The Challenges of City Wide DAPs - The Coventry DAP

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Introduction

Severn Trent were required in AMP 4 to produce a number of large catchment models which brought a number of challenges particularly in relation to spreading resources and ensuring data quality across large areas or large parts of a model. This paper outlines a number of the challenges faced in the delivery of the Coventry DAP model and what steps were undertaken to help offer value and reduce risks to costs and programme.

Coventry is situated 30km east of Birmingham, with the catchment area comprising a total of 12 individual drainage areas, which accounts for approximately 7% of the Severn Trent AMP4 DAP Programme. The entire catchment covers an area of 108 km² and 345,000 population. The sewerage system, extensively rebuilt after the Second World War, drains to Finham STW.

The DAP drivers comprised of over 50 registered floodings, operational concerns at large ancillaries such as Canley Storm Tanks and Sowe Valley syphon, and flooding of the inlet works at Finham STW. The DAP model would also be used to understand growth, climate change and creep, and to inform operational, management and strategy decisions.

Coventry DAP Model - Overview

The model was verified against a three phase flow survey, due to monitor availability preventing the full quota of flow monitors being installed as a single batch, and was subsequently built and verified in three separate sections, following the three main trunk sewers which drain the catchment. The models were then combined to give a single catchment model, and other inputs to Finham STW (e.g. Kenilworth) were included using previous models.

The base data for the catchment was reasonably well populated with the initial data import for all 12 DAP areas containing the following information:-

	Nodes	Conduits	Nodes without CL	No Pipe Size	No US Invert	No DS Invert
Total	43,472	43,643	14,873	9,994	15,490	14,742

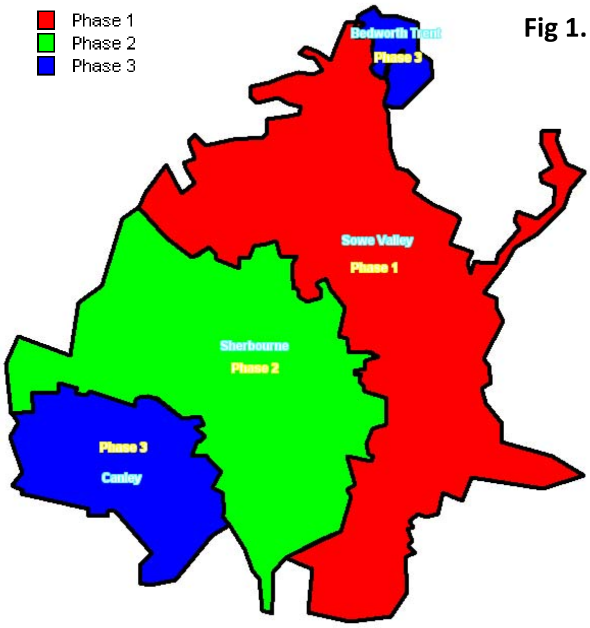

Fig 1.

In total the final verified model included 14,700 subcatchments, 3,100ha of digitised area, 25,000 nodes and 25,200 links. Fig 1 shows the different flow survey phases. The three separate model sections are:

Catchment	Population
Sowe Valley	147000
Sherbourne	152414
Canley/Bedworth	44212
Total	343626

Phase 1 - Sowe Valley Model - Contains 6 of the 12 DAP areas, is relatively hydraulically independent from other areas and discharges to Finham STW to the SE of the works (Sowe Inlet).

Phase 2 - Sherbourne Model - Contains 4 DAP areas and discharges to Finham STW at the Sherbourne inlet. With the exception of a number of small interactions with the Sowe Valley and Canley areas, this catchment is hydraulically independent

Phase 3a and 3b - Canley and Bedworth Trent Models - Both of these DAP areas are largely hydraulically independent from the rest of the Coventry Model with the exception of a number of small interactions. Canley discharges to the south of the Sherbourne catchment in Earlsdon. The Bedworth Trent model discharges to the north of the Sowe catchment via a sludge main from Marston Lane STW, and has a limited impact on the Sowe catchment.

Manhole Surveys

Extensive manhole and ancillary surveys (circa 700 surveys) were required across the catchment to ensure network data quality and confidence. These required a different approach to planning to ensure value and optimum focus, and to allow alternative strategies (i.e. CCTV) to be identified at an early stage to minimise impact on programme where manhole surveys were not possible:

1. Strategic pre-surveys were undertaken in areas of complicated or unknown connectivity to better focus the main programme of surveys.
2. To ensure a high percentage completion rate of the surveys scheduled, all key survey manholes were located prior to issuing plans to the contractor.

Asset surveys were phased to allow model build and verification to be undertaken in parallel with the next phase of the flow survey. This ensured the best use of available resources for programme purposes, both in terms of contractors and technical staff.

Flow Survey

The flow survey was carried out in three phases as there were not sufficient flow monitor resources available in Year 2 of AMP4 for such a large survey. The phases were installed concurrently, to ensure the equipment availability through roll over and to maintain catchment familiarity with the survey crews. This approach led to more manageable data handling and assessment, resulting in higher quality data return. A phased approach was possible as the models could initially be developed in isolation due to the hydraulic independence across the three spine sewer catchments. Summary of the survey details are provided below.

<table>
<tr><th>Phase</th><th>STD</th><th>FloDar</th><th>ADFM</th><th>Depth Only</th><th>Pump State</th><th>RG's</th><th>Install Date</th><th>No of Weeks</th></tr>
<tr><td>Phase 1- Sowe Valley</td><td>113</td><td>0</td><td>0</td><td>1</td><td>0</td><td rowspan="4">30</td><td>9/3/07</td><td>17</td></tr>
<tr><td>Phase 2- Sherbourne</td><td>95</td><td>1</td><td>0</td><td>1</td><td>0</td><td>6/7/07</td><td>13</td></tr>
<tr><td>Phase 3- Canley & Bedworth</td><td>53</td><td>0</td><td>0</td><td>1</td><td>0</td><td>10/8/07</td><td>15</td></tr>
<tr><td>Strategic Flow Survey</td><td>18</td><td>2</td><td>1</td><td>0</td><td>1</td><td>22/2/07</td><td>39</td></tr>
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In addition, a strategic flow survey was installed for the entire period, monitoring flows in trunk sewers at 15 key locations across the catchment. The strategic survey was installed for the following reasons: -

- To provide a structure of high quality monitoring sites at key locations, covering the entire period of the flow survey.
- To allow the long term assessment of seasonal effects such as infiltration and slow response flows from the catchment.
- To allow a comprehensive assessment of verification under all conditions in the main trunk sewers which drive much of the hydraulic mechanisms in the catchment and in vicinity of Finham STW where all sewers ultimately converge.
- To provide a catchment wide detailed rainfall coverage for an extensive period, to allow the assessment of spatially varying rainfall.

In order to gain more confidence in the data received, strategic monitors in sewers greater than 1800mm diameter were ‘doubled up’ (i.e. two monitors were installed adjacent to one and other in the larger diameter trunk sewers) to prevent a total loss of data should a monitor fail.

Several different monitor types were used to best suit installation and flow conditions, particularly the variable velocity profiles evident in the large diameter trunk sewers. For instance, new technologies such as the FloDar monitor and ADFM were installed at Finham STW. Each site was discussed in detail with the flow survey contractor to ensure the most fit for purpose equipment was installed. As a result of the more complex nature of the installations, pre-installation surveys took far longer that normal, with only 3-4 sites pre-installed per day. The modeller was present at all pre-installs, installs and numerous downloads in order to ensure best possible knowledge of each strategic site.

Flow Survey Issues

Monitor data generally appeared reliable and of good quality. However, at some ‘doubled-up’ sites significant discrepancies were found where one monitor would read significantly higher than the other located only inches away (Fig.2). In this example, one of the monitors records 10% higher for depth and velocity with the pipe running half bore. This results in a difference in flows of over $1m^3/s$.

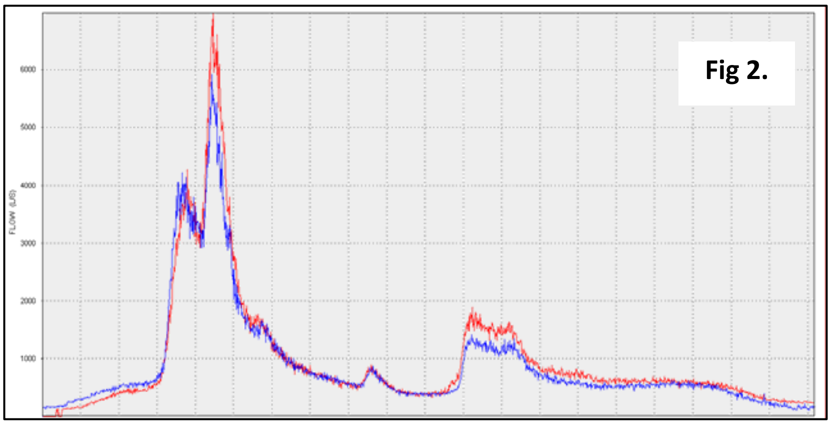


Fig 2.

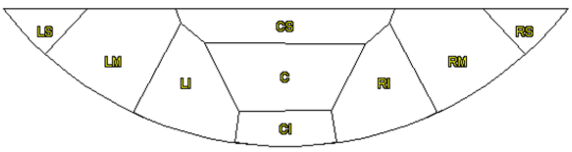
Significant volume balance errors were encountered, requiring high levels of data assessment in order to decipher which were the most reliable data-sets to be verified against. This involved analysing scattergraphs in depth, looking at downloads, checking site conditions and also verification achieved across different events, assessing the flow data took 2 modellers a full week to ensure any issues were identified.

Due to the concerns over the accuracy of the monitoring of flows in the large diameter trunk sewers as a result of variable velocities, every reasonable precaution was made in the flow survey planning stage to ensure quality of data captured in the trunk sewers where velocities were variable such as:

- detailed pre-installation surveys at each site,
- locating numerous alternatives to ensure most suitable site was selected with hand held measurement,
- installation at night to ensure monitors could be installed in favourable flow conditions,
- diversion of flows to provide the best possible conditions for installation,
- use of a range of flow monitoring technologies.

Due to the concerns of measuring variable velocity profiles, 9-point velocity checks were carried out by the flow survey contractor at each strategic site, where variance of up to 200% between lowest and highest velocities were observed across trunk sewer flow profiles.

To calibrate the flow data, the flow survey contractor compared the average of the raw 9-point velocities with the velocity recorded by the monitor. The velocity coefficient could then be calculated to estimate the average velocity measured by the flow monitor across the flow area. Assessment of the flow data suggested significant volume imbalances, and the flow calibration was re-visited by Clear, using weighted values of the velocity co-efficient depending on the area of influence as illustrated below: -



Circular 9-point	% x-section of flow
Left Invert	13.2%
Centre Invert	6.2%
Right Invert	13.2%
Left Mid	16.0%
Centre	15.8%
Right Mid	16.0%
Left Surface	3.6%
Centre Surface	12.5%
Right Surface	3.6%

This resulted in significant differences in the velocity calibration coefficient, resulting in a significant difference in measured flows at some sites (shown to be 20% in Fig. 3) yet little change at others.

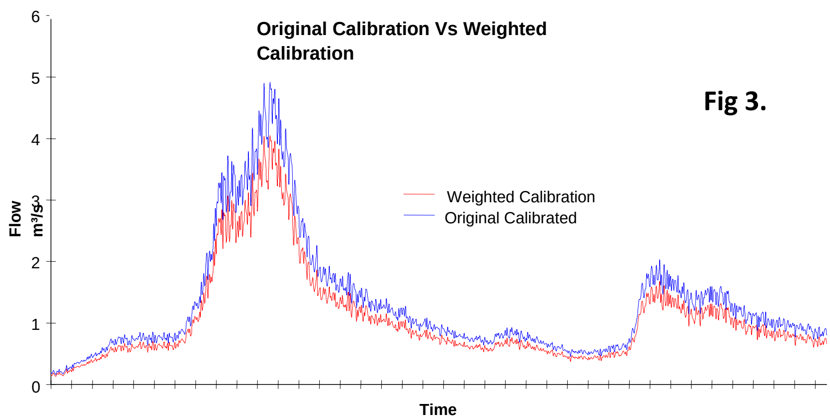


Fig 3.

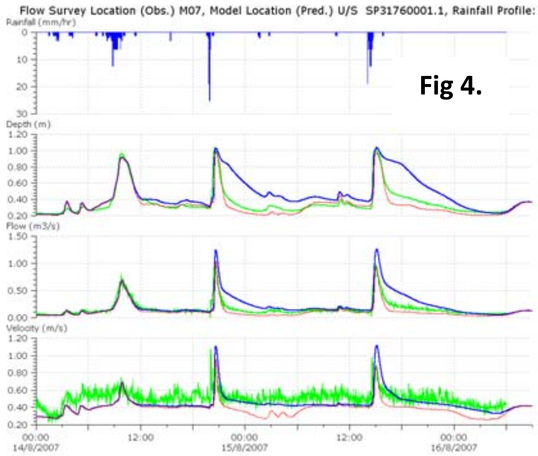
This highlights the significant potential for inaccuracies (as large as the verification criteria bands!) in the observed data in large sewers due to this aspect of the flow calculation and calibration when using single point velocity monitors.

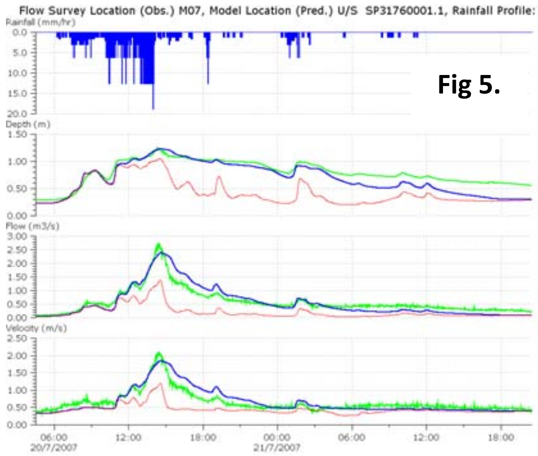
Canon Hill Drive Flooding Project

During the course of the DAP study a high priority flooding scheme was commisioned within the Canley catchment. This involved the installtion of an addition detailed flow survey and upgrade of a localised area to type III model detail.

Consequently, three flow surveys were undertaken in this area: the model upgrade localised flow survey, the short-term catchment wide flow survey and the long-term strategic flow survey. The variation in events captured and flow conditions encountered led to three differing conclusions when the model was verified to the different flow surveys (Fig. 4 and 5):

- Localised flow survey verification: Flooding had been solved by a recent capital scheme which involved removal of a set of blinded screens, with no flooding predicted upto a 40 year return period rainfall event. However, significant flooding was predicted with screens modelled.
- DAP short-term flow survey verification: Verification in local area unchanged, no flooding predicted but trunk sewer flows increased .
- Strategic Flow Survey: Significant flooding predicted with application of slow response flows only observed when strategic monitors were installed. Flooding in the area caused by backing up from the trunk sewer with the addition of significant amounts of slow response slows.





Observed Data Type III Verification DAP Final Verification

Figures 4 and 5 detail the verification achieved for the flow monitor installed on the trunk sewer running adjacent to the flooding properties. Fig. 4 details the verification for the largest event captured in the two short-term flow surveys, with the verification achieved (red) for the model upgrade and catchment wide flow surveys. Shown in Fig. 5 is the significant under-prediction in flows (red) for the type III model, with the plot in blue showing the final plots for the verified model.

Consequently, without the long term monitoring, there would have been no reason to suggest the type III model did not fully replicate the higher flows and flooding associated with certain events, even though this was based on two separate short-term flow surveys. This brings into doubt the validity of short-term flow monitoring for the assessment of such high level flooding drivers and highlights the benefits of long term flow monitoring. The long-term survey identified different flows and flooding mechanisms not identified by two short term surveys.

Conclusions

To conclude, it is essential to ensure extensive pre-planning and investigation is undertaken to ensure a full understanding of both catchment needs, planned works in addition to the operation of the network. Furthermore, extensive consultation with all parties throughout the study leads, not only to a more robust modelling solution, but a smoother transition between phases of the works.

The importance of flow survey planning to minute detail cannot be underestimated, particularly in respect of understanding and identifying erroneous data.

The benefits of long term monitoring are outlined in this paper; it is of particular importance when dealing with phased flow survey data. However, the benefits of long term data in regard to understanding network operation, seasonal influence and slow response flows significantly increase model confidence.

Acknowledgments

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