Rethinking Water Planning

Integrated Modelling

Overview

Each discipline – flood risk, water resources, water environment, and water quality - within the water system is complex and multifaceted. Those managing investment planning have spent significant time and resource working to develop increasingly sophisticated computer models to help understand how their discipline interacts with the water system. However, one of the major drawbacks of these models is that they are designed to represent a specific core (or part of a core) discipline. Therefore, to achieve a system-wide or holistic understanding of the impacts of investment decisions often requires consideration of multiple models.

Phase 1 of the Oxford to Cambridge Integrated Water Management Framework (IWMF) programme identified an opportunity to develop a more holistic, integrated multi-disciplinary, model to aid investment planning. It is widely accepted that integrated modelling is not as detailed or as precise as single discipline models, but instead focuses on interactions/interdependencies and the wider picture. An integrated model needs to be complimented by the existing, more specific models which provide detail and further resolution.

How we used integrated modelling in Approach 1

To explore the potential of integrated models, the IWMF Rethinking Water Planning project used the Water Systems Integrated Modelling (WSIMOD) model produced by Imperial College London (ICL). We worked with ICL to further develop the model. The outputs of the model take the form of Water Framework Directive (WFD) water body polygons on a map.

In this project we used WSIMOD to assess various portfolios of interventions to understand if 'better' portfolios can be identified if water disciplines work together and consider the full impacts/benefits of each intervention.

How it works

The WSIMOD model works by representing physical parts of the system as 'nodes' and the interactions between these as 'arcs' (Figure 1). The benefit of working in this way is that it is relatively easy to update the model if new items are added to the system, or if new operations or assumptions are subsequently implemented.

To implement the model in a new location, the basis of the system can remain the same, but the user will need to refine the 'system' map to reflect the case study area.

Within the model physical items/parts of the system are referred to as 'nodes'. Within each model each node must be tailored to represent the catchment being modelled.

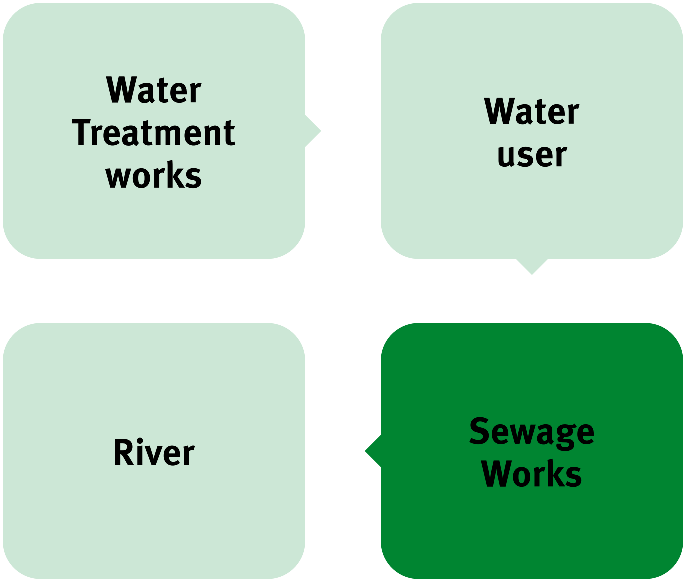
They are displayed as circles or squares.

Arcs are the connections between nodes. There are two main types.

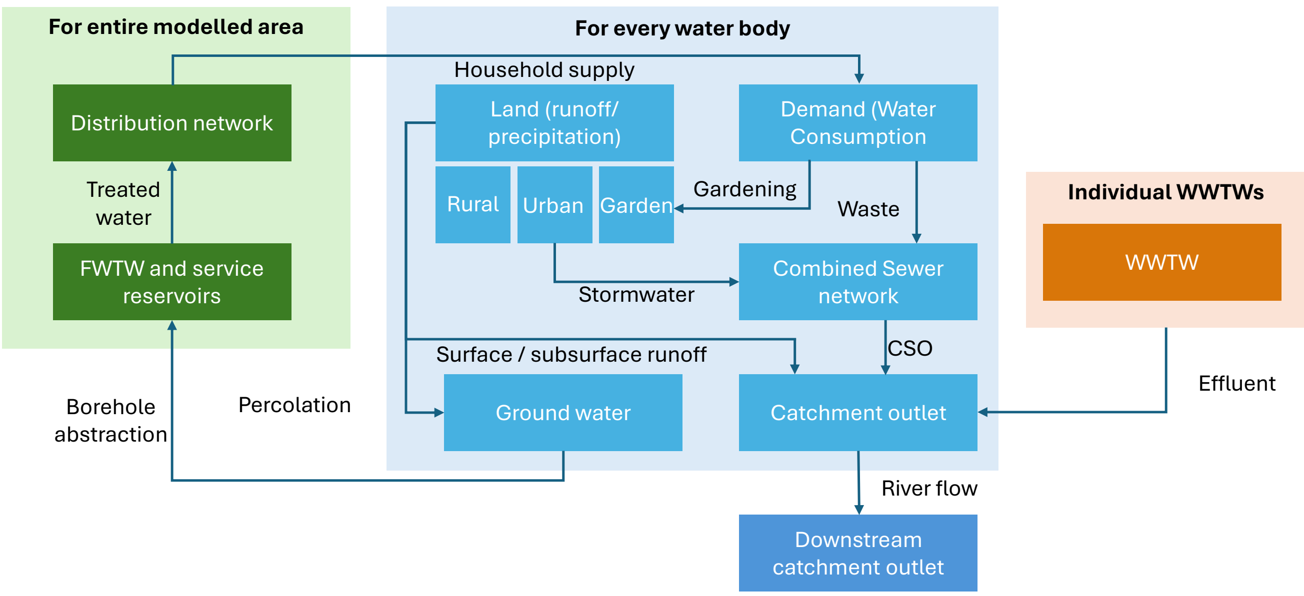
- Pulls e.g. a water demand node can pull water from a water storage node.
- Pushes e.g. a sewage treatment works node pushes effluent into a river node.

Arcs can also have properties, for example a limit on the volume of water that can move through the distribution network in a timestep. They are displayed as arrows.

Figure 1



Integrated Modelling: System Map Diagram



Metrics

When using integrated water modelling to assess the whole value of interventions it is necessary to select metrics that can be represented in the model to demonstrate the impacts on the water system. These need to be agreed by representatives of the various planning disciplines that are being brought together.

Metrics that we used through our trials did not cover all aspects of the water system. In some instances, proxies were needed, or metrics were qualitatively assessed outside of the modelling.

If we compare data inputs for WSIMOD and detailed flood modelling, for instance, the metric used is a 3D of flood inundation map. Whereas the flood metric used through integrated modelling was the number of days flow is over Q5 (Q5 = the average flow for any one day expected to be greater for 5 days in any 100 days). This does not provide as much detail but is the limit of what the integrated model could represent.

Inputs

When modelling, the inputs affecting the system need to be defined.

We split these into two groups.

Scenarios*

(out of our control)

Climate change	**Adverse: RCP 8.5.**
	Benign: RCP 2.6.
Population growth	**Adverse: ONS high growth**
	Benign: ONS Low growth

*Examples of the scenarios used for the Oxford to Cambridge IWMF project provided

Interventions

(within our control)

- **Physical interventions**
- **Behavioural interventions**

How we intended to use this modelling

The intention of integrated modelling is to optimise decisions and actions within and across 'water disciplines' (water quality, water resource, water environment, and flood risk). In particular to:

- Avoid unintended consequences (lose-lose or win-lose; common in complex systems).
- Help identify win-win decisions.

The modelling is used to assess and model all the potential interventions before the statutory planning portfolios are created.

By considering the full impact of interventions, they can then be selected from and assessed across the statutory planning frameworks. The aim of using the model is to deliver an integrated approach using multi criteria analysis to provide numerical values which represent the overall value of benefits.

The application of such broad-scale integrated modelling and multi benefit analysis needs to be built into and work with the current modelling, analysis and decision-making processes. We suggest that the integrated modelling is built into the planning processes when all potential interventions are on the table, before the statutory planning portfolios (water quality, water resource and flood risk) are fully developed. This would allow the 'full benefit' of each intervention to be considered before any are rejected, and also means that there does not need to be an additional 'selection round'. It also potentially allows for a wider range of interventions to be considered, which might act best across the whole system as opposed in just a single domain.

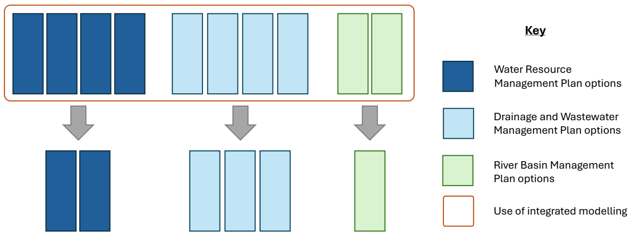


Diagram showing that the modelling should be used at the option selection phase of the planning process

What are the benefits of integrated modelling?

- Gives a wider understanding of the interconnectivity and interaction of domains in the water system as a complex system.
- Gives a wider understanding of both unintended consequences and benefits that scenarios or interventions have across the system.
- Allows for interventions to be considered across the whole system and therefore ensure greater cost-effectiveness of interventions or cross funding opportunities.
- Generates a common understanding across disciplines that allows for broad-scale and more systemic decision-making.
- Relatively easy to tailor to new areas.
- It provides familiar numerical values for people to be able to comprehend the scales of changes.
- The WSIMOD model is published and open source.

What are the challenges for integrated modelling?

- Does not give enough detail to be robust enough to make site specific and final investment decisions.
- Does not provide good coverage of flood risk impacts.
- It needs someone to own and administer it as part of the analysis and decision-making process.
- The existing available data across the water system is inconsistent in its level of detail, this therefore makes it difficult to compare consistently/fairly.
- There was mixed confidence in the validation of models in both trials, with a lack of confidence, particularly in the upper catchments.
- There are lots of assumptions that need to be made to allow the modelling to run. This could be improved with better data, but it would add significant resource demands to the set-up of the model.
- The interfaces between some elements (such as surface water and groundwater) could be viewed as simplistic.
- The metrics that can be represented in the model are limited.
- Use of proxy metrics means that it could be hard to use the modelling outputs to influence statutory processes.
- Some interventions were unable to be modelled because they were too small and did not provide an impact on downstream water bodies.
- Some interventions were an amalgamation to enable representation, however this loses the local detail and the ability to separately select different groups of these options or interventions.
- Some interventions were unable to be modelled because they did not match up with the metrics used within the modelling.

What it should do

- It should identify interventions that would benefit the wider water system while achieving statutory targets.
- It should support interventions being chosen as part of portfolios because of their wider benefits that would otherwise not be selected.

What it shouldn’t do

- The modelling is not intended to replace the detailed modelling undertaken as part of the statutory planning processes. They are complimentary.
- It is not meant to stand up to the scrutiny of a detailed project appraisal / cost benefit analysis.

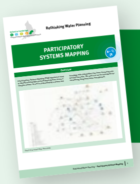
The project

Project background and purpose

Project background, purpose, approach and conclusions

Techniques applied in the trials

Integrated Modelling summary



Participatory Systems Mapping

Trialling ways to achieve the ambition

Approach 1: Systems Approach to Integrated Water Management (SIWM)

Approach 2: Options-Based Catchment Reconciliation