The Severn Trent Approach to Tackling AMP4 – Investment Planning Perspective

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Introduction

Severn Trent Water is a regulated business with statutory responsibilities for the sewerage services to 8.2 million people and water services to 7.3 million people in an area stretching from the Severn Estuary to the mouth of the Humber.

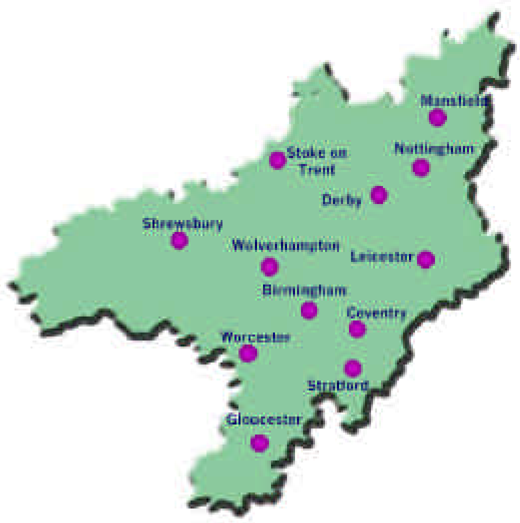

Figure 1 - Severn Trent Water – Who We Serve

We serve 3.6 million domestic customer households and 0.3 million business customer properties and sites and our wastewater assets include:

- 54,040 kilometres of sewers
- 1,017 wastewater treatment works
- 2,953 sewage pumping stations
- 39 sludge treatment facilities

Level of Investment

Between 1989 and 2005 Severn Trent Water has invested over £8.5 billion which has improved the quality of service to its customers and our environment. This equates to £2,400 invested for every home served.

In December 2004 the Director General of OFWAT determined the price limits for Severn Trent Water along with the other water and sewerage companies in England and Wales for the period April 2005 to March 2010, the AMP4 period. In doing this certain capital investment obligations were set and these outputs amongst other performance measures will be monitored over the AMP4 period. These were set by OFWAT based upon the company's final business plan submission for this period helped by guidance on the outputs required given by key stakeholders.

During AMP4 we will invest around **£2.3 billion** maintaining and improving the quality of service we provide to our customers and our environment. Of this around **£1.3 billion** will be spent on sewerage services.

Sewerage Capital Investment Areas

Investment Planning within Severn Trent manages the major capital investment programme, ensuring that promoted projects meet the various investment needs and that solutions are verified to ensure they deliver the required outputs and benefits.

During AMP4 our capital works programme for sewerage services will deliver major improvements to our assets. Some of the key investment areas will be:

Wastewater treatment works - substantial upgrades and or improvements to 158 of our treatment works. As well as asset renewal of ageing or failing assets this includes amongst others the following quality driven outputs:

- Phosphorus removal from sewage effluents at **22** sites under the Urban Wastewater Treatment Directive (UWWTD).
- Tighter ammonia consents at **18** sewage works including our largest works, Minworth serving Birmingham.
- Tighter standards at **51** sewage works to protect sites designated for conservation under the Habitats Directive or Countryside and Rights of Way Act (CROW) Act.
- Tighter copper consents at **3** sewage works to secure compliance with environmental standards under the Dangerous Substances Directive.
- Investigate the impact of **11** discharges to determine whether improvements are required to meet the requirements of the EU Groundwater Directive.

Asset renewal projects to upgrade or replace 75 of our largest sewage pumping stations along with many more smaller sites.

Structural rehabilitation of critical and non-critical sewers including major projects in Derby (£3.3M), Walsall and Sandwell (£1.2M) which are currently underway in Year1 of the AMP.

Unsatisfactory Intermittent Discharges (UID's) - Reduce the impact from and improve the performance of 174 CSO's currently considered to be unsatisfactory. These consist of:

- Aesthetic only improvements to **23** CSOs
- Aesthetic and quality improvements to receiving waters from **121** CSO's. These are made up of **24** CSO's with F1b drivers where quality improvements were identified during previous quality studies including major UPM studies and **97** CSO's with a requirement to pass Formula A.
- **30** other improvements required at wastewater treatment works, sewage pumping stations and investigations to groundwater discharges etc.

Sewer Flooding will continue to be a priority investment area in AMP4 with our obligation to deliver a net reduction in properties at risk of internal flooding of 158 properties and relieve 309 properties from external flooding. To achieve this we must deliver:

- Solutions to resolve internal flooding to **993** properties. **248** of these will be known flooding problems with the remaining **745** being new emerging problems during the AMP4 period.
- At least **316** properties which suffer from external flooding linked to internal flooding solutions.
- Resolve external flooding to **309** properties.

Investment Planning Challenges

Each and every project has various constraints, design difficulties or external influences that challenge our ability to deliver, either in timescale and or cost. However, solutions which require detailed hydraulic modelling of the sewerage system, primarily the UID and sewer flooding programme, set additional challenges to investment planners.

The UID programme outputs have regulatory delivery dates monitored by the EA and OFWAT. Projects can be subject to change from year to year by agreement but the delivery profile of numbers delivered per year is part of our obligation and is more closely monitored. Delays or scope change during feasibility due to upgraded or re-verified hydraulic models therefore affects ability to deliver projects within the required regulatory dates and may also adversely affect cost.

The majority of project outputs were known when formulating the AMP4 business plan, including the UID's, and costs were based on matrix or standard solutions using historical cost models. Apart from a very small percentage where cost benefit may be considered if costs rise significantly, UID solutions that increase in cost is a risk largely born by the company. Sewer flooding however differs in the following ways:

- The flooding programme is monitored on numbers delivered. Individual flooded properties are therefore not named obligations and the company decides which benefits to deliver.
- A significant part of the programme was and still is unknown, problems have not yet emerged.
- Only known problems could be costed when formulating the AMP4 final business plan therefore funding is based largely upon a unit cost to deliver these as yet undiscovered problems.
- Flooding mechanisms are often complex and need to be fully investigated, they are largely hydraulic model dependant.
- The solutions to sewer flooding vary dramatically from catchment to catchment dependant upon spare capacity in the system etc.

To ensure we maximise the benefit to customers from flood alleviation projects we need to maximise the number of benefits whilst keeping solution costs as low as possible. OFWAT have suggested that the majority of flooding solutions should be delivered for less than £120k per benefit (flooded property) although the average unit cost is expected to be around £90k per benefit based on the level of funding received. All projects to alleviate flooding to properties added to the register after March 2007 must be subject to a rigorous detailed cost benefit analysis.

As we do not have named outputs for sewer flooding unlike other areas of the programme we need to ensure we target the best value for money problems. To achieve this we must ensure we deliver effective, efficient, best value solutions and continually monitor the cost per benefit of projects to filter out high cost problems. To effectively carry out cost benefit analysis of emerging problems we must also have a high confidence of solutions and cost. This necessitates greater modelling confidence and cost certainty in the early stages of project feasibility and must be achieved at minimum cost in order to avoid abortive feasibility expenditure. This is why from an investment planning perspective sewer flooding will undoubtedly continue to be one of the most challenging parts of the AMP4 programme to deliver.

AMP4 Investment Process

Lessons Learned

In AMP3 we saw a notable trend for solutions involving hydraulic modelling, both UID's and sewer flooding to increase in cost, sometimes dramatically. This occurred from initial feasibility through into detailed design as the hydraulic modelling developed and hydraulic complexities understood. Whilst this caused uncertainty in the programme forecast it also created a specific problem for the sewer flooding programme where it is essential that only value for money solutions are being targeted. Projects that were approved for design on the basis of an acceptable cost per benefit for instance could become high cost problems late in a projects life. This either led to projects being aborted at a late stage incurring high feasibility and design costs, or allowed little or no scope to withdraw from the project as it was too late in the process to abort due to customer expectations etc. (see fig. 2)

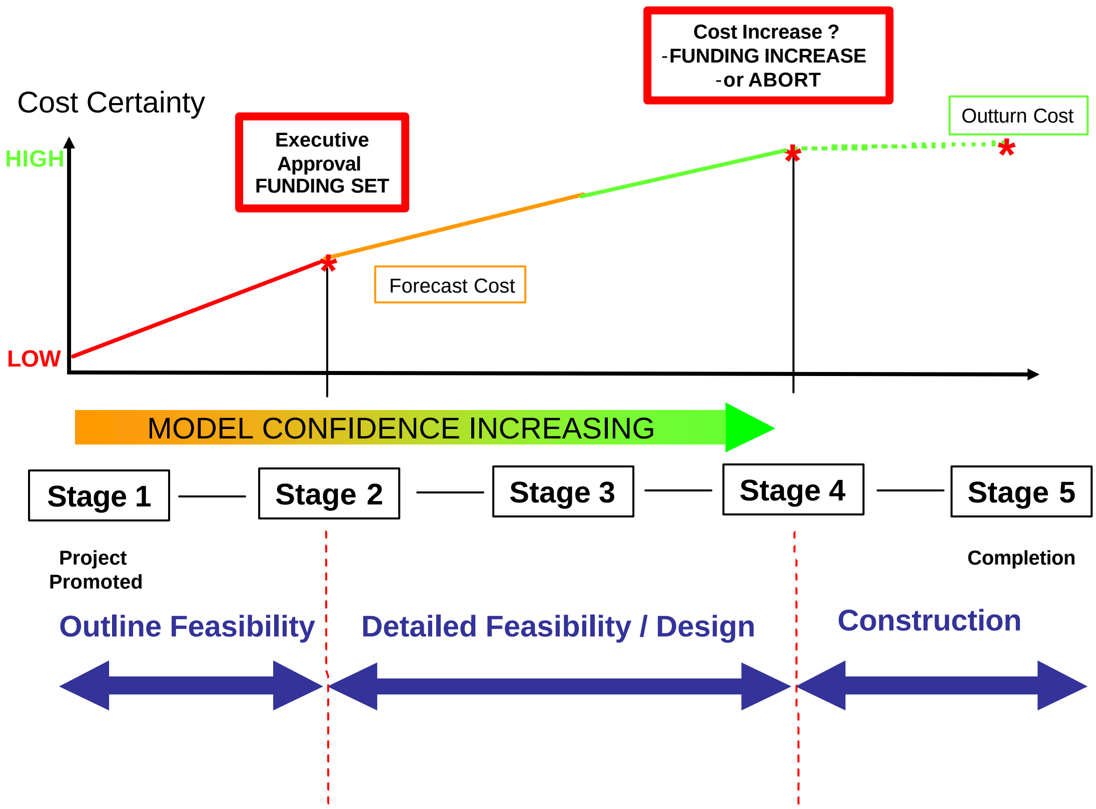

Figure 2 - AMP3 Investment Process

AMP 4 Model

Drawing on the lessons learned in AMP3, we have made changes to the investment process for AMP4 to address this issue. (see fig. 3). In essence we intend to achieve greater cost certainty in projects before executive approval is sought to continue to detailed design. This will enable investment planners to make informed decisions at an earlier stage, giving opportunity to withdraw from certain projects ensuring only value for money solutions are progressed to detailed design stage. For named obligations such as UID's this will enable alternative solutions to be assessed in more detail to ensure the company is fully aware of the cost of delivery before detailed design commences.

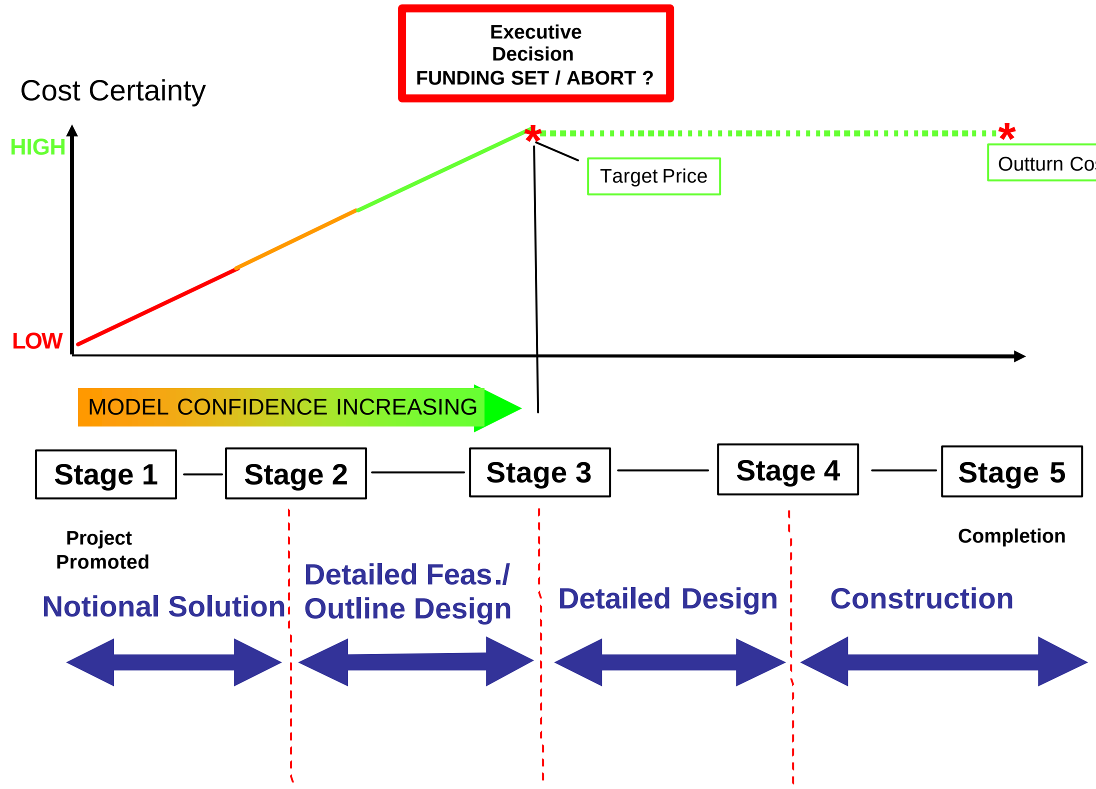

Figure 3 - AMP4 Investment Process

To facilitate this improved investment process other key changes and improvement to the way we work have been made across the business such as:

- Protocols have been further developed and improved for various project types to ensure consistency of approach by our in-house designers and consultants.
- Standardisation – template solutions have been developed allowing standard design approaches to be used that are proven and pre-approved by our operators.
- Supply Chain improvements and development of fee and cost target contracts allowing estimates and target price setting with increased cost certainty at an early stage.

It is known that hydraulic model confidence is a key factor in achieving cost confidence in projects. Whilst processes, procedures and procurement strategies for AMP4 have been improved and revised to allow better cost confidence earlier in the investment process, achieving confidence in the hydraulic models at an early stage is a key enabler.

AMP 4 Modelling Considerations

In order to produce better models to allow more accurate estimates of solution scope and costs at an early stage our approach to modelling has evolved considerably. This approach is based on lessons learned during AMP3 in terms of good and poor modelling practice, and is also based on being flexible so new approaches and advances in modelling can be evaluated and embraced when required. This has been achieved on a number of scales:

- **Improved DAP Specification** – Attempt to standardise models and incorporate what is considered by Severn Trent to be best practice. The specification also attempts to address some of the major modelling issues, such as variable and slow response runoff modelling.
- **Specific Advanced Modelling Tools** – Use of state of the art modelling tools and approaches as they develop, particularly recognising that overland flow modelling may be important in flooding scheme design, RTC may be a fundamental part of flood optimisation schemes, and the need to use integrated catchment modelling as the Water Framework Directive is enforced.

Improved DAP Specification

During the final year in AMP3, ST API spent considerable time developing a more comprehensive DAP specification to standardise the identification and reporting of catchment Needs and outline solution outputs for advance planning purposes, particularly addressing AMP4 drivers and the PR09 submission. The specification ensures models are built to a consistent standard format following rigorous guidelines, considered to be following best practice. The improved reporting and handling of catchment data opens the DAPs up to a wider user base within Severn Trent. The specification also pays considerable attention to data collection issues and survey programming, allowing more time at the start of a study to better focus survey requirements to specific catchment drivers in an attempt to avoid wide scale general surveys for all DAP study catchments.

This paper will focus on two of the key elements of the improved DAP Specification that will aid successful deliver of drivers in AMP4.

- **Modelling Issues**: The AMP3 DAP process highlighted many limitations with the current approaches to modelling. The AMP4 DAP specification attempts to resolve some of these, or at least ensure modellers are considering the issues and adequately reporting. Of particular importance is the approach to runoff modelling. Severn Trent have undertaken numerous field tests and built upon the practice in AMP3 to provide a more robust and auditable approach to predicting runoff. This was seen as a key requirement of the model build specification, as erroneous assumptions in terms of runoff estimation within models can totally undermine the worth of the data collected in other parts of the model and ultimately devalue the model predictions.
- **Model Combination**: Many catchments are considerably large, and require the combining of numerous models constructed by different modellers and consultants. By ensuring a standardised approach, combining of models is made much easier as the potential for parameter conflicts is reduced.

Whilst the specification is essential for the successful delivery of the DAP process, many of the models produced will be used as the basis of detailed engineering solutions during AMP4. The better models produced as part of the DAP process lead to a much better initial evaluation of specific UID or, particularly, flooding solutions. This should lead to a much smaller difference in cost not only between Stage 3 and Stage 5 (see Figure 3), but also in the initial estimate of cost when the project is promoted (Stage 1).

Taking this a stage further, by ensuring a high quality of the general DAP catchment hydraulic model, it is envisaged that the cost estimates of drivers analysed for PR09, AMP5 and beyond can be more accurate. These models will be used to identify future AMP drivers and notional AMP business plan costs. The use of higher quality models across all catchments will increase cost certainty of outputs in the early stages of project feasibility.

DAP Specification Modelling Issues – Runoff Modelling Approach

During AMP3 many 'verified' models were produced that were based on considerable time and survey in the early stages to identify contributing area, but then during the verification stage were changed based on numerous assumptions in terms of additional or less area to make the model predictions match observed flow survey data. Many models produced within the industry as a whole begin to make these large, low confidence assumptions during the verification stage, contradicting much of the detailed work to produce the model in the first place.

As a result, some models contain significant amounts of 'dummy' or unproved contributing area, just because 'that is what the flow survey shows'! The slow response runoff phenomenon has only made the problem worse, with models containing 100's of hectares of New UK pervious dummy contributions to match the long recession tails observed during many winter flow surveys.

Observations and site survey work undertaken in 2004 by Severn Trent (see Terry and Margetts 2004), indicated that model discrepancies are often not due to un-modelled area, but due to the following:

- Limitations with empirical fixed PR models, especially Wallingford (wetness and contribution **does** change during storm even on impermeable areas, and the 10m rule severely reduces the transparency of the model).
- Inappropriate consideration of surface losses, particularly depression storage and its varying status under different antecedent conditions and across different surfaces depending on age and type.
- Inappropriate consideration to scales of surface losses and the variation in surface connectivity during storm events.
- Low understanding of mechanics of New UK runoff model by many, and how predictions differ significantly with changes to surface and evaporation losses. This in turn leads to many of the problems with applying the New UK model under design conditions.
- Lack of appreciation of the sensitivity of all these parameters and what the modelling software is actually doing with many of the input / default values (criticism of the industry as a whole?).

As a result, for AMP4, the whole approach has been turned on its head. It is assumed that the area digitisation process is accurate and that all impermeable surfaces have the potential for 100% of the rainfall to runoff. However, rather than immediately assume that it is the amount of modelled area that is incorrect should the model predictions not match the flow survey data, focus is given to the impact of the rainfall and runoff parameters. It is these processes, particularly depression storage and antecedent conditions that vary so much across different surfaces within a catchment yet are frequently left as (inaccurate) default estimates within a model.

Attempts are made to model connected pervious area at the start of the study as part of the area digitisation process. These are defined, and then should slow response runoff be evident in the flow survey in these pervious areas or slow response from impervious areas, an informed decision can be made to either activate any areas by using the New UK runoff volume equation or the ground infiltration module. Adding large calibrated New UK surfaces is to be avoided.

Runoff Surface ID	Description	Runoff Routing Value	Runoff Volume Type	Surface Type	Initial Loss Value	Fixed Runoff Coeff
1	Paved Good Intact Surfaces	1	Fixed	Impervious	0.000071	1
2	Paved Reasonable Intact Surface	1	Fixed	Impervious	0.000110	1
3	Well Surfaced, Formal Drainage	2	Fixed	Impervious	0.000110	1
4	Well Surfaced, Overland Flow	3	Fixed	Impervious	0.000110	1
5	Poorly Surfaced, Formal Drainage	2	Fixed	Impervious	0.000230	1
6	Poorly Surfaced, Overland Flow	4	Fixed	Impervious	0.000335	1
8	Paved Poorly maintained surface	2	Fixed	Impervious	0.000360	1

Figure 4 – Selection of Paved Runoff Surfaces

The Specification goes a step further by ensuring catchments are split into defined land uses, with a different combination of distinct runoff surfaces representing different degrees of depression storage and runoff routing values. For example, different parameters are specified for major roads, secondary roads and minor roads / tracks / paths, where the typical surface type and quality varies significantly. Figure 4 highlights the key differences in runoff parameters for a selection of different paved areas.

Figure 5 – Micro, Meso and Macro Topography

It is also assumed that some of the slow response runoff observed is not from pervious contributions, but rather additional impervious contributions that only become active as different levels of depression storage become full. See Terry and Margetts (2004) for more details on the concept of Micro, Meso and Macro depression storage. This is highlighted in Figure 5, where increasing amounts of impermeable area are connected as depression stores, of differing scales, progressively fill. By focussing more on the rainfall runoff processes and better representing many of the surface loss parameters, it is anticipated that more robust models will be produced.

<u>Model Combination Issues</u>

In order to achieve DAP programmes it is frequently required that large catchment multi DAP area models are split up and constructed as smaller individual DAP area models by a variety of modellers and consultants. Figure 6 highlights some of the key catchments within the Severn Trent Region where combining numerous DAP models is likely to be an issue. Whilst splitting catchments allows models to be constructed much faster, it frequently results in problems when the models are joined back together to form the full catchment model. This is because different modellers and consultants have preferred approaches for defining land use parameters, runoff surfaces, wastewater generator profiles, simulation parameters etc, even when WaPUG CofP methodologies are followed. For example, users frequently amend the characteristics of default runoff surfaces 10, 20 or 21 rather than create new specifically defined surfaces. Hence, when models are combined there are multiple conflicting versions of these default surfaces. Unravelling conflicts in these parameters can be a laborious task, and frequently leads to errors on combining the individual models which can cause the verification status to be severely compromised.

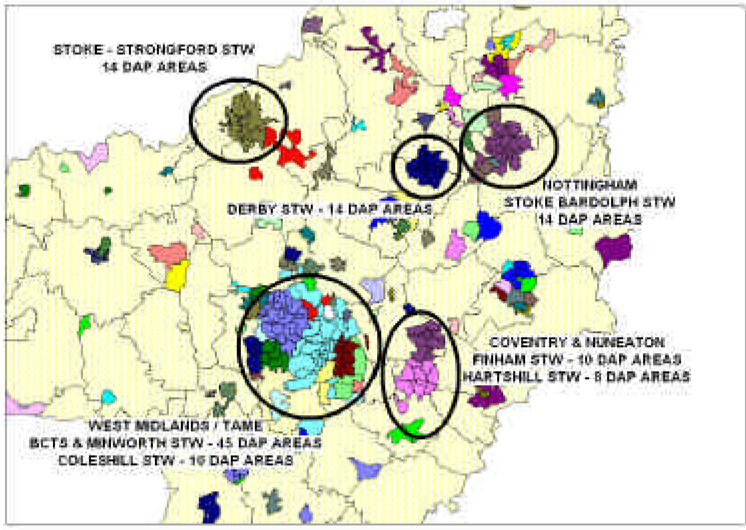

Figure 6 – Key areas where model combining is likely

The DAP specification attempts to prevent this problem by more rigorously defining land use and runoff parameters and ensuring that any changes to the specification baseline parameters are reflected in the creation of new runoff surfaces or landuses. It is anticipated that the creation of new parameters will be tracked centrally within the company to ensure no two DAP teams create a new parameter with the same reference. By ensuring the same baseline parameters through the rigorous specification, the potential for conflicts across the majority of models will be considerably reduced.

Specific Advanced Modelling Tools and Data Analysis Approaches

Whilst the DAP Specification generally focuses on the construction of hydraulic sewer models to produce robust planning tools, the company will also embrace more state of the art technologies and analysis methodologies to address particular drivers and develop optimum solutions where required. This section aims to summarise some of the key recent developments in the water industry that will be utilised to achieve this.

A key part of the process will be to identify the need to utilise more advanced tools as a scheme is promoted, rather than after much abortive modelling work with the traditional approaches, so that accurate, reliable model outputs can be obtained at an early stage. This will reduce the number of situations where initial modelling produces abortive high cost solutions, and further more detailed iterative modelling approaches home in on a more optimal solution. Early identification of the need for advanced modelling tools allows this optimisation to occur earlier in the process, thus giving higher solution cost certainty at an early stage.

Furthermore, there is the flexibility within the DAP programme to utilise these tools as part of catchment DAP Need and DAP Options analysis. This will hopefully allow a more accurate identification of Needs and likely solutions for AMP5 and beyond, thus increasing cost certainty and minimising abortive feasibility costs associated with these. The following tools are likely to play a major role within the company in future, and are seen as extensions to baseline sewer modelling approaches.

Non Default Water Quality Studies

Experiences in AMP3 show that the 'default & available data' approach to water quality and river impact assessment allowed robust solutions to be developed for the majority of UIDs in the region. However, in a number of cases, this approach led to excessive high cost solutions and the subsequent iterative data collection approach identified by the UPM resulted in large feasibility costs and delays to programme delivery. Obviously, collecting more data for all studies in the programme is not the viable alternative due to the high cost associated with data collection.

It is important that AMP3 experiences be used to develop a framework of likely scenarios where excessive high cost solutions may be developed, thus trying to minimise the feasibility spend of iteratively collecting more data and developing progressively less cost solutions. The following parameters have been identified as the two most key issues that should be addressed immediately, rather than even attempting default scheme design:

- **Default River Flows**: Where river flows are provided by calculated data and not measured. Experience shows these are often under estimated, particularly on small streams and drains, or in urban areas. This was the case in Scunthorpe where a stream with a DWF of 350l/s was believed at default stage to have a flow of less than 20l/s (Figure 7). Such erroneous initial data can cause significant scheme over design.

Figure 7 – Bottesford Beck
Figures supplied indicate 20l/s baseflow!

- **Background Failures**: Significant feasibility costs have been accumulated on a number of projects developing solutions to improve all RE and FIS criteria in a watercourse, often with the scheme attempting to reduce the number of background failures to achieve compliance. However, in many of these instances it is limitations with input data or the modelling software that produce these background failures. This is easily checked by undertaking background assessments in the first instance. High background failures have been caused by issues such as the impact of upstream steel works, and modelling software unwittingly carrying out wet weather analyses during periods of no spill to a watercourse.

It is anticipated that default water quality assessments will be undertaken as part of some DAP studies. This broad brush default approach will allow a better understanding and targeting of likely UIDs for future AMP periods, rather than the current approach of agreeing water quality UIDs based on spill performance or anecdotal evidence along a reach containing multiple CSOs. Again, this will reduce the frequency of UIDs found to be satisfactory following feasibility work and the requirement to 'swap' UIDs in the future.

Integrated Catchment Modelling and Simulation (ICS)

ICS has formed a part of many UPM studies for a number of years, but only really as an 'in series' approach where time varying outputs from sewer models are used as input to river models, as in many simplified RI assessments. It is possible that in AMP5 and beyond more focus will be given to STW storm discharges, as catchment solutions have increasingly transferred storm flows downstream. This is likely to result in more complex RI assessments being undertaken. These will certainly include all the STW discharges, but also with the implementation of the Water Framework Directive, are likely to be undertaken on a catchment and basin scale. UIDs at STW storm tanks could well involve significant solutions and it is essential that when these are investigated, the most robust tools are utilised, to supplement the simple 'default' approaches used for many small UID investigations.

This will increase the need to develop more detailed sewer and river model interactions, and looking forward to the WFD, increase the need for parallel ICS. Parallel ICS involves the two way transfer of data on a timestep basis between river and sewer models. For example, discharges from the sewer system may be limited in real time by river pollutant concentrations upstream (see Margetts and Long, 1999).

Whilst this modelling is more likely to be required in AMP5 and beyond, the modelling tools exist to allow adequate ICS to be undertaken now. Both Wallingford Software (InfoWorks CS and InfoWorks RS) and DHI (MOUSE and MIKE11) have the facility to undertake this. With the implementation of the WFD and the need to better appreciate a range of river impacts along the whole of a river, it may be time soon to begin implementing these technologies.

Overland Flow Routing

The last few years have seen a number of studies begin to utilise digital terrain mapping to develop flow routing paths on the surface and link this to out of sewer flooding (Hale 2003, Allitt 2004). What these studies have shown is that it is relatively simple to utilise GIS software to determine detailed overland flood paths, on a number of scales.

The implications of this are quite clear from an engineering solution perspective. Traditionally, sewer models have been used to predict out of sewer flooding locations (on a manhole basis) and in-sewer solutions developed, sometimes even where overland flow from a non sewer source was suspected as a major contributing factor. Often, where overland flow was suspected, less quantitative approaches were used to formulate the engineering solution. This frequently resulted in wrongly designed solutions, or inappropriate high cost in-sewer solutions.

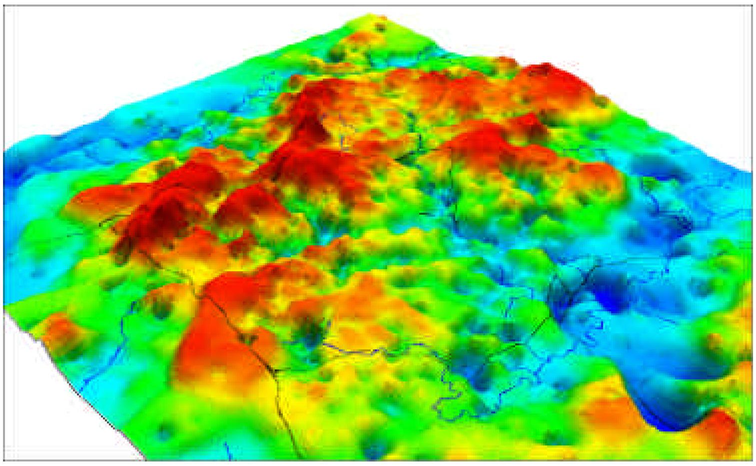

Figure 8 – 3D Mapping of Tame Catchment

A number of different sources of ground elevation data are available to allow flow routes to be visualised and generated. On a simple scale, levels from sewer records or simple topographic surveys can be used, and on a more detailed scale these can be generated by Synthetic Aperture Radar (SAR) and Light Detection And Ranging (LiDAR). Digital Elevation Models (DEM) and Digital Terrain Models (DTM) can then be produced in GIS packages such as MapInfo or ARCVIEW, and subsequent analysis programmes used to determine flow routes. Figure 8 shows the 3D mapping of the whole Tame catchment, and Figure 9 a more detailed part of the catchment where distinct overland flow routes can be visualised.

Furthermore, InfoWorks has for the last year or so had the facility to generate overland flow paths between manholes in a sewer system, and use topographic data to route this flow either back into the sewer system or away from the system to, say, a likely flood area.

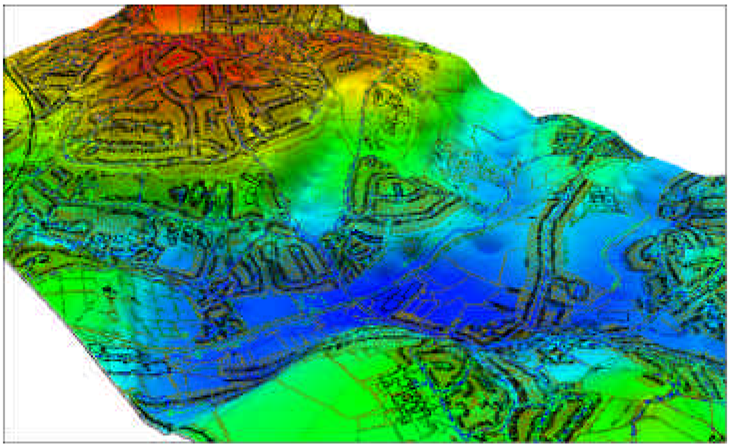

Figure 9 –Detailed Overland Flow Routes (Tame)

The technology is now certainly available to ensure that where overland flow is suspected to be part of the mechanism of flooding at a reported flooding location, then at an early stage these tools can be utilised, rather than undertake abortive work attempting to force fit inappropriate in-sewer solutions to the nearest sewer flooding location. In many cases, it may be possible to demonstrate through this modelling that a more cost effective out of sewer solution is more appropriate, or that the mechanism of flooding is not sewer related, thus avoiding abortive feasibility work on inappropriate in-sewer solutions.

Solution Optimisation Techniques

Many of the flooding drivers remaining in catchments are stand alone issues, as the majority of clustered flooding problems have been addressed in previous AMP periods, due to these offering a large number of benefits per scheme. Addressing these more difficult standalone drivers is likely to be based on optimisation of existing assets, rather than constructing new assets, due to the low benefit to cost ratio. Improved solution optimisation could be achieved on two differing levels:

- **Rapid Optimisation Software**: Packages have recently been developed (e.g. FastNet & CasDEF) that utilise existing sewer models to automatically generate optimal engineering solutions for hydraulic problems. Severn Trent is part collaborator on the FastNet Project, and testing of the software is ongoing. Whilst the solutions generated by such optimisation software still need to be fully engineered and designed to take account of other civil and construction issues, these tools offer an excellent opportunity to develop better estimates of solution scope and cost at an early stage, again thus reducing abortive feasibility study costs. Furthermore, this software should allow all options to be considered at an early stage, rather than possibly missing the obvious solution until considerable time and money has been spent on a more complex solution, which does occasionally occur.
- **Better use of Real Time Control (RTC)**: RTC has been available in most sewer modelling packages for many years, yet is rarely used to develop new solutions due to both its complexity to develop and often a reluctance by operators to place confidence in the RTC functioning adequately in the ground in years to come. The functionality offered in many software packages to replicate the performance of monitors, controllers and the regulators is excellent, albeit complex. This will certainly deliver cost savings to future projects, particularly in

stand alone flooding solutions where optimisation of existing assets is likely to offer significant cost benefits over new sewerage schemes.

Conclusions

Severn Trent faces a large programme in AMP4, with hydraulic modelling forming the basis of delivery for 174 UIDs and 1,618 internal or external flooding drivers. Of primary importance is developing robust, accurate models at an early stage to achieve greater cost certainty before solutions are progressed to detailed design. In the past, the confidence in models has often been iteratively increased as scheme design is ongoing, often leading to abortive outline solutions and higher feasibility costs. By ensuring accurate models from the outset, a long term higher degree of confidence can be placed in an initial outline solution.

In terms of preparation for future price reviews, ensuring a higher degree of model accuracy will allow more confidence to be placed in future business plans. This will be achieved by allowing better identification of specific catchment problems and increasing cost certainty in proposed solutions.

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