself, and it is hypothesised this may be related to Copper in contaminated sediment. This could be inhibiting algal activity in the Lea Navigation.

From the observed data it appeared that daily fluctuations in DO in the Lea Navigation could be linked to the changes in algal activity in Pymmes and Salmon Brooks. Secondly, in the days after a wet weather event observed data suggested low DO levels in the Pymmes and Salmon Brooks. This was possibly due to wash-out of algae. It appeared that the recovery of DO in the Lea Navigation could be linked to the recovery of algae in the days immediately after a wet weather period.

Therefore, it was essential to model the changes in algal activity to improve the day-to-day fit against observed data, as well as modelling the DO profile after a storm event. The SIMPOL3 model used the diurnal range in DO from observed data at Pymmes Brook as a surrogate for algal activity, and the maximum photosynthesis and respiration rates were factored depending on this range. Using this approach improved the model predictions against observed data in the Lea Navigation.

Figure 3 provides a comparison of the observed and predicted DO profile at Lea Bridge after a storm event on 4th July 2006. The period after the storm event is characterised by very low DO, which the model is able to replicate. From the 9th July onwards the DO begins to recover, and this can be related to the recovery of algal activity in Pymmes Brook.

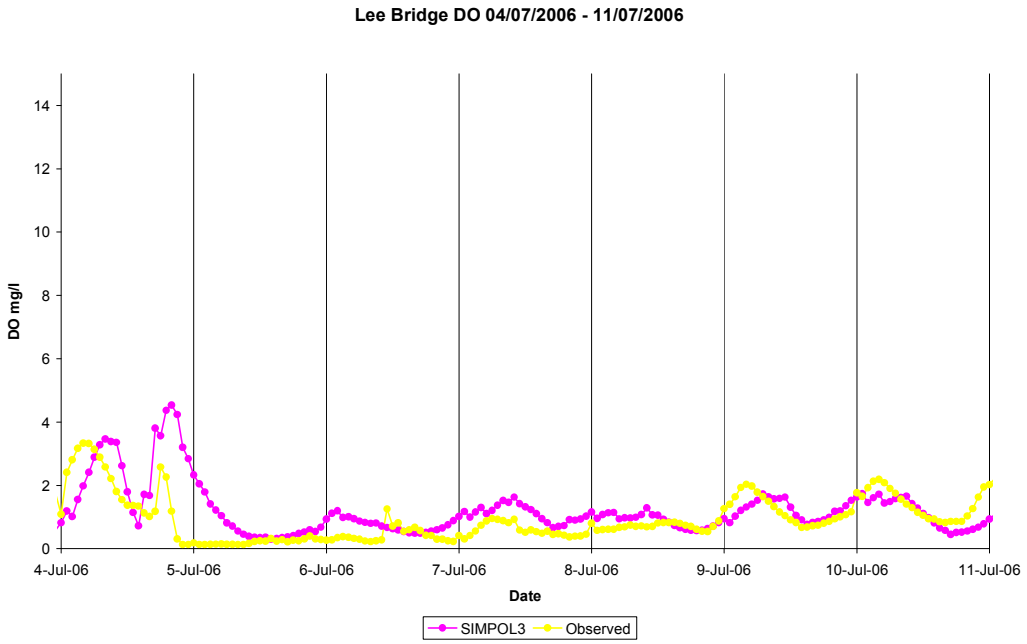

Figure 3 Predicted and Observed DO at Lea Bridge in July 2006

Scenario Work

Work on scenarios is still ongoing, and includes:

- Removal of all or part of the SOD, including the effect on velocities. This represents possible dredging of the Le Navigation;
- Oxygen injection at Deephams STW;
- Introduction of photosynthesis and respiration in the Lea Navigation, assuming removal of algal toxicity in the Navigation.