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Using "Inherited Models"

Introduction

With the changes to the Water Industry in Scotland there will be a considerable quantity of models held within Scottish Water that were produced for the former Water Authorities and prior to that for the Regional Councils. Many of the models stem back to the days when sewerage was still a function of the Regional Councils. In East of Scotland Water many of the newer models have been audited. However, there remain a number of models that were 'inherited' from former organisations and Consultants.

In the other regions of Scotland there are also a large number of models from former organisations and Consultants and not all of the newer models will have been audited.

The dangers of using these "Inherited" models without carrying out a series of checks will be discussed in this paper. In many cases the inherited models were built for specific purposes that were frequently different from Drainage Area Planning requirements. Many of the models have little or no documentation and it is rare for any verification plots to be available. The consequences of using unsuitable models are demonstrated with some fictitious examples.

What are "Inherited Models"

Inherited Models can generally be characterised as being:-

- Built by previous or other organisations
- Built to previous specifications (if any)
- Built for a previous purpose
- May have an unknown history

But the important question is. Are they an Asset or a Liability?. The truth is probably somewhere inbetween with some models being an important asset, some being a serious liability and the majority lying somewhere inbetween.

Many Client organisations view their stock of models as an asset that can be used to reduce costs, reduce the timescale for modelling studies and to increase confidence in the results. By contrast, many Consultants have found from experience that the use of Inherited Models can increase costs, can prolong project timescales and can decrease the overall confidence in the results. The use of Inherited Models if imposed on a Consultant can also provide an excuse for not delivering the project on time or within budget.

Inherited Models can be used safely, can be cost effective and can reduce timescales but this can only be achieved if the models are thoroughly checked, are fully understood and above all are discarded if they are not adequate.

A current project by the Author comprises reviewing and updating 7 Drainage Area Plans. All these drainage areas have previous models dating from 1989 to 1994. After careful consideration it was decided that none of these model were suitable for re-use and new models are currently being built. The inherited models were discarded because of major changes in the sewerage network (3 models), insufficient detail (1 model), no coordinates (1 model), redevelopment of the catchment (1 model) and because 8 CSO's had been abandoned in the meantime (1 model).

The Dangers

The Dangers of using Inherited Models without the necessary checks having been carried out are almost endless but the more common ones are:-

- The model is out of date and does not include all the current catchment,
- The model has serious errors which are unknown,
- Ancillaries in the model may have been changed,
- Industry in the catchment may have ceased and been replaced with ‘dry’ industries,
- The model was poorly verified,
- The model was built for a specific purpose,
- The model may have been built to consider ‘what if’ scenarios,
- The model may have been built very quickly to give very urgent answers at one specific location,
- The model may include various design options to alleviate problems but were evaluated but never implemented.

A few examples of some of these are:-

Example 1 is a case of a very quick model build. In this case the model building was carried out by the Author using Infoworks when answers were required within 48 hours. The catchment has a population of about 20,000 and has a main spine sewer which terminates at a CSO with an off-line storage tank. The catchment has changed significantly since earlier models were built of the catchment with over 60% of the catchment re-developed with a resultant change in impermeable areas and population. A model was required quickly for use in evaluating whether changes in operation of the off-line tank and associated weirs could reduce the CSO spill frequency sufficiently without any other works. A flow survey had been carried out and there were 8 suitable storms. The model was effectively calibrated rather than verified with all pipes of less than 300mm diameter pruned out of the model, all nodes allocated identical population figures and all nodes also allocated the same contributing areas and impermeable surfaces. By adjustment of these factors it was possible to achieve a good correlation with all 8 storms at the flow monitor immediately upstream of the CSO. However, at every other node in the model the flows would probably be incorrect and the model certainly would not be suitable for any form of flooding assessment or hydraulic analysis.

Example 2 is a small coastal catchment which was originally modelled using the WASSP program. The town is in two halves divided by a river under which there is an inverted syphon conveying the sewage from the northern half into the southern half. The modeller at the time had concerns about having negative invert levels in the model and raised all ground levels and invert levels by 6.5 metres. Unfortunately there was no surviving documentation with this model which explained what the modeller had done. If all the levels had been raised by 100 metres it would quickly have been spotted but it took some considerable time when the model was re-used for the 6.5 metre difference to be realised. The difficulties encountered by use of this model delayed the project by about 4 months and involved the re-surveying of over 100 manholes which were actually not required.

Example 3 is another coastal catchment but this time with varying topography with some steep areas and a very flat area alongside the sea where there is a Promenade (possibly reclaimed land). The original model was built using the WALLRUS program which was incapable of modelling the looped sewer system in the flatter coastal areas. The sewers were therefore modelled with a dendritic structure which did not fully simulate all the hydraulic conditions in the sewers and in particular did not adequately simulate the flows at 2 known flooding locations. The original modellers recognised and documented the limitations of the model but unfortunately this was overlooked when the model was converted to Hydroworks and re-used. It would have been relatively easy to add the necessary additional pipes after conversion stage but these omissions only became apparent to the modelling team when the model could not be verified adequately.

Example 4 is a model which was used solely to design improvements to a CSO structure. The upstream sewer network has a number of inadequacies which may in due course be eliminated by improvement schemes. In order to ensure that the CSO design takes full account of future sewer upgrading schemes the Modeller took the very simple and effective step of increasing the sizes of all the upstream sewer by two pipe increments (ie the 225mm dia pipes were upsized to 375mm dia). Also the projected future population was included. Use of this model, without realising what had been done, failed to simulate and confirm the significant flooding problems at 3 locations in this upstream catchment.

Example 5 is a model which was only required to calculate flows to a Sewage Treatment Works which was due to be improved. The model had a very simple skeleton structure with the invert levels at many locations estimated, as there was no reliable information. The model was too coarse with too much estimated data for it to be used for any other purpose.

Example 6 is a case where a detailed model had been built of a medium size catchment which has a sewer system which terminates at a CSO and storage tank complex before discharging almost constant flows into a Trunk Sewer. The model only went as far downstream as the CSO and tank complex as the model was primarily concerned with simulating flows and surcharge levels within the catchment, there was no need at that time for the CSO and tank complex to be modelled. When a model was to be constructed of the Trunk Sewer network the detailed model of this catchment (amongst others) was simply plugged in without any appreciation that the CSO and tanks had not been modelled. This of course meant that the simulated flows in the Trunk Sewer were several orders of magnitude different from reality.

The list of possible dangers as stated earlier is almost endless but with adequate documentation and suitable checks it does not mean that all models should be discarded, and many models can be used with some revisions or changes.

Comparisons

It is possible by making a few comparisons with everyday activities to gain some ideas of how potential dangers can easily be overcome. The simplest comparison is with buying a car which if a defective one is purchased could have serious consequences.

Buying a new car from a reputable main dealer could be likened to commissioning a Consultant to build and verify a new model. However, if one wants to buy a cheaper car and looks at the secondhand market this could in many ways be compared to using previous models. One could look in the local paper in the Classified Adverts section, in specialist publications or on the internet but in all these cases one is always looking for some form of assurance that the quality of the car is at least to certain minimum acceptable standards. The main form of assurance is the MOT certificate which has a series of checks in all aspects of the safety of the vehicle. If one wants greater assurances then all the motoring organisations such as the RAC or AA offer specialist vehicle inspection services.

It is considered by some that all models should have some form of MOT certificate and this has its merits though there are great difficulties in keeping that system up to date. It is however clear that some form of improved documentation combined with some form of checking is required, especially if models are going to be re-used reliably.

A checking procedure is suggested below in 3 categories.

Checks

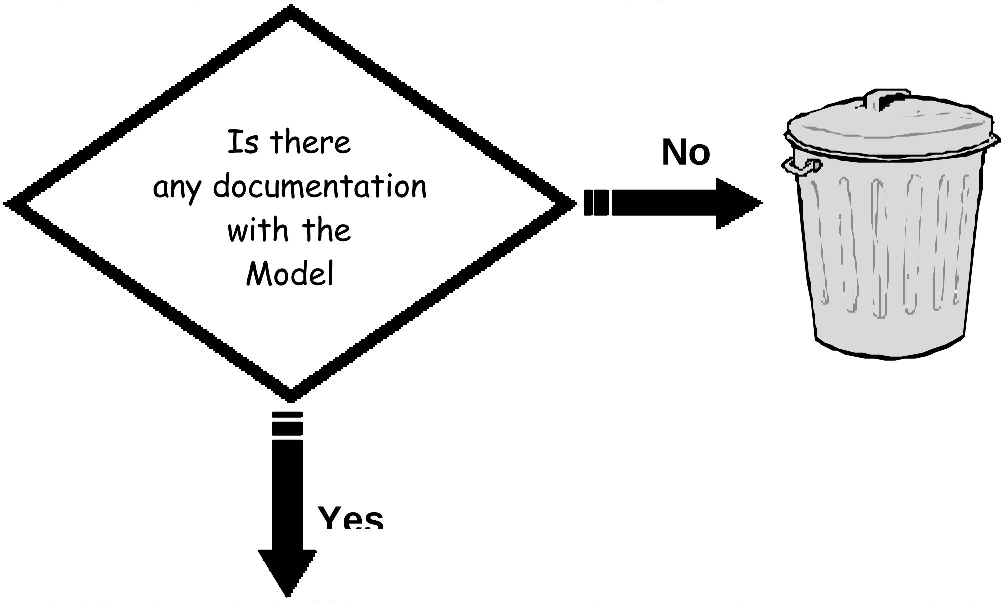
The suggested checks are grouped into 3 categories or stages which are distinguished by who should undertake the checks and what the actions should be if checks are unsuccessful. The first two categories of checks are intended to be carried out by the Client so that a greater understanding of the model can be gained by the Client so that they can assess whether or not the model should be offered to the Consultants or Modellers for further checks and possible re-use. The Author is strongly of the opinion that previous models should only ever be offered to the modelling team and not imposed. The third stage of the checks should be carried out by the Consultant or Modeller and are intended to be a detailed series of checks to ensure that all aspects of the inherited model are fully in accordance with any new elements of the final model and to ensure that the resultant (new) model can be fully documented.

The checks are summarised below and should be considered as a minimum and any user should not be afraid to carry out additional checks if they are considered necessary.

At the planning stages of a modelling project the checks should be undertaken sufficiently far in advance that they do not impinge on the overall timescale for the project.

Stage 1 Checks – Model Data Checks

The important thing with all of the checks in this category is that if the model fails any check it should be



discarded (or thrown in the bin). In many cases Clients are reluctant to actually throw a model away but these checks are of such fundamental importance that if any checks do fail they clearly demonstrate that the models are a liability and not an asset. The diagram above only shows the first check. The full checks are:-

- Is there any documentation with the model;
- Is the purpose of the model defined and does it match current requirements;
- Are there any model verification details;
- Does the model have any coordinates;
- Is the model complete (eg LUD files etc);
- Is there sufficient information provided about the model building in order that detailed checks can be carried out;
- Is there a reasonable expectation of passing the Stage 2 and Stage 3 checks.

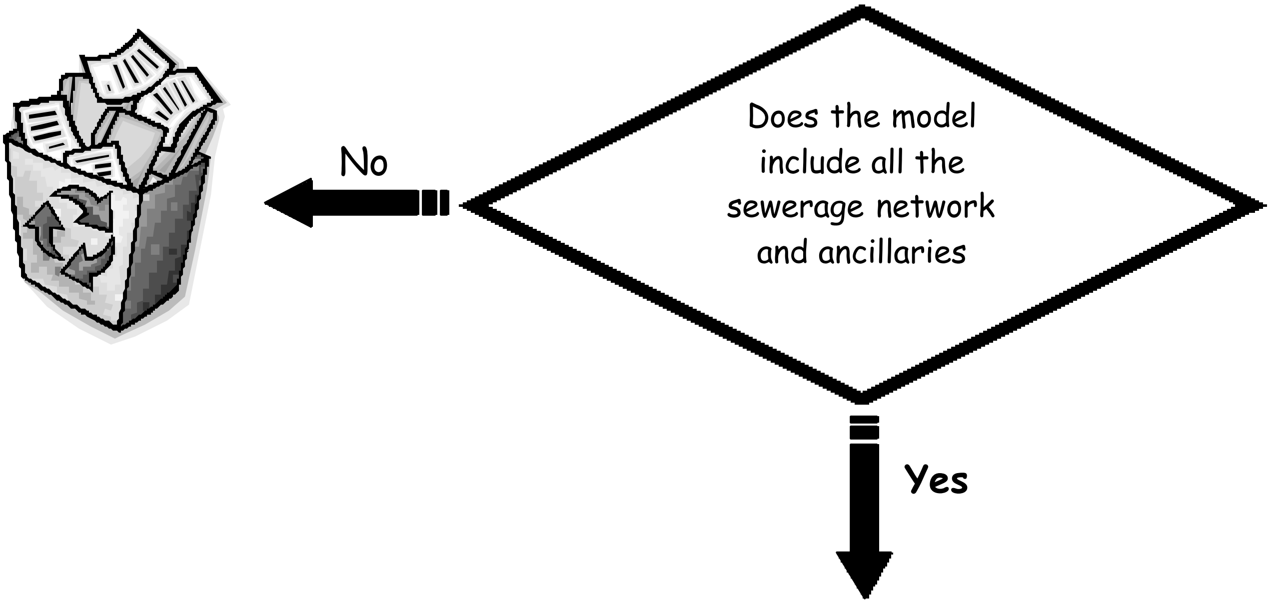
In normal circumstances it is expected that these checks can be carried out within a period of less than 2 hours.

Stage 2 Checks – Model Validity Checks

The important difference between these checks and those in Stage 1 is that these checks are intended to establish how up to date and how valid the model is. If a check is not passed the model is relegated to the recycling bin rather than totally discarded as it is possible to obtain some useful data from the model though the model in its entirety is not suitable for further use.

It is again considered appropriate that the Client undertakes the Stage 2 checks as the Client is more likely to have access to the necessary supporting information.

The checks are:-



- Does the model include all the sewerage network and all the ancillaries;
- Does the model include all the catchment including all new developments;
- Does the model include all recent sewerage upgrading schemes;
- Are the known flooding problems (and any other known problems) in the catchment simulated by the model.

Clearly the list of checks here could be lengthened but those given above are considered to be the essential ones.

It is expected that normally these checks would only take about 1 hour though it should be recognised that it will be necessary to run the model during these checks and on large catchments this may extend the time required.

After the Stage 2 checks have been undertaken the Client can then if they so wish offer the model for use by the Consultant or Modeller who will be undertaking the modelling project. If the model is imposed on the Modeller there is a possibility that this may compromise the overall quality achieved. By only offering the ‘inherited’ model to the Modeller the responsibility for the overall modelling project can remain clearly with the Consultant or modelling team.

Stage 3 Checks – Detailed Audit Checks

The Consultant should carry out the Stage 3 checks if they are offered the model. These checks will effectively take the model apart and check how it has been built, what the data sources were, the quality of the model building and the quality of the model verification. These checks are intentionally identical to the normal audit checks because if the Consultant does decide to use the model it is likely that the eventual model (the inherited model plus any changes) will be subject to a full independent audit and it is therefore important that the Consultant not only has the opportunity to do these checks but that they are actually done.

The checks are:-

1) Is there sufficient data;
2) Was the software used suitable for the catchment;
3) Is the Model detail appropriate;
4) Are the Model extents adequate;
5) What manhole survey data was used and was it adequate;
6) Was any interpolated manhole data correctly calculated;
7) Were the contributing areas properly defined and measured and input;
8) Were the impermeable areas correctly determined and input;
9) How was flooding represented;
10) How were the foul flows created and input;
11) How was infiltration modelled;
12) How were Trade Flows modelled;
13) How were manhole headlosses modelled;
14) How was storage compensation calculated and modelled;
15) What runoff model was used and was there any slow response runoff;
16) Was the runoff model correctly applied and was the correct Soil Type used;
17) Were all ancillaries correctly modelled;
18) How was silt allowed for and how was the system capacity calculated;
19) What rainfall data was used for verification and was it correctly input;
20) What flow data was used for verification and was it adequate;
21) Was the DWF verification to acceptable standards;
22) Was the Storm verification to acceptable standards;
23) Is the model stable and are there any anomalies;
24) How good is the historical verification.

It is not necessarily important that all of these checks are passed; what is important is that all the checks are carried out so that the Consultant knows exactly what deficiencies there are with the model and what needs to be done in order to bring the model up to an acceptable standard. Of course at any stage through these checks the Consultant or Modeller can decide that the model is not suitable and can advise the Client that the model would not be of benefit.

From experience it is usually possible to decide within about 1 hour whether the model needs to be discarded, within about 8 hours whether or not substantial elements of the model will need to be updated but it may take many days to complete all of the checks which may ultimately lead to use of the model.

It is matter between the Client and the Consultant whether or not a formal report on these checks is required or whether a simple summary report will suffice.

Maintenance

Several of the UK Water Companies have now developed systems and procedures for the maintenance of hydraulic models. The key attributes of each of these systems are:-

- A ‘good’ library system with adequate storage and a formal checking ‘out’ and checking ‘in’ of models;
- A single person responsible for administration of the system and the maintenance of the models;
- A regular review of the model and the catchment at pre-determined intervals (3 years, 5 years or 10 years);
- Routine use of the models to check the effects of proposed developments and to check flooding incidents;
- An adequate budget.

Probably the hardest part of maintaining the models is keeping track of what is happening and changing in the catchment and whilst individual large developments can easily be added it is generally only at the regular review periods were changes in population, changes in industrial activity and consequential effects on the sewerage system become apparent.

Many of the model maintenance systems currently in place with UK Water Companies clearly demonstrate that models can be maintained and the difficulties associated with ‘inherited’ models are overcome.