# Is there life after verification?

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## 1 Introduction

Building and verifying a good sewerage model is a complex and challenging process. There is therefore a temptation to think that once it is done the difficult work is over and there are just the loose ends to tie up. Building and verifying a model has become an end in itself.

This paper aims to demonstrate that the use of the model to assess needs and develop options requires as much thought as building and verifying the model in the first place.

### 1.1 Stages of a sewerage study

The main stages of a sewerage study can be defined as:

- Build model
- Verify model
- Assess needs
- Develop options
- Feasibility
- Design
- Construct
- Monitor and review

Much has been written on building and verifying models and we have had a WaPUG code of practice for many years for these areas. The code of practice is now extended to include needs and options stages to recognise the significance of these. This paper concentrates on the modelling aspects of the needs stage and identifies some of the pitfalls. The lessons that are set out in this paper have been learnt from my colleagues carrying out needs assessments and strategy plans for major developments. They have also been learnt from the many models that I have audited over the last few years.

## 2 Needs assessment

This stage of the study is intended to identify where the levels of service relating to flooding, environment or operations are not met or are at risk of not being met.

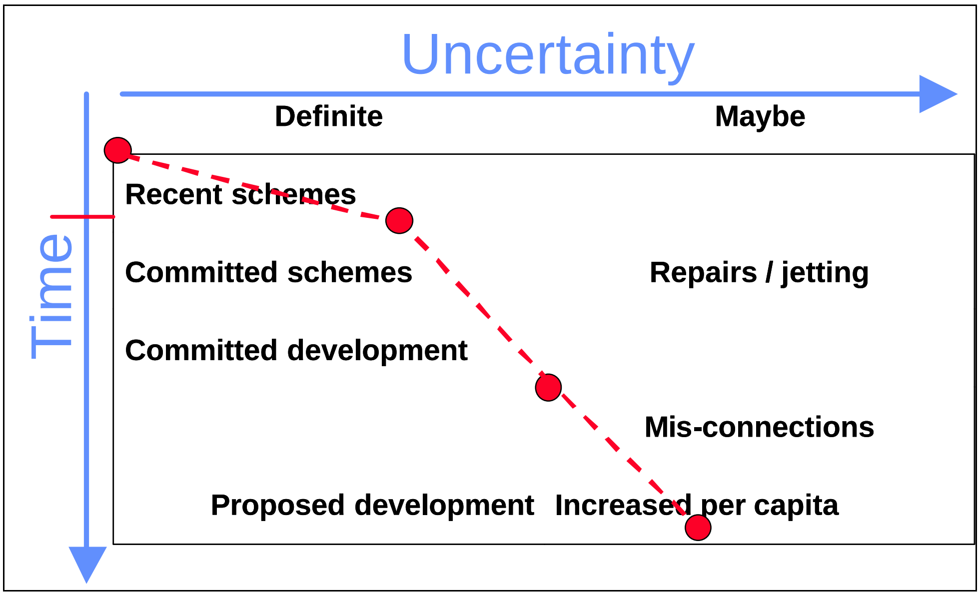
There are three key steps to this.

- Define the required levels of service
- Update the model
- Compare the performance with the required levels of service

### 2.1 Define required levels of service

An important first step is to define and agree the required levels of service. This might sound obvious but it is surprising how many studies go ahead without a clear definition of this. There are three aspects to the definition. The first is the required level of service in terms of frequency of flooding and environmental standards. The second is how long into the future we are going to make the assessment, and the third is the allowances for risk that we want to allow for in our assessment conditions. These are related as shown in Figure 1.

*Figure 1 Time horizon and design conditions*




### 2.1.1 Levels of service

The level of service that we define first is the Trigger Level; that is an existing level of service that is considered unacceptable and which requires improvements to be developed. This has normally been defined as property flooding at a 1:10 year return period or an overflow classed as unsatisfactory. This is used for assessing the needs of an existing system.

We also need to define a Target Level of service that will be used for the design of schemes or of systems to serve major new developments. This could be 30 or 50 years for flooding and compliance with UPM standards for CSOs.

### 2.1.2 Time horizon

The time horizon that we use for needs assessment depends on the likely development in the catchment and the problems to be addressed.

Normally the first horizon will be about 5 years in the future. This fits with the water industry asset management planning cycle and also with the typical life of a local authority development plan. Unfortunately the dates of the two planning cycles are unlikely to coincide.

Other longer term horizons may be used as well for catchments where major development is planned. We have carried out a study with a 15 year horizon and know of others with a 22 year horizon.

### 2.1.3 Design conditions

Many of the parameters that we use in the models vary with time either daily, weekly or seasonally. We therefore have to choose whether to use daily, monthly or annual average values or some multiplier of the average values to represent likely conditions. These parameters include dry weather flow, infiltration, catchment wetness and tide levels.

## 2.2 Update model to time horizon

After deciding on our assessment framework we need to update the model to represent the known or likely changes until the time horizon.

Changes will occur to both the sewerage assets; which we can affect and to the above ground catchment; to which we have to react.

### 2.2.1 Asset changes

***Recent & committed schemes***

Some capital or maintenance schemes might already have been carried out while we have been building and verifying the model. These might include schemes to solve DG5 flooding problems and unsatisfactory overflows. Other schemes may already be approved although not yet constructed. It will be necessary to get as built or design drawings for all of these schemes and update the model.

It is often necessary to check against several different capital or operational maintenance programmes to identify all of the schemes. Schemes to replace or upgrade pumping equipment is often organised separately and will need to be checked. Schemes to upgrade treatment works may also be organised separately but can have a significant influence on the sewerage system. This is particularly the case of schemes to upgrade screening arrangements at inlet works; which directly affect backing up of flows in the inlet sewers.

***Repairs and cleaning***

The drainage area study will have identified structural and operational problems that are affecting the operation of the sewerage system. These include:

- sediment
- blockages
- partial collapses
- pump faults
- roots
- broken flap valves
- blocked screens

All of these need to be included in the verification model in order to get agreement with the flow survey. However it should be a recommendation of the DAP to fix these and in an ideal world that will happen. However we need to assess whether they will be fixed and whether they will recur.

Some of these problems are likely to recur and we need to consider whether they can be controlled by ongoing maintenance or whether we should assume that they remain.

Sediment problems due to flat gradients or backing up from downstream sewers will recur unless there is ongoing maintenance to prevent the buildup.

Similarly problems of roots are likely to recur unless the sewers are relaid or relined.

Other sediment problems due to debris or partial collapses can probably be solved once and for all.

We need to make an assessment of which problems need to be retained in the model and to clearly document this assessment and the risks if assumed maintenance does not occur.

### 2.2.2 Catchment changes

Changes to the catchment are not within the control of the water companies and so are more difficult to predict.

#### *Recent and committed developments*

This includes developments that have recently been constructed or those that have planning applications and so are very likely to be built within 5 years.

Details can be obtained from the planning authority. It is important to check whether any of these developments have already been included in the verification model because they were already under construction.

New developments will generally be constructed with surface water sewers, although small infill developments may drain both foul and surface water to combined sewers.

Once a housing development has reached planning application there will be a good estimate of the likely population so that foul flows can be estimated. Estimating foul flows for commercial or industrial developments is more complex but can be related to the planned floor area.

#### *Planned development*

The local plan for the catchment will identify major development sites that are likely to be developed over the next 5 years and might even give estimates of when the development will occur. Development for the next 15 to 20 years will be outlined in the County or Regional strategic plans. We have carried out studies for catchments where massive future development is planned that will double the population of the catchment. To deal with these studies it is helpful to set several milestone dates and look at the needs at each milestone rather than immediately trying to plan for 20 years in the future.

The local plan will identify those areas allocated for housing and others to be used for commercial, retail or industry. For our purpose it may be important to distinguish between those three groups as they have significantly different sewage flows. Unfortunately definitive allocations are unlikely to be available until the development is about to happen.

The density of housing development may be uncertain at this stage and can also have a significant impact on the sewage flows.

All of these major developments will generally be designed to be separately sewered, although as discussed below we may wish to make an allowance for illegal connections.

It is also useful to identify areas for first time sewerage of existing rural developments that can be connected into the sewerage system.

### *Mis-connections*

Although systems are designed as separate foul only systems they rarely stay that way. They gradually acquire mis-connections of runoff as properties are extended, patios are constructed and soakaways fail due to lack of maintenance. It is therefore important to allow for this to identify future performance and needs.

Typical estimates for mis-connections for domestic properties are:

- 4 – 8 $m^2$ per property
- 4 – 10 % total development area

Some estimates are that about half of this is likely to happen within a year of the property being built as new owners adapt the property to their own needs. The rest will happen over the next 10 or more years.

We should therefore make an allowance for mis-connections for planned new development but should also consider making an extra allowance for recent developments even if some mis-connections have been allowed for in verification of the model.

Commercial developments are usually less prone to mis-connections as they have professional managers who are more aware of the issues.

### *Population density*

The size of all households in the UK is showing a long term downward trend. Future developments should therefore use a lower estimate of population per property than current development.

It is also possible that this effect may lead to population reducing in older parts of the catchment. However this may be countered by infill development or division of properties and so is often ignored.

For catchments with a seasonally varying population, such as seaside resorts, it is important to consider whether the levels of service are also seasonal - for example river water quality standards. They therefore need to be matched with the appropriate seasonal population. It may even be necessary to have two versions of the model.

### *Per capita flow*

Per capita flow is still generally increasing in England and Wales and needs to be allowed for in the needs model. Most water companies will have a standard design value that should be used.

There is a trap here if a higher value of per capita flow has been found to be necessary during verification. I was presented with a model for audit where the per capita flow had been reduced to the design value for long term needs assessment. It is unlikely that high values of per capita flow will reduce of their own accord. In fact such high values are unlikely to be due to per capita flow but are probably a representation of trade flows or infiltration. If a high value has been found to be needed during verification then try and explain why and it is unlikely that you can justify reducing it.

***Trade flow***

Trade flows may be in the verified model as actual discharges if these are less than consent limits. For needs assessment it is normal to assume that trade discharge consents may be utilised in full unless there is firm evidence to the contrary.

***Infiltration***

Representation of infiltration falls somewhere between updating the model to represent changes and selection of a design value to overcome uncertainty. It will be considered under both headings.

If we do know of major point sources of infiltration and are confident that they can be eliminated then this is a definite change to the catchment conditions and can be included in the model.

Other issues of infiltration are dealt with later.

## 2.3 Design conditions

### 2.3.1 DWF multiplier

Dry weather flow varies on a daily, weekly and seasonal cycle and we therefore have to represent it as either a varying value or as an average value with a multiplying factor of safety. There are various approaches adopted by different people. These include:

- Diurnal curve starting at 7 am
- 1.0 – storms are as likely at low as at high flow
- 2.0 – because it says so in Sewers for Adoption
- 6.0 – for pumped systems because that is what the pumps will be running at
- 6.0 – for foul systems to allow for illegal connections

The choice does depend on an assessment of the needs and response of the catchment but my own preferences are:

- For large city catchments – a diurnal curve starting at 7 am
- For other catchments - 2.0 multiplier on constant flow

### 2.3.2 Infiltration

Infiltration flows may at times be much more extreme than those observed during verification and there is a strong correlation with flooding and overflow events, so the appropriate design value may be close to the most extreme value that occurs.

The methodology here is to identify the likely worst case from long term flow records at the treatment works and use this for needs assessment. It may be appropriate to omit records for the winter of 2000 as this is believed to represent conditions with a very long return period.

#### 2.3.3 Tide / river / outfall levels

Where the system is affected by high water levels at outfalls to the sea, rivers or other sewerage systems we need to consider the appropriate choice of design outfall level to use for the needs assessment.

In a similar way to infiltration the appropriate value may be more extreme than those observed during verification.

Tides are substantially independent of rainfall conditions and so the method of joint probability set out in User Note 22 can be used.

For river and sewer outfalls we need to consider issues of joint probability with storm events. There is probably a high likelihood that the outfall level will be at a high value during a rainfall event and it may therefore be appropriate to use the highest recorded level.

#### 2.3.4 Rainfall

The selection of appropriate rainfall conditions requires a choice of return period, critical duration and antecedent conditions. This last requires consideration of the critical season.

Critical duration is normally identified by running a large range of durations and selecting the worst results. However it is important to remember that there may be different critical durations for different parts of the model and for flooding and overflow spill. The critical duration might also change with different versions of the model to represent different time horizons. It should therefore be rechecked for each situation.

#### 2.3.5 Slow response

The issues over slow response are similar to those for infiltration, but perhaps even more complex. The subject is too broad to go into here but the best advice is to model it in a sensible manner and then trust the predictions of the model. However some checks against worst-case conditions from long term flow records is recommended.

### 2.4 Compare performance with required levels of service

Having updated the model and selected the design conditions the model can be used to predict the performance of the system for flooding and overflow spill for the various time horizons.

It may also be appropriate to carry out some sensitivity testing to investigate how the results are influenced by design parameters such as infiltration flows, outfall levels etc. This can identify areas that are at risk of failure if conditions change by only a small amount.

Similar sensitivity testing can be done on operational failures such as pump failures or partial blockages to identify maintenance priorities.

## 3 Options development

The development of options to meet the identified needs is beyond the scope of this paper but there are a few obvious guidelines. The basic options to all sewerage problems still remain as:

- Increase flow capacity
- Separate or spill storm flows
- Add detention storage

It is often helpful to initially try and solve each problem with a purist solution that uses only one of these techniques and then take the best parts of each solution and develop a hybrid.

The most common mistake during option development is to forget that the critical duration probably changes as the system is changed; particularly when looking at detention solutions. Remember, the critical duration is the time to drain a storage tank; NOT the time to fill it.

## 4 Conclusions

A modellers job is not finished when the verification is signed off. The real work is to use the model to identify and solve problems and this needs consideration of other aspects that were not involved in model build and verification.