Suffolk Flood Risk Management Partnership

Briefing August 2014

Why Model Drainage Systems?

1 INTRODUCTION

It is understandable that those who suffer the effects of flooding want the problem solved a soon as possible. However, when flooding is on a large scale it will take a considerable time period to investigate, understand the causes, consider options and obtain funding.

In such cases drainage models are essential tools - but they are often seen as causing delays to resolving problems. Model development can be time consuming, and often unexpected delays occur. However, once a model is working it is a very effective tool to quickly develop cost effective, sustainable options and can help identify unintended consequences of implementing what might appear to be an obvious solution. Properly modelled options are more likely to receive national funding.

In simpler circumstances drainage models or calculations may not be necessary.

The aim of this paper is to provide a briefing for staff, Councillors and the public on what drainage models are and the circumstances when they are needed.

2 WHAT IS A DRAINAGE MODEL?

Physical scale models are expensive and are now rarely used, mathematical computer models are most commonly used as described below.

The simplest form of model could be calculations on a spreadsheet but these have limited use. Several commercial software packages are now able to replicate complex situations and the term modelling usually refers to the use of one of these computer packages.

Modelling software simulates the effect of rainfall by calculating flows, water levels and flood volumes throughout the modelled drainage network over a period of time, at defined time intervals. Animations use these results to show graphically how the system fills and empties. Locations of hydraulic problems are then easily identified.

Drainage systems including rivers, watercourses, ponds and pipe networks are represented by numeric data obtained from site surveys or records. This would include for example, ground levels, conduit levels, shapes, sizes, roughness values and catchment data, for example paved areas, roof areas, green space and soil type.

Rainfall and stream inflows, and water levels at outlets are represented as time varying data – known as hydrographs. The modelling software can quickly generate site specific rainfall data for any rainfall duration or return period.

To gain confidence in the results, the model should be verified. This would normally entail recording flows, water depths and rainfall on site over a period of several months. The model is then used to simulate the observed rainfall. The resulting predicted flows and depths are then compared to those recorded during the survey.

Unexplained variations between observed and predicted results may indicate errors or omissions in the model or survey data.

The time taken for surveys of river flows and verification often needs to be increased due to lack of suitable rainfall or verification issues.

The frequency of flooding at various locations throughout a network is determined by repeated simulations using a range of rainfall return periods and durations. These results may also be used to verify the model against historic flooding.

3 SITUATIONS WHEN DRAINAGE CALCULATIONS ARE UNNECESSARY.

Drainage calculations or analysis are unlikely to be needed if there is a very simple, low cost solution that will obviously reduce flooding and have minimal affects downstream, or if cost benefit analysis is not required.

Such situations may include:

- Maintenance of pipes – clearing silt or blockages
- Clearing highway drains, soakaways, storage ponds
- Adding a few extra road gullies or grips
- Where the immediate downstream water body is large (e.g. an estuary, large river or the sea) and where the outfall from drainage systems could not be affected by the height of the water in that water body.

4 SITUATIONS WHEN DRAINAGE CALCULATIONS ARE NEEDED.

Calculation or analysis is needed when more confidence in the proposed flood alleviation option is required, such as when costs are higher, flooding more widespread or the system is not fully understood.

More confidence in the solution is gained by calculating the frequency of flooding with and without the proposed improvement. This involves repeating calculations for various storm durations and return periods, with and without the proposals.

The estimated flood frequency before the proposed work should be verified against and historic records and evidence from the public. This will help ensure the causes of the flooding are understood and, in turn enable the appropriate solution to be implemented.

For example:

Initially it may appear more road gullies are needed but calculations show the carrier drain that connects them to a ditch is too small. Adding gullies would have had little or no effect. Calculations might indicate the ditch fills and water backs up in the highway drain. In which case the ditch would also need improvement or perhaps the highway drain could be made larger – or both.

Calculations can avoid wasting money, ongoing flood damage and anxiety.

Unfortunately hand calculations or spreadsheets can only be applied to simple drainage systems. In the example above it is unlikely hand calculations would have dealt with the added complexity of the ditch or to estimate the possible downstream effect of the scheme. Many simplifications are made and resultant proposals are likely to be overdesigned. Such analysis demands specialist knowledge, skills, training and engineering judgement especially regarding likely downstream affects.

5 SITUATIONS WHEN A DRAINAGE MODEL IS NEEDED.

Estimating the likely frequency of flooding in a simple system by hand is difficult and repetitive but is virtually impossible in real, existing, overloaded systems with relatively flat gradients, which often include multiple pipes, cross connections (grid layouts), attenuation ponds, tanks or soakaways, or where there are inputs from watercourses, or where the outfall becomes submerged. A modelling package is needed.

Modelling would also be needed to estimate water levels in watercourses with variable gradients, sections, or local obstructions such as weirs or culverts.

In such channels flow depths vary along the channel. Obstructions increase the depth of flow which then gradually diminishes over some unknown distance upstream (a backwater curve). Equations governing this "gradually varying flow" are complex and can only be solved by iterative computer techniques which are now incorporated in modelling software.

Thus the effect of a particular obstruction or the cumulative effect of several obstructions, on upstream flooding can be determined by modelling. A model is therefore needed to determine the effect of removal of obstructions on upstream flooding.

2D modelling is useful when there is a lot of flooding. 2D models need additional topographical data such as Li----------DAR and can predict the route of flood water, as well as depths, velocities and flood hazards.

6 USE AND BENEFITS OF MODELS AND SOFTWARE

Once created, drainage models have many uses - to inform future flood investigations, flood relief schemes or decisions around drainage on new developments.

Apart from the ability to quickly compute flows and depths in complicated drainage systems, modelling software provides other related benefits to enhance efficiency.

Modelling software includes facilities to compare observed flows and depths with those predicted by the model – i.e. the model verification process.

The multiple simulations needed to determine the frequency of flooding are easy to set up, run and analyse. This is also useful for cost benefit analysis and flood funding bids.

Design of possible options follows a trial and error process which inevitably again involves multiple simulations trialling different sizes or locations for solutions, eventually "homing in" on the design for an option.

The resulting option models are used to test a range of options and compare their effectiveness.

So the process involves repeated simulations with various versions of the original model.

Most modelling software now takes into account of the effect of attenuation and storage within all elements of the drainage system and should produce more accurate results than traditional methods. This in turn should lead to economies in storage pond designs.

Most modelling software now produces Geographical Information Systems (GIS) maps which can double as drainage records or be used for viewing predicted flooding over aerial photos or Ordnance survey maps. GIS mapping can be used to identify properties at risk and assess the frequency of flooding at each property.

7 POLICIES

Policies also drive the need for drainage models.

Traditional flood alleviation involved up-sizing pipes or channel improvements where channels were enlarged and straightened. These reduce water levels locally but are liable to increase downstream flows. Less water is stored on upstream floodplains and more flooding downstream is liable to occur. Weed growth and wildlife are less able to survive within the new channel as they get flushed out by the faster velocities of flow.

The policies referred to below mean major flood alleviation projects must now nearly always rely on storage and attenuation techniques which require modelling.

- The Catchment Flood Management Plan (CFMP) and Suffolk Local Flood Risk Strategy which also form part of the Flood Risk Management Plan (required under the Floods Directive)
- The Water Framework Directive (EFD) and River Basin Management Plan which aim to improve water quality
- Floods and Water Management Act general duty to improve biodiversity.

Flood Defence Grant in Aid (FDGiA) funding applications require data on the numbers of properties flooded at in a range or different storm return periods.

8 MESSAGES TO THE PUBLIC

With any flood alleviation scheme there is a clear message to be given to the public – the scheme should alleviate the flooding, but is unlikely to prevent it ever occurring again. It is usual to quote, based on the model and past records, that we estimate flooding will occur every XX years on average or xx% likelihood of flooding each year.

The term alleviation is used rather than prevention. This is because however large the system is - and whatever the cost - there is always a possibility it will be overwhelmed. Designs normally aim to reduce the frequency of flooding to an acceptable standard - for drainage systems this is usually a 30 year return period or 3.33 % annual probability, but protection of a large urban area from deep water river or sea flooding may be to a higher standard such as a 1 in 100 year return period. Cost benefit analysis may show a lower or higher standard is more cost beneficial.

9 REFERENCES

1	**DEFRA SWMP Guidance, March 2010**	http://www.defra.gov.uk/publications/files/pb13546-swmp-guidance-100319.pdf.
2	**EU Water Framework Directive, EEC directive 2006/60/EC**	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:NOT
3	**Anglian River Basin Management Plan, December 2009**	http://www.environment-agency.gov.uk/research/planning/124725.aspx
4	**Suffolk Local Flood Risk Management Strategy Dec 2012**	http://www.suffolk.gov.uk/emergency-and-safety/civil-emergencies/flooding#LFRMS

10 USEFUL DRAINAGE/FLOODING ABBREVIATIONS & GLOSSARY

AEP = Annual Exceedance Probability. The probability associated with a return period. Thus an event of return period 50 years has an AEP of 1/T or 0.02 or 2%.

AOD = Above Ordnance Datum

ASTSWF = Areas Susceptible to SW Flooding (ignoring underground drainage, buildings or walls)

AW = Anglian Water

CFMP = Catchment Management Flood Plan (for East Suffolk)

DEFRA = Department for the Environment, Food and Rural Affairs

EA = Environment Agency

FDMS = Flood Defence Management Strategy (for Ipswich - tidal and fluvial).

FMfSW = Environment Agency's Flood Map for Surface Water

FREEBOARD = An allowance that reduces risks due to potential inaccuracies in flood prediction such as waves, settlement of defences and errors in levels i.e. the difference in level of defences and the design flood.

FRM = Flood Risk Management –e.g. Flood defences, SuDS, other drainage, emergency plans, resilient designs etc.

FRMP = Flood Risk Management Plan

GIS = Geographic Information System. A software framework that captures, stores, analyses, manages, and presents data that is linked to location

IDB = Internal Drainage board

LP = Local Plan

LiDAR = Light Detection and Ranging. Methods for collecting high-resolution topographic data (ground levels).

PFRA = Preliminary Flood Risk Assessment – for Suffolk undertaken by SCC

RBMP = River basin Management Plan (Anglian - Environment Agency)

RP = Return Period – average time between reoccurrences

SAB = SuDS Adoption / Approval Body

SCC = Suffolk County Council

SRF = Suffolk Resilience Forum - Principle mechanism for multi agency cooperation under the Civil Contingencies Act, Members include EA, NHS, Police, Fire & Rescue Service, E England Ambulance service, SCC & District Councils.

SFRA = Strategic Flood Risk Assessment

SFRMP = Suffolk Flood Risk Management Partnership

SuDS = Sustainable Drainage Systems – for surface water runoff

SuDs Train = A series of SUDS features linked together.

SW = Surface Water

SWMP = Surface Water Management Plan

For further information on flooding: **www.greensuffolk.org/flooding**
or email: **floods@suffolk.gov.uk**