Section 24 Modelling – Proposed methodology

Session 5 - Paper 2

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SYNOPSIS

Modelling private sewers is desirable since their regulation became effective from 1st October 2011.

This methodology provides a simplified approach to representing the lowest connection point in each formerly private drainage network.

This was developed in collaboration with Yorkshire Water and partnership of Pick Everard and WSP. Using InfoNet and InfoWorks software by MWH Soft we have developed an innovative solution for representing formerly private sewers.

The process developed does not detrimentally affect the modelled network or interfere with traditional model build procedures i.e. manhole storage compensation. A number of assumptions are required to undertake simplification.

There are limitations to this modelling methodology which resides with the level of data accuracy. DTM and GPS data can provide increasingly accurate ground models therefore a greater confidence may be achieve. Although the source of detail provided in the private sewer records varies significantly.

The many advantages to the modelling solution include:

- Reduced time and cost of modelling all local connections
- Reduced simulation time
- Consistent approach to model formerly private drainage
- Predictive flooding location tool by determining most vulnerable locations
- More accurate representation of flooding volume
- Potential to be used as a proactively tool to prioritise private drainage
- Potential to identify need for modelling private drainage

1.0 BACKGROUND

The following extract from WaPUG user note 15 clearly defines current thinking on modelling private drainage.

"*When simulating the behaviour of drainage networks using hydraulic modelling software, the system is normally to a greater or lesser extent represented in a simplified form. This is necessary in order to reduce the data collection that would be involved if all pipes from the main sewer to the buildings were included and to reduce computer run times. This means that not all of the storage available in the drainage system under surcharged conditions is included in the model. This unmodelled storage includes connections, gulley pots and unmodelled pipes and manholes. If this storage is not added to the model, it will over-predict the flooding that occurs during storm events.*

Accurate measurement of the unmodelled storage is extremely difficult. The information on sewer records normally shows the location of the sewers in the roads but not the building drainage. If the missing pipes are on the sewer records the volume of these could be measured, although this is a time consuming business. Normally, manholes will also be marked and the volume of these can be estimated by assuming a standard diameter. The volumes associated with gulley pots and pipes connecting gulley pots and properties to the sewer cannot be measured from the records. The lengths of the connecting pipes can be measured but determining the numbers of the gulley pots and the size of the connecting pipes can only be ascertained by fieldwork. Carrying out such fieldwork would require an enormous amount of effort.

The problem is further complicated by the fact that not all of this measured volume is available as storage since some of it will be taken up by flows in the pipes. The volume available will therefore be different for every storm event. Another complication is that not all of the system connected to a surcharged pipe will fill to ground level and so some storage will not be utilised.

As no realistic user of a sewer hydraulic model would expect the program to predict volumes of flooding to the nearest cubic metre, it is not worth attempting to define accurately the additional storage available. What is needed is a method which provides a realistic estimate of the available additional storage without requiring any information other than the pipe data".

However, this approach does not consider or identify the first point of flooding in the additional storage compensation of the private drainage system it represents.

The transfer of private sewers to the appointed sewerage undertaker was approved by an Act of Parliament through Section 98 of the Water Act 2003, which became effective from 1st October 2011. The result, a homeowner will now only have responsibility for the drainage on their property up to the point where they connect with another's drain to create the status of public sewer, or the point at which the drain passes beyond their property boundary creating the status of public lateral drain.

2.0 THE PROBLEMS

At present no guidance documentation exists on modelling private drainage

To deal with the formerly private drainage there are three options to explore moving forward. Ignore modelling the formerly private drainage altogether and continue as before. However, this will be visible to external stakeholders, does not conform with a view to prioritise asset maintenance costs and not understanding the risks associated with adopted assets.

If the formerly private drainage becomes public drainage and modelled using current modelling practices the results would be unfavourable. The extent of a hydraulic model would increase drastically, in terms of total modelled sewer length and total modelled nodes, and perhaps beyond the limitations of hydraulic modelling software. These elements would be time consuming and costly.

To understand the problem of modelling formerly private drainage in its entirety we have considered a case study. Yorkshire Water has permitted the use of their model data in the Leeds catchment. The public drainage contains roughly 79,000 pipes and 111,000 nodes. The extent of the private drainage contains roughly 139,000 pipes and 141,000 nodes.

It becomes apparent to model a public and private drainage hydraulic model of this size is not only impractical but currently impossible, due to software limitations (extent of model limitations in the region of 100,000 nodes).

The alternative is to simplify the formerly private drainage with sewerage undertakers' records, for further details on this process refer to the page headed 'The Solution'.

Whilst developing the proposed methodology to model (or simplify) the private drainage the following issues had to be overcome, these represent both software limitations and data anomaly corrections:

- Missing data
    - Ground levels, invert levels, pipe size, pipe shape, pipe length, pipe material and pipe roughness
- Instabilities
    - Short pipes and number of modelled nodes
- Connectivity
    - Missing pipes, missing upstream (u/s) or downstream (d/s) node references
- Sewer mapping
    - Accuracy of private drainage, connection to public sewer, connection to public manhole
- Duplications
- Isolated manholes

3.0 THE SOLUTION

This is achieved by simplifying the network to a lateral connection per public sewer.

The solution is not just the simplification of formerly private drainage to a lateral connection but the additional benefits this methodology brings to the modeller and Client. It compliments the traditional model build; by giving a more accurate representation of flooding volume and has the potential to more accurately identify flooding locations.

Consequently the methodology may be used as a 'proactive' tool for sewerage undertakers to prioritise private drainage mapping requirements, only in terms of hydraulic capacity.

To simplify the formerly private drainage to a lateral connection the modeller is required to identify the upstream and downstream nodes.

To determine the upstream node (manhole or inspection chamber) a ground model is applied to the model to establish unknown cover levels. Then, analysis is undertaken to identify the minimum ground level in each formerly private drainage network.

The downstream node (junction) connections were identified using a Yorkshire Water preset. In this particular case the relevant nodes were attributed with the reference "F24". This was invaluable because it clearly identified connections between the formerly private drainage and public drainage.

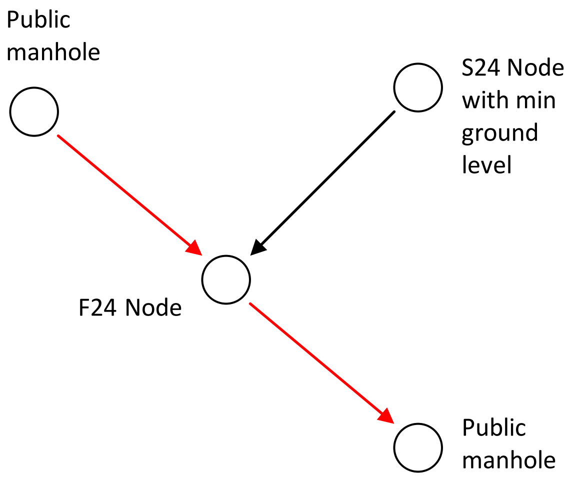

Figure 3.0 Illustration of simplified formerly private drainage network (lateral connection)

Connectivity is a significant concern as the time it takes to resolve the issues is dependent on the accuracy and reliability of the formerly private drainage records.

The following three steps show key stages to undertaking the proposed methodology and illustrate the potential savings, in modelled nodes and conduits, which can be achieved.

3.1 STEP 1

The figure below shows the hydraulic model of a test area found within Leeds, known as Roundhay Park.

Model build has been carried out and completed on this public drainage network which omits private drainage. It is at this stage the proposed private drainage simplification should begin.

The most important element to note about the model is the **881** total nodes. This would typically conclude the model build aspect of the public sewer model.

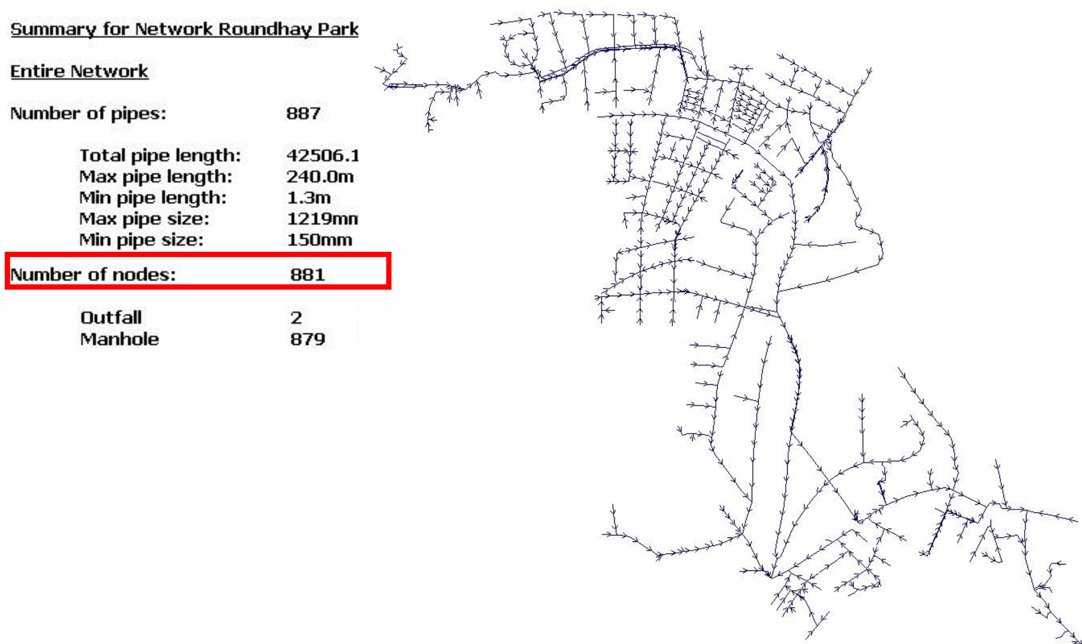

Fig 3.1 Roundhay Park – Public Drainage

3.2 STEP 2

The figure below shows the extent of formerly private drainage records maintained by Yorkshire Water, in the vicinity of Roundhay Park.

The image here does not convey the missing data population required to simplify the formerly private drainage but it does highlight the scale of the problem should we consider adopting traditional model build procedures.

The formerly private drainage records, in this instance, contain roughly 2.5 times more nodes than the public drainage network in Figure 3.1. The most important element to note about this model is the **2211** total nodes.

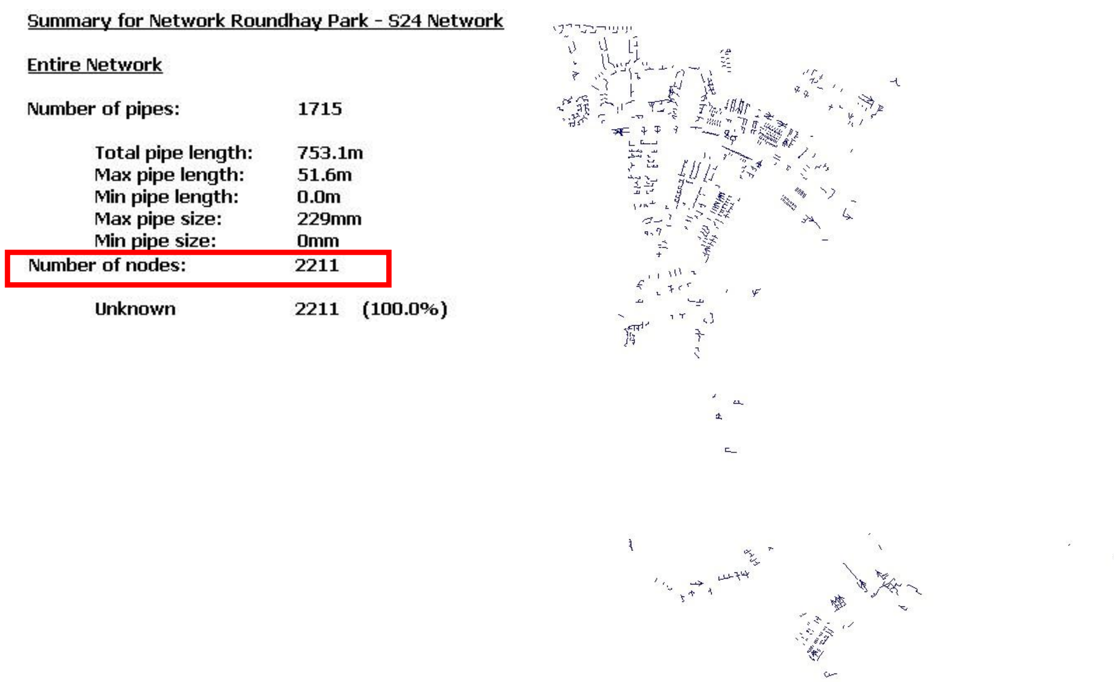

Fig 3.2 Roundhay Park – Formerly Private Drainage

To attain a simplified private drainage the key elements to achieve this are done by applying ground levels using a ground model, addressing connectivity issues, identifying the upstream and downstream manholes to each lateral connection and the application of modelling assumptions.

3.3 STEP 3

The figure below shows the result of combining the public drainage and the simplified lateral connections together.

It was found after completing the simplification process a 75% reduction in the formerly private drainage nodes was achieved. The total nodes now required for modelling in the simplified network are **1311**

This is a significant saving in terms of number of modelled nodes and as a result will lead to reduced simulation time.

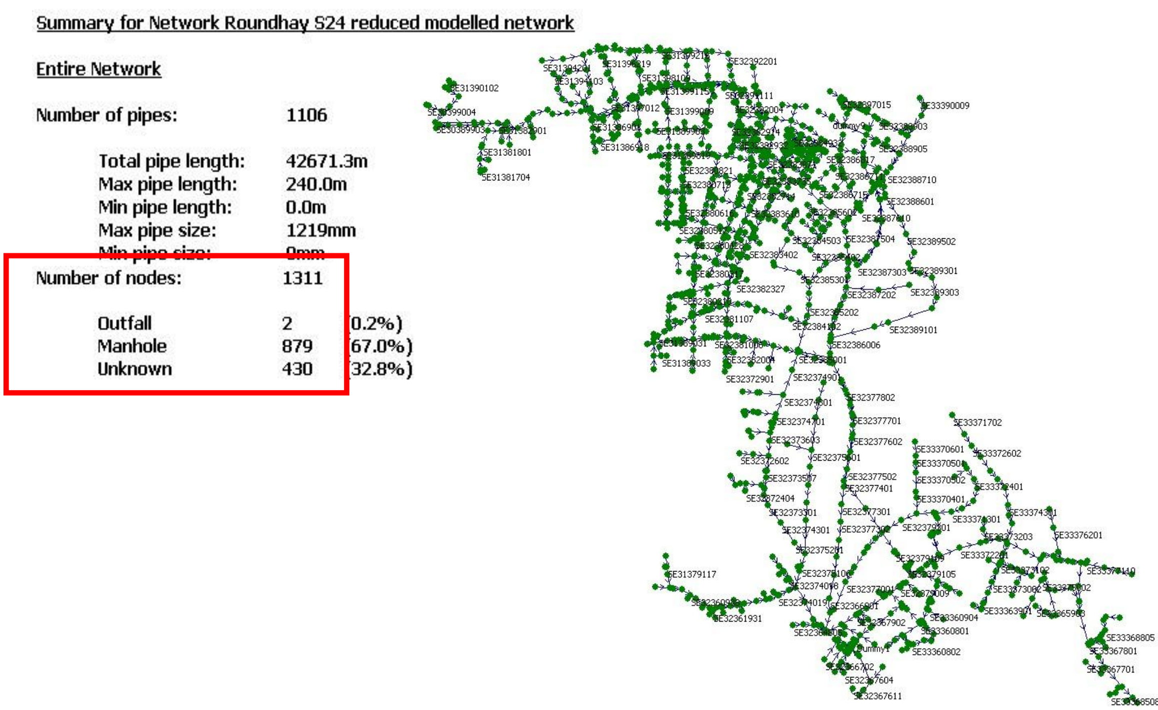

Fig 3.3 Roundhay Park – Simplified Network

Although the numbers offer a significant reduction in modelled nodes it should be considered this is solely based on one area within Leeds. Undoubtedly the reduction of modelled private sewers will differ between catchments.

4.0 MODELLING ASSUMPTIONS

From a modeller's perspective several assumptions have been made, not only to validate the simplification but also data completeness and software limitations:

- Pipe lengths fixed at 1.0m or #D (calculated by software), whichever is greater
- The downstream headloss coefficient is set to 8, typically private drainage connects perpendicular to public sewer
- Pipe size set to 100mm diameter to reduce impact on storage compensation, regardless of existing sewer record data
- Upstream invert level set to 300mm below depth from cover (the upstream nodes are likely to be inspection chambers in the rear gardens of residential properties
- Downstream invert level is interpolated to invert level of the public sewer, can be done using soffit to soffit considered to be negligible impact
- Connection nodes to public sewer are set to sealed
    - Chamber area set to #D (calculated by software)
    - Shaft area set to 0
- Pipe material is assumed to be VC (Vitrified Clay)
- Pipe roughness (top and bottom) set to 1.5mm

5.0 LIMITATIONS

One of the principle time consuming elements in the simplification process comes when correcting connectivity issues. The problems associated with connectivity have been highlighted under the section headed '2.0 The Problems' on page 3.

The length of time will vary from catchment to catchment depending on several factors, typically including:

- Location in urban or rural area
- Size of catchment or hydraulic boundary
- Weighting of residential properties
- Extent of mapping sewer records

Like most modelling methodologies they are not perfect and consequently come with limitations to bear in mind:

- The representative flooding volumes are as good as the ground model
- Accuracy and reliability of sewerage undertakers sewer records
    - The predictive flooding locations are as good as the sewer records
- The additional storage created by simplifying the formerly private drainage is considered to have a negligible affect on manhole storage compensation
    - Further study is required to determine the affect this has on a model

6.0 CONCLUSIONS

Using the proposed methodology developed would provide a consistent approach to 'simplifying' private sewers.

Comparison of undertaking model build on formerly private drainage and implementing the proposed methodology clearly shows there will be a reduction in total number of modelled nodes and conduits (manholes and sewers) and thus a reduction in modelling time and simulation time.

The simplified private sewer (lateral connection) upstream node and downstream node are identified using a unique manhole references and preset node type references.

Flooding at manholes of lateral connections could potentially be used as a more accurate predictive flooding location tool and provide a more accurate flooding volume.

It is believed the current methodology to maintain the mapping and record requirements of formerly private drainage will be undertaken on a 'reactive' basis. Simply put this means if a structural or operational issue is encountered an investigation to ascertain these details will be carried out. The proposed simplification may be used as a 'proactive' tool for sewerage undertakers to prioritise private drainage mapping requirements, in the function of hydraulic capacity only.

There is potential to reduce the lateral connections to a greater degree. This is accomplished by removing the lateral connections that have an upstream node cover level higher than the public sewer's downstream cover level. This suggests that surcharge would initially flood from the public sewer, not the lateral connection.

Finally, it is worth noting the methodology was carried out using industry standard software:

- InfoWorks v10.5
- MapInfo v10
- Vertical Mapper v3.5
- Excel 2003