# Paper 9 – Tame UPM Study – key Lessons learnt

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## Introduction

The Tame UPM study is centred in and around Birmingham in the West Midlands, as shown in Figure 1. Geographically it encompasses all of Birmingham, Walsall, Sandwell and major parts of Dudley, Wolverhampton & Solihull and has a population of 1.9 million. The catchment covers an area of 1,067km2, incorporating 6 significant WwTWs (Minworth, Coleshill, Ray Hall, Goscote, Willenhall & Walsall Wood). There are 481 operational CSOs in the catchment. Of these, 92 have been identified as being unsatisfactory by the Environment Agency and require improvement by 2005. Severn Trent Water (the Company) commissioned the UPM Study to help develop a long term upgrading strategy that would deliver the necessary improvements within tight time and budgetary constraints.

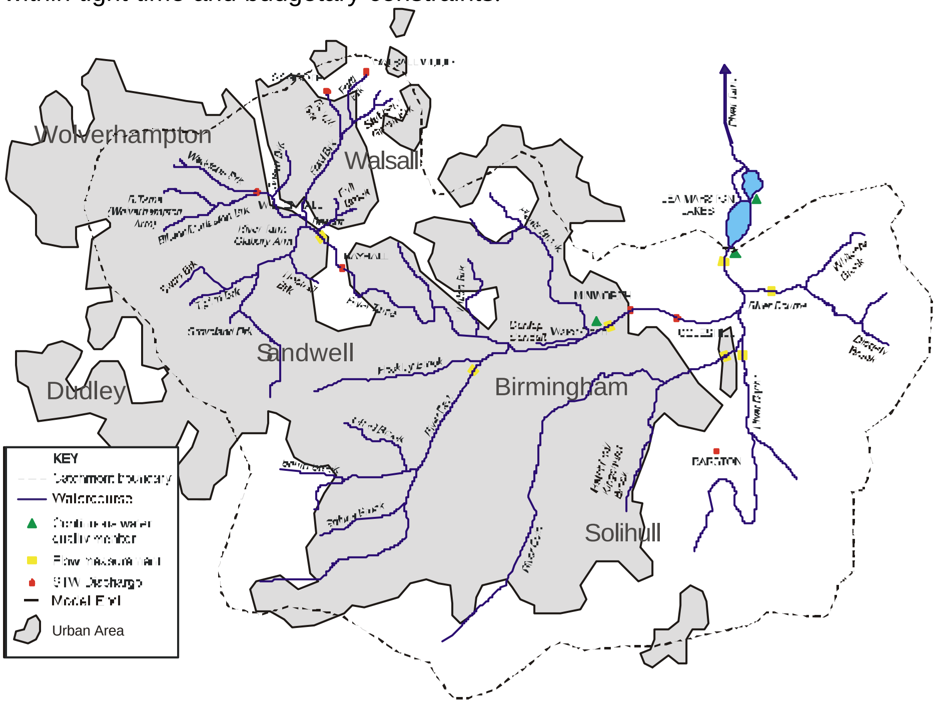


**Figure 1 The Tame UPM Study catchment**

The study area is a very large, complex catchment both in terms of the sewerage and river system. The UPM study needed to represent these interactions in a way that allowed the effects of upgrading to be quantified both in terms of water quality improvements in tributaries as well as on the River Tame as a whole. An integrated approach was, therefore, essential – both technically and from a project management viewpoint.

This paper sets out to discuss some of the key lessons learnt in managing and implementing this large and complex UPM study. The planning/modelling was substantially complete by early 2003. These lessons are discussed under the following headings:

1. Identifying UIDs
2. Modelling tools
3. Allocating river capacity to intermittent discharges
4. Developing the solution
5. Project Management

### Identifying UIDs

Identifying UIDs firstly requires identification of an environmental problem and to then link this to a cause, which may be or may not be a UID. This identification process was performed mid way through AMP2, prior to any specific AMP3 related data collection exercise or modelling. We were therefore tasked with the exercise of identifying UIDs, based on the limited information that was available at that time.

Routine GQA chemistry data which the Agency collects, works well with the measurement of general river quality, but due to the infrequent temporal (once a month) and spatial (one site per reach) resolution does not lend itself to picking up intermittent water quality problems. In the Tame catchment the Agency were aware of RQO failures, but were not able to associate these directly with UID impact, and certainly not with individual UIDs. Continuous water quality monitor data is valuable, but is often unavailable, due to the resource implications that it carries. In the Tame catchment the Agency were fortunate that there were three long term monitors in the catchment. These showed a definite wet weather water quality impact particularly in dissolved oxygen, although it was difficult to link this to individual CSOs (Figure 2).

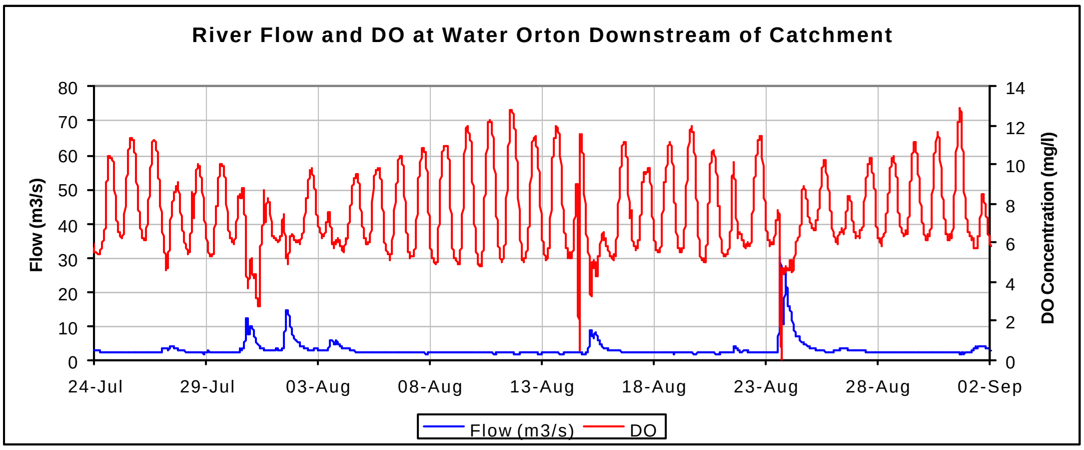


**Figure 2 Observed wet weather impacts at Water Orton**

The river network in the catchment does not have a good biological quality. This is not solely due to poor background water quality and urban runoff, but also due to the physical characteristics of much of the watercourses. These are in culvert for much of the time and even when in open channel are often concrete/brick lined and rectangular in cross section. Whereas in most catchments biology data would assist in the identification process, in the Tame catchment it did not.

The aesthetic impact resulting from UIDs in the form of sewage litter, at or just downstream of a CSO outfall can normally allow the CSO to be identified as unsatisfactory. This process can be formalised through an FR0466 survey. In the Tame catchment many of the CSOs spill to surface water sewer systems which act as a common outfall for numerous CSOs. This combined with much of the watercourse network being culverted or canalised, results in the combined aesthetic impact from UIDs being observed some distance downstream (>5km) of its source (UID). This makes identification of the UIDs impossible based on observation alone.

Sewer hydraulic modelling obviously helps in identifying poorly performing CSOs, but at the time the AMP3 list was being prepared many of the sewer hydraulic models were awaiting review and had been primarily developed to address flooding issues, so were not specifically set up to look at CSO performance. Models do not allow non-storm related UID problems, such as recurrent blockages to be identified, which can cause more acute impact than storm performance.

Hence, when the AMP3 list was drawn up, there was a considerable amount of *judgement* made. It was clear that the CSOs were having both a significant water quality and aesthetic impact in the catchment, but it was not possible at that time to identify with a high level of certainty which CSOs were UIDs. Now that the models have been fully developed, we have found that (not surprisingly), in some cases satisfactory performing CSOs were identified as UIDs and in others UIDs were not identified for improvement when they should have been. With such levels of uncertainty during the setting of the AMP3 obligation, the basis of costs, which formed the business plan, must also be questioned. We are now (end of year 3) in a position where the scope of the work required on UIDs in the catchment is very much different from the agreed obligation. The Change Protocol has and will continue to be critical in allowing the agreed level of AMP3 environmental improvements in the catchment to proceed, even though these may not be those listed in the original AMP3 obligation. There are issues that the Change Protocol is unable to help with, such as the identification through modelling, that the scale of investment on UIDs in the catchment is significantly greater than anticipated in the setting of the AMP3 obligation. With hindsight we could have said that the planning/modelling work should have been performed prior to defining the obligation, but this would have either created a financial commitment for the company prior to the AMP3 determination or a delay in delivery.

AMP4 may well be the answer to the development of a long-term plan for UIDs in the catchment and for AMP4 we will have a better idea of what we a tackling prior to AMP commitments being agreed as much of the planning/ modelling work is now complete.

**Modelling tools**

At the start of the study (2000) there were over 60 separate sewer hydraulic models for individual Drainage Areas (DAs). There were no water quality models for either the sewer or river systems. The need to rapidly develop an integrated modelling framework was recognised.

The integration of the sewer hydraulic models was carried out by the Company using InfoWorks. First, a core model representing the Black Country Trunk Sewer (BCTS) and other major carriers was created. Then, the individual DA models were connected in to give an overall model of some 50,000 nodes. All nodes were geo-referenced and GIS was used to assign populations and trade flows from address point, census and trade effluent databases. Various design events were used to test the stability of the model and to check that the overall hydraulic performance was in line with expectations.

The model is currently run as two separate models – the Northern and Southern models – with the split occurring at the Sandwell Wedge penstock which creates a distinct hydraulic breakpoint. There is an on-going process of refinement and verification as new data become available.

The process of hydraulic model integration was time consuming and costly - the work began in late 2000 and took about 2 years to complete. But it was essential – if anything, a key lesson was that it should have started earlier. Major hydraulic interactions occur at different points in the system, particularly when the BCTS surcharges during large rainfall events. Without the fully integrated model, these interactions could not be adequately represented. In addition, the integrated model has been invaluable for developing and testing potential upgrading solutions involving different weir settings and storages to modify the hydraulic gradient down the BCTS.

The second major modelling tool was SIMPOL3 which was used to integrate the sewer hydrology/hydraulics with river hydrology/hydraulics and to add water quality elements. SIMPOL3 is a WRc modular modelling package used for a range of environmental applications. For UPM applications, different modules are used for sewer subcatchments, trunk mains, treatment works and river reaches. Networks of modules are created to represent complete sewer/river catchments and simulations are carried out in continuous mode over multi-year periods to help identify and optimise solutions.

The integrated Tame SIMPOL3 model comprised:

- 180 Sewer subcatchments
- 30 Trunk Main elements
- 4 Storm Tanks
- 6 WwTWs
- 129 individual river reaches

All the sewer subcatchments were hydraulically calibrated against the strategic InfoWorks models. The sewer quality and river quality aspects of the model were calibrated and validated using the newly collected data and other historical data.

The SIMPOL3 model represented all the key interactions, both within the wastewater system and the receiving waters. River flows were generated by the same rainfall series used to simulate sewer flows; surface washoff from roads and rural areas was included. The model was run in continuous mode such that the build-up of pollutants and the emptying of storages between storms were represented adequately.

Following recalibration, the model was used to reassess the baseline performance of the river system in terms of compliance with the Fundamental Intermittent Standards (FIS) and 99 percentile standards. Areas of non-compliance were identified in a number of tributaries and, in particular, in the lower reaches of the Tame. This was followed by a number of iterations to find a storage solution and a number of sensitivity runs to help assess the robustness of the solution and help understand the importance of the 'non-CSO' discharges. All the assessment runs were based on using a continuous 10 year historical rainfall series from four local raingauges, thus taking account of spatial variation. In addition, the proposed future WwTW effluent quality was used.

Among the key lessons regarding the modelling tools were:

- the immense benefits gained by integration - including better understanding of how the systems were really operating, the ability to assess the importance of different pollution sources and greater confidence that the 'knock-on' effects of any solutions are taken into account.
- the value of strategic data collection (good quality data over a wide range of conditions at a few critical locations) on both the sewer and river systems to provide overall validation of the models.

**Allocating river capacity to intermittent discharges**

The application of SIMPOL3 has allowed the extent of the intermittent water quality problems to be assessed against both the FIS and the 99 percentile standards. It was known at the start of the AMP3 period that there were other water quality issues in the catchment, than the UIDs. However, it was anticipated that the UIDs would be dominant in contributing to failures of the intermittent water quality standards. The SIMPOL3 model was initially set up as calibrated from historic and study specific data. This model showed a considerable amount of failing reaches within the catchment as was to be expected. What was not expected was that when the CSO spills were removed from the simulation, reaches continued to fail. Through sensitivity analysis it was demonstrated that; final effluent, surface water sewer and non urban background river quality were significantly contributing to the number of failures. It was agreed that if solutions to the UIDs were to be developed then a reasonable assumed quality for these other inputs was required, otherwise we would be in a position whereby whatever was done to the UIDs (even complete abandonment) would still not achieve compliance with the water quality standards. The following was agreed:

- Final effluent set at anticipated AMP4 consent level.
- Surface water sewer quality set at 13mg/l BOD, 0.5 mg./l ammonia.
- Non urban runoff set at mid-class of objective.

The UID solutions in AMP3 in this catchment will only go part way towards meeting water quality objectives. To fully realise these objectives in the watercourses will require background non-urban water quality improvement, surface water sewer quality improvement and the delivery of AMP4 continuous and AMP4 UID schemes. The AMP schemes have a funding route/implementation mechanism, but the improvement of background non-urban water quality and surface water sewer quality do not have a clear route for improvement at present. It is these areas together with the development of suitable habitats for the biology, that should be the focus of our attention in the future.

**Developing the solution/AMP3 Programme Management**

The solution or proposal for each UID was required to comply with both of the Company's capital investment and AMP3 UID processes. Figure 3 represents the interaction between these processes.

The Company saw communication with the Agency as being key to the success of the UID process and delivering agreed solutions. At an early stage, notional solutions were given to the Agency for their comment. These Agreements in Principle (AiPs) included a confirmation of the UID criteria/data and a generic statement as to 'way forward'. The Company required an AiP agreement before it would move to detailed design, which gave the Company confidence in the chosen modelling route before committing to some significant expenditure. Following detailed design, a Letter of Intent (LoI) was submitted to the Agency. The LoI provided agreement to the more specific solution and provided data for any consent application/modification.

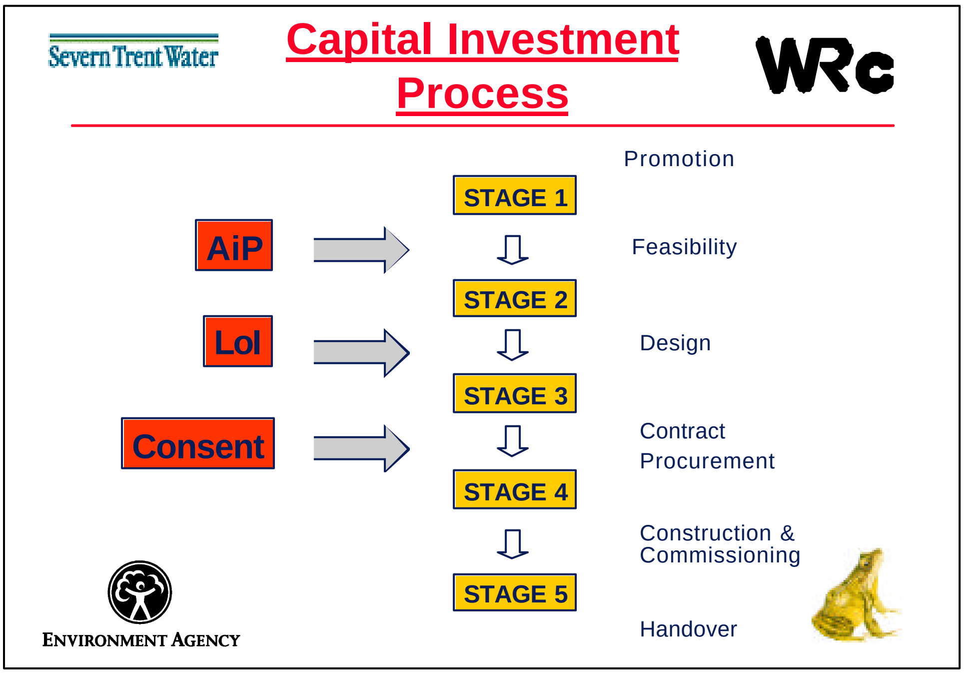


**Figure 3 The Capital Investment Process**

The AiP/LoI process was established to promote a relationship with the Agency based upon co-operation and consultation, to programme workloads and to provide early 'buy in' from the Agency to the Company's solutions. Such benefits already existed within the UPM study, as regular meetings between the key stakeholders had been an important part throughout. Nevertheless, the process still provided an important 'audit trail' and a mechanism for requesting swaps of UIDs deemed to be satisfactory by the study, with unnamed CSOs found to be requiring work by the same. Severn Trent is currently negotiating with the Environment Agency, in respect of agreeing such swaps within the UPM Study, through the Change Process.

It should be noted that the process for AiP, LoI and consent application could potentially add some 8 months to the design and construction of a project. This is a significant length of time, when the period for delivery has already been shortened by having to complete the study and construct the proposals within the same AMP.

The interface between the study and engineering design is also time-consuming. The SIMPOL3 model generates notional solutions in terms of the provision of additional storage, within individual subcatchments, to achieve compliance in the river reaches. These storage solutions must then be represented within the InfoWorks models, for detailed hydraulic design, and some 'optioneering' carried out to rationalise efficient solutions. The preferred solutions must then be 'fed' back into the SIMPOL3 model to confirm compliance.

Whilst this iteration of solutions takes time, so too do other constructional issues, such as the purchase of land and the periods required to construct some significant volumes of storage. Also, the planned construction of the solutions is inevitably targeted towards the end of the AMP period and this in its self creates problems. Contractors are already stretched in delivering the AMP3 DG5 programme and Severn Trent has recently experienced difficulties in obtaining multiple road closures within already disrupted areas of the conurbation.

So could anything have been done to avoid the backlog of schemes now to be constructed in the last two years of this AMP? The scale of the study has been such that many of those involved believe that study and construction periods should have been planned for consecutive AMPs. That aside, earlier agreement in the type, quantity and collection of river quality data would have expedited the study findings. Finally, the AiP/LoI submissions appear to add unnecessary steps into the design process, however, they do significantly reduce the risk of enduring abortive time and expenditure in developing inappropriate solutions.

### Project Management

At the start of the AMP period, a PODT (Preferred Option Development Team) was established to manage the UPM Study. In an attempt to capture the views of all those involved, the Tame PODT membership was initially large and sometimes unwieldy. With time, however, the team has developed into a leaner, more effective unit and, whilst the full PODT still meets, much of the work is now progressed through working groups comprising the key stakeholders.

Throughout, the study has followed a structured, procedural format, with all elements being documented within protocols. Each protocol has been developed at PODT meetings and their formal 'sign-off' obtained from the Agency. Like the AiP/LoI process, this type of approach has the following benefits:

- Engenders a relationship with the EA based upon co-operation and consultation.
- Obtains early, formal agreement to the direction of the study.
- Avoids abortive work.
- Targets resources and expenditure.
- Ensures consistency in providing information to the EA.
- Provides the Company with an understanding of the EA's requirements and concerns throughout.

Again, like the AiP/LoI process, the development of these protocols was found to be time consuming and certainly added to the scope of the study. Whilst their usefulness might therefore be questioned, they too reduced the risk of enduring abortive time and expenditure in progressing the study without the 'approval' of the Agency. Once again, the Company saw communication and consultation with the Environment Agency as being key to the success of the Tame UPM Study.

## Conclusions

In conclusion, some key lessons gained from the Tame UPM study are:

- To reliably identify UIDs in a complex urban catchment requires reliable models;
- As many UIDs in the Tame catchment were mis-identified in the original AMP3 list, because of the lack of suitable models at that stage, the Change Protocol has been critical in allowing the AMP3 improvement process to proceed effectively;
- Hydraulic model integration was a time-consuming and costly process – but was essential for the proper understanding of how the carrier system interacted with local drainage areas and, ideally, should have been started earlier;
- The integrated water quality modelling (SIMPOL3) provided a direct route to linking CSO upgrading to water quality standards. It allowed the importance of different pollution sources to be assessed and gave greater confidence that the 'knock-on' effects of any solutions were being taken into account.
- Strategic data collection (good quality data over a wide range of conditions at a few critical locations) on both the sewer and river systems was central to the overall validation of the models.
- The AMP3 UID solutions identified for the Tame catchment will not, by themselves, achieve the water quality standards - to fully realise these objectives will require improvements to background/surface water runoff quality and the delivery of AMP4 continuous and AMP4 UID schemes.
- The translation of the notional storage solutions generated by the SIMPOL3 model into engineering designs, using the InfoWorks models, was a significant step. An iterative process, between the two models, was needed to ensure that engineered solutions continued to give the water quality improvements
- Maintaining effective communication/consultation processes (AiP/LoI submission process, the regular PODT meetings and the establishment of agreed protocols) was time consuming and added to the scope of the study. This has put a lot of pressure on the delivery of solutions. Ideally, many decisions woith respect to data collection and model development should have been agreed earlier in the AMP.
- Nonetheless, effective communication and consultation between the Company and the Environment Agency was essential to the success of the Tame UPM Study and helped reduce the risk of both abortive time and expenditure in developing inappropriate solutions.