Oxford to Cambridge Arc, Integrated Water Management Framework: a high level summary

The Environment Act sets out ambitions to take a more integrated approach to water planning. The OxCam Arc has significant existing water pressures, which planned (or unplanned) growth and a changing climate will exacerbate. Local leaders are committed to working across local authority boundaries and have agreed environmental principles which support our ambition to consider water holistically. Integrated water management will underpin sustainable economic growth and environmental improvement in the OxCam Arc.

This project is assessing options to establish an innovative framework to drive more integrated water management (IWM) across water resources, water quality and flooding. It requires an understanding of the current water landscape across the Arc, taking account of where investment is planned and future housing development needs.

The Defra Group working across the Arc align their work to three main themes, as shown below.

Nature recovery

- Enhanced and protected
- Connected
- Accessible

One of the project's **core objectives** is to improve the water environment. This means helping nature to recover and thrive across the OxCam Arc.

Rethinking natural resources

- Sustainable
- Integrated
- Resilient

The project will deliver its objectives through **rethinking how we manage water**. It will challenge current approaches, and **test and trial** new methods of appraising and selecting interventions, capturing benefits and future mechanisms.

Green growth

- Green and grey integrated
- Strategic planning
- Design and build standards

The project will investigate, evidence, test, and propose ways we can **harness growth to improve the water environment**. This will include consideration of building standards, spatial plans, and blue/green infrastructure.

The IWM framework is to be developed across several phases of work to provide ongoing opportunity for stakeholder consultation, as shown below.

Spring 21	Phase 1 Winter 21/22	Phase 1a	Phase 2 Autumn 22	Phase 3 Autumn 23
Scope	**Define** Engage Evidence Explore	Pilot modelling	**Design** Strategy Framework Investment	**Decide** Ownership Solutions Delivery

Approach to Phase 1

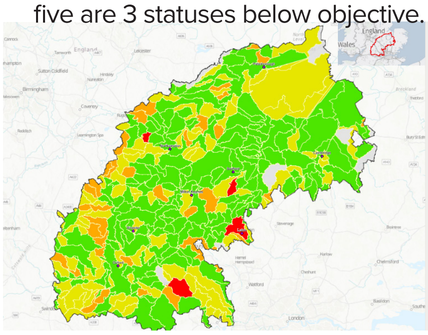
Evidence and understand	Assess and define	How do we move forward?
1, Water systems baseline	3. Options appraisal	Key insights/ implications • **Influencing policy** • **Influencing infrastructure delivery mechanisms**
2. Systems mapping	4. IWM requirements	

1. Water systems baseline

To establish a holistic baseline for water systems, we have brought together key data from: River Basin Management Plans, Water Resource Management Plans, Drainage and Wastewater Management Plans and Flood Risk Programmes.

Baseline environmental challenge

- In the 25 Year Environment Plan, we committed to restoring 75% of our water bodies to be close to their natural state (good status). Currently, no English rivers have good chemical status and only 14% have good ecological status.
- This presents both risks and opportunities, for example if there is large scale home building, increases in wastewater and runoff could exacerbate (Water Framework Directive) WFD pressures. However, if managed well, this investment in the Arc could be used to reduce pressures on the environment.
- Out of 346 water bodies in the OxCam Arc, currently only 190 meet their WFD overall status objective. 114 are 1 status away from objective, 37 are 2 statuses below, and five are 3 statuses below objective.



Baseline environmental challenge

Key to symbols:
WFD status gap (current to objective)

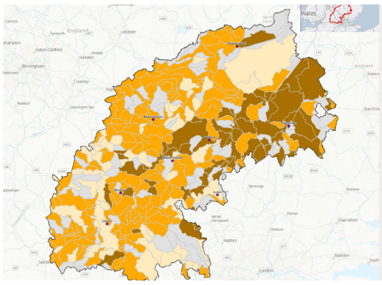
0
1
2
3
Unknown

Water resources

- There are significant water supply pressures in the Arc and surrounding areas, with multiple waterbodies failing flow targets during low flows (e.g. in summer). This is forecast to worsen due to increased pressure from the impacts of development and climate change.
- Water companies have identified multiple new or enhanced supply interventions in their emerging regional plans. However, it is anticipated there could be a significant water resource deficit.
- Water resources are also of critical importance to agriculture (particularly spray irrigation), power supply, industry, and food and drink processing.
- These resources are allocated through abstraction licences, issued and managed by the Environment Agency to meet RBMP objectives.

Water quality

- Phosphate is a key pressure impacting WFD water body status. Causes of poor phosphate performance identified include; wastewater, poor nutrient management and poor livestock management in places.
- Nutrient neutrality is a concept that is being promoted to ensure that development does not add to existing nutrient burdens on protected sites. It could involve some combination of enhanced wastewater treatment and offsetting through catchment management.

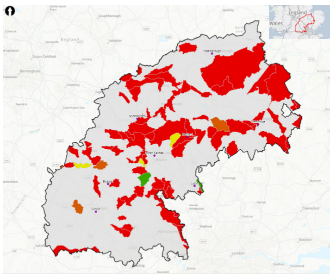


Water quality

Key to symbols:
Phosphate challenge

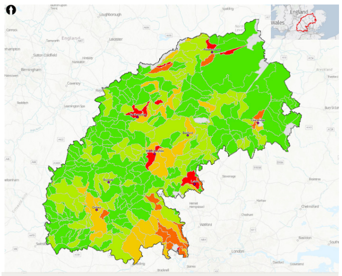
Confirmed
Probable
Superseded
N/A

- Current technological limits to treatment are likely to place a limit on where additional wastewater can be discharged without impacting WFD status.



Water quality
Key to symbols:
Sewage treatment works (average phosphorus limit mg/l)

0.0-1.1 1.2-2.3 2.3-3.3
3.4-4.4 4.5-5.5 Unknown



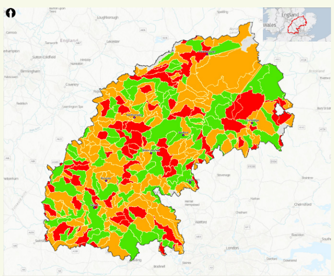
Water quality
Key to symbols:
Potential nutrient loading from farmland (property equivalent per Ha)

0-16 17-22 23-29
30-35 36-42 Unknown

- Catchment offsetting through land use change could mitigate wastewater nutrients in some places, subject to seasonal variations. However, there are some waterbodies where existing discharges and associated nutrient loads could limit future development in some locations/ waterbodies, unless alternative strategic solutions are identified.
- There were 9,500 sewage storm overflow events recorded across OxCam in 2020, totalling >100,000 hours.

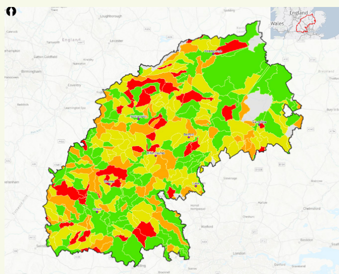
Flooding

- Around 50,000 properties and 17% of the OxCam Arc land area are at risk of fluvial flooding once every 100 years. 12,000 properties (6.5% of land) benefit from flood defences. More than 7,000 properties are at risk of surface water flooding once every 100 years.
- The OxCam Flood Risk Investment Study estimates up to 90% more properties will be at risk of flooding by 2100 as a result of climate change, under an upper end climate change scenario.



Flooding
Key to symbols:
Water Body Flood Risk

1 2 3 Unknown



Flooding
Key to symbols:
Climate Change Flood Risk Score

0 1 2 3 Unknown

2. Systems mapping

With technical experts through a series of mapping sessions, the project mapped interactions and dependencies across environmental systems (river water quality, water resources and flooding); water utilities (PWS and wastewater treatment); spatial planning and land use; and agricultural systems.

These are interlinked to create one overall meta-system map – a "system of systems" – which provides us with a common, more coherent view of the existing systems and therefore helps us take a more integrated, 'bigger picture approach'.

The maps identified the potential for integration through better planning so that synergies are achieved across for example; urban planning, flood control and water quality. By providing us with a better understanding of the wider impacts of our choice of intervention, be that policy or infrastructure, we are able to make better informed decisions - so that components of the system work together to achieve our shared objectives.

Creation of the system maps served the following five objectives:

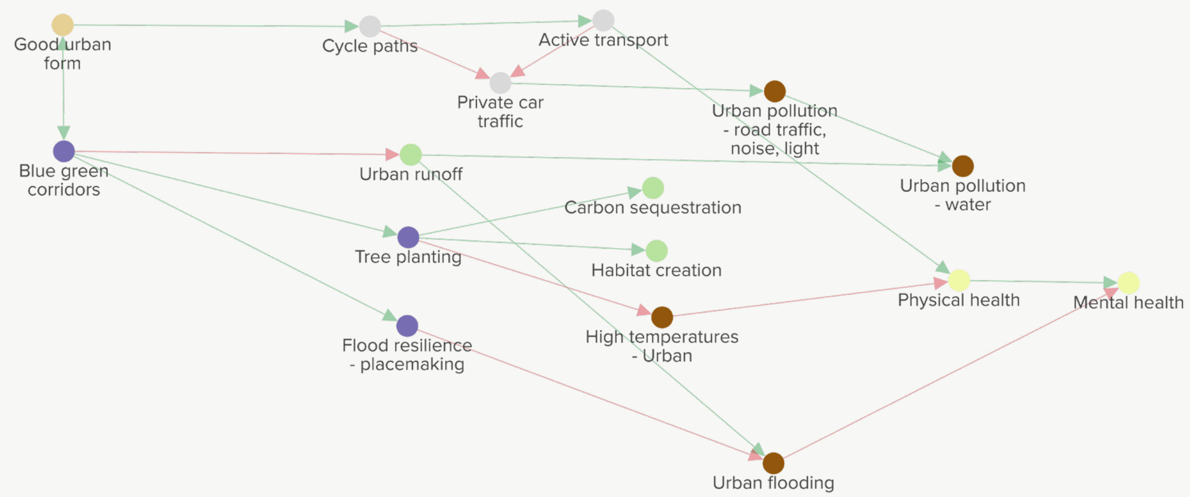
1. To create insights and participant buy-in, to foster improved collaboration and participation
2. To clarify the categorisation of interventions/options and benefits across the different systems.
3. To identify system linkages and potential co-benefits of interventions/options and policy priorities.
4. To validate the selection of criteria for use in the MCA.
5. To enable prioritisation of effort on numerical modelling of the systems in future.

Legend

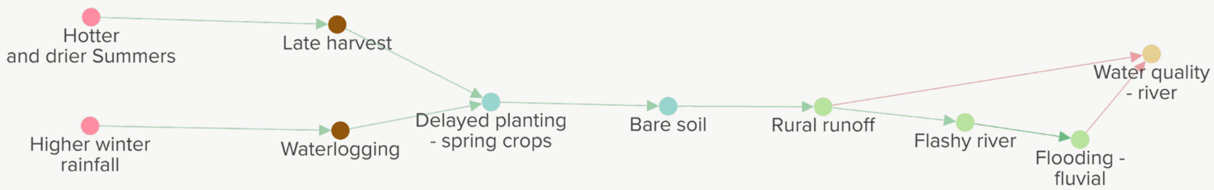
- Positive correlation link: More 'A' means there will be more 'B'
- Negative correlation link: More 'A' means there will be less 'B'
- Complex correlation

- Agriculture
- Climate
- Environment
- Infrastructure and Industry
- Water Utility
- Intervention
- Key System Outcome
- Policy
- Pollution/pressure
- Social and economic

Example 1 - Multiple benefits of blue green corridors: Good urban form and blue green corridors are mutually reinforcing developments. Blue green corridors provide flood resilience and reduce urban flooding. They also provide opportunities to create cycle routes that enhance active travel and reduce car use, thereby reducing water and air pollution. Other benefits can be realised since the corridors provide opportunities to plant trees that sequester carbon, reduce urban temperatures and create connected habitat.



Example 2 - Agriculture and climate change: Climate change drives hotter, drier summers, increasing the likelihood of a late harvest. Climate change also drives higher winter rainfall which increases waterlogging. Both effects increase the likelihood that the farmer opts to plant spring crops leaving bare soil exposed over winter. This increases rural runoff, increasing flood risks and poor water quality. The impacts of climate change on flooding and water quality may therefore be amplified (or mitigated) through agricultural practice. This shows how agriculture is a 'system lever' that merits policy attention.



3. Options appraisal

There are four aspects of water planning that are currently appraised in a largely siloed manner using different approaches, across different spatial scales. These are water resources, wastewater, environment and flooding.

Water resources

Aims to maintain continuity of supply under specified drought conditions and to develop a "best value plan".

Wastewater

Aims to reduce sewer flooding, storm overflows and pollution risk. It aims to ensure wastewater treatment works quality and flow compliance.

Flood risk

Interventions are typically appraised via cost/benefit assessment. A strategic sequential approach is applied for flood risk/resilience of new developments.

Environment

WFD Objectives specified for each water body are based on achieving good ecological, water quality and environmental status, unless costs are "disproportionate", in which case a lower status may be accepted.

By adopting a consistent approach to planning, it would be possible for options with benefits to more than one system to be included for appraisal in more than one planning framework.

For planning across the Arc to be integrated, it is necessary to agree:

- A common set of metrics.
- A common set of planning assumptions.
- A consistent set of management targets and performance thresholds.
- A common set of scenarios.
- A consistent categorisation of option types.

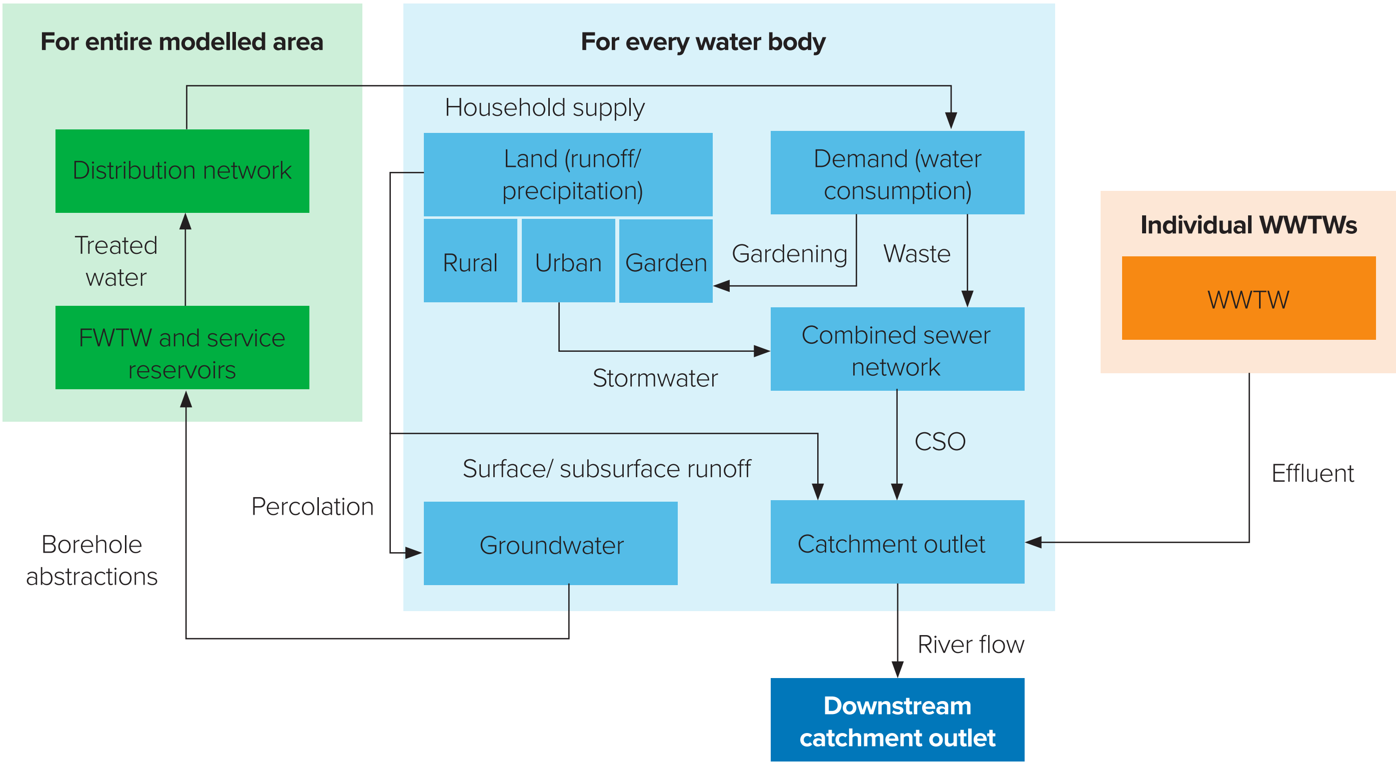
We reviewed the different categories of option type and produced a synthesised option list. We undertook a high-level review of the benefits of different option types and a pilot modelling exercise to assess how benefits could be scored.

On the basis of this work and consultation with stakeholders, the provisional set of criteria and metrics for use in a multi-criteria analysis is presented below.

Criteria	Subsystem metric data	IWM metric data	IWM data source
Flood protection	Property flood risk band numbers Others under development	Q5 QMED flow R-B Index	ICM modelling
Flood placemaking			
Flood recovery	Under development by others		Subsystem analysis
Flood response	Under development by others		Subsystem analysis
Water quality	WFD metric Protected site status	Phosphorous, nitrate, ammonia concentration Suspended solids	ICM modelling
High flow water quality	99 percentile BOD		
Environmental flow	WRGIS deficit (Ml/d)	Q10, Q5 flow	ICM modelling
Water resources	Dry year supply demand balance benefit	Dry year supply demand balance benefit (Ml/d)	ICM modelling
Morphology	WFD status	No comparative metrics	Subsystem analysis
Invasive non-native species	INNS WFD pressure status		Subsystem analysis
Carbon sequestration	Tonnes carbon equivalent		Subsystem analysis
Embodied carbon	Tonnes carbon equivalent		Subsystem analysis
Biodiversity	Biodiversity net gain		Subsystem analysis
Soil health	No consistent metrics	Soil health and erosion risk metrics	Subsystem analysis
Mental health		Weighted score based on increased access to green/blue space for recreation	Subsystem analysis
Physical health			Subsystem analysis
Social connectivity and networks		Local connectivity impacts and stakeholder networks	Subsystem analysis

Pilot modelling

WSIMOD framework



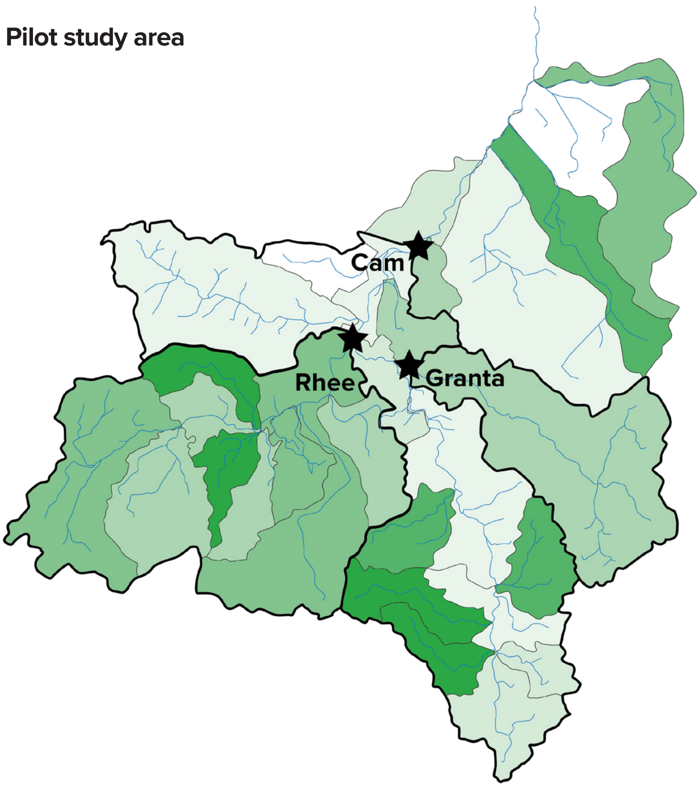
Pilot modelling was undertaken with the WSIMOD model in partnership with The Centre for Systems Engineering and Innovation, (CSEI) at Imperial College. The aim of the pilot modelling exercise was to assess the capability of integrated modelling to deliver MCA across the OxCam Arc.

The pilot plot was the Cam, Rhee and Granta rivers as shown on the map on the right. The stars on the map indicate the points where the model results were analysed.

The model framework is shown in the figure above and it was applied with a resolution of each water body. Modelling water quality and water resources together integrates the key variables in water resource, environment and wastewater planning. It is hard to appraise flood options directly with these models because a geospatial assessment is required to assess flood impact. However, the modelled changes in flow variability and maximum flows can be used to appraise flood risk indirectly, thereby identifying potential synergies between flooding and the other three planning frameworks.

Results of the pilot modelling indicated its strengths in bringing together a combined perspective across the planning frameworks and its potential contribution to creating an integrated approach across the Arc. Applying the model across the Arc, with a water body resolution, would create a balance of achieving a broad perspective on water resources (given that the water resource system operates at this scale) and detail in each catchment (which is an important scope for environment, flooding and wastewater planning). Refinement to scale and resolution to address hotspots can be applied relatively easily in the model as required using an iterative approach.

Pilot study area



Summation of benefits

Having adopted a common set of metrics and planning assumptions, it would be possible to select options that work together for increased benefits across the planning frameworks. This diagram sets out a way that the process could work.

The diagram shows how benefits from the four planning frameworks could be summed and then a combined portfolio negotiated and agreed.

This graphic shows a method for the summation of benefits across four planning frameworks leading to the creation of a combined portfolio of options.

Rows 1-4 show benefits and co-benefits of the options selected within each individual framework. The primary benefits in each system are coloured bold and co-benefits are coloured faintly:

- Water resource benefits are blue,
- wastewater brown,
- environment green and
- flooding pink.

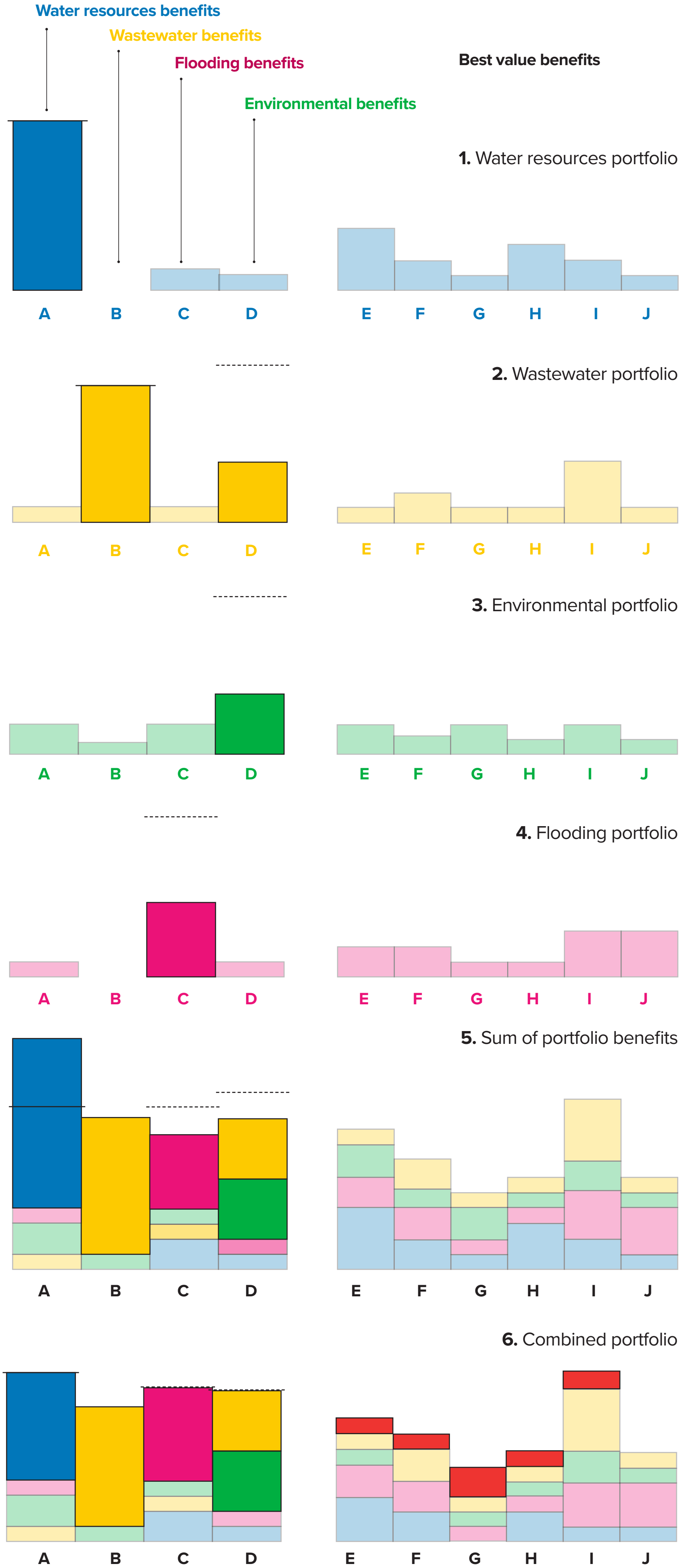
Columns A to D show the benefits to each of the four planning frameworks. Columns E to J show co-benefits that represent show additional value ("Best Value" to use the terminology of WRMPs) such as social benefits, carbon sequestration etc.

Performance requirements for water resources and water management are shown as hard horizontal lines. Performance targets for environment and flooding are shown as dashed horizontal lines.

Row 5 shows the sum of all the portfolio benefits. Row 6 shows how a revised set of options could be negotiated to create a portfolio that reflects the efficiencies and potentially enhanced delivery of an integrated approach. Row 6 includes some additional best value benefits (red) from in combination effects.

As an example, using this method, a SUDs flood management with a secondary benefit to water resources would appear in both the flooding portfolio in Row 4 and summation of benefits in Row 5. A review would then be made to assess whether it should be included in the combined portfolio Row 6. This option could displace a more costly water resource option and create a more cost-effective water resource portfolio. If another similar project exists that does not meet the cost benefit threshold for flood schemes when considered in isolation, then identifying a cost share with another portfolio may mean that it becomes viable for inclusion in the flood portfolio too.

Method for the summation of benefits across planning frameworks



4. IWM requirements

Building on the baseline assessment and systems understanding, we have identified the following ways of influencing development:

- Design requirements
- Market incentives
- Strategic planning/coordination.

Design requirements

Whilst they are not in isolation the answer to our capacity issues, improved design requirements are needed to ensure we use our existing supplies more efficiently.

Water efficiency measures, such as water efficient devices and smart metering, are likely to be cost effective in new developments and worthwhile to reduce the demand for water and wastewater services. Specifying water efficiency standards for new-home appliances would be a 'no-regrets' policy.

Mandating rainwater harvesting or greywater reuse could be done according to need on the basis of local water supply constraints, flood risk and water quality risks.

Water and nutrient neutrality concepts could form the basis of policy tools intended to mitigate the risk of development on designated environmental sites, through: on-site efficiency; water reuse; enhanced wastewater treatment; and offsetting through property retrofitting and land use change. However, to offset 540,000 additional new properties within the OxCam Arc would be highly challenging:

- Offsetting additional water demand would require retrofitting between 40% and 120% of existing properties in the Arc.
- Offsetting additional nutrient loading (nitrate and phosphate) would require eliminating nutrient runoff from 5% of existing arable and/or pasture land in the Arc.

There are risks in offsetting, such as: maintaining long-term offsetting benefits, e.g. diminishing returns of nature-based solutions if not managed effectively; temporal variation in nutrient loading between agricultural runoff (seasonal peaks) and domestic wastewater (continuous year-round); measuring against the right baseline (good practice); social viability; and impacts on rural communities.

For some proposed development locations, legal obligations or environmental ambitions cannot be satisfied even with all available water and nutrient offsetting. Here, development should not occur until sufficient new supply-side resources can be delivered to mitigate impacts.

Market incentives

Market incentives are already applied to existing properties in several ways, e.g. the gas boiler scrappage scheme, loft insulation schemes, photovoltaic solar, cavity wall insulation.

Developer contributions could be updated to better reflect whole-life costs of development on water resources, wastewater infrastructure, flooding and the water environment.

On-site reuse (rainwater harvesting and greywater reuse) could be incentivised via a levy based on mitigating any flood and environmental impacts, tailored to local risks, which would be reduced through installation of effective rainwater harvesting and greywater reuse.

Strategic planning

The impacts of development on water are very site-specific. Therefore, a degree of strategic assessment and planning would be necessary to determine where and when different combinations of design standards and incentives would be appropriate.

Effective strategic urban and infrastructure planning for water resources, wastewater and flooding, including the most effective mitigations for any chosen development site, will require knowledge of; supply networks, abstraction constraints, water body pressures, flood risks and designated sites. It may need to take place at a broader scale than individual catchments. We propose a collaborative approach across:

- Water companies, who have the best knowledge and control of their assets, and whose planning accounts for the regional system already in WRMP, WINEP and DWMP.
- Regulators, with knowledge and responsibility of the wider pressures on catchments, flood risks and enforcement of environmental regulation.
- CABA partnerships with detailed local knowledge of local river catchments.

Development spatial planning could be fully integrated with water system planning, such that water resources, drainage and wastewater, flood risk and local development planning is aligned and reconciled in an iterative process.

For large-scale development there may be an opportunity for developers to propose solutions that reflect a strategic integration of systems (e.g. flooding and transport earthworks). This could be brought forward at a local plan level, allowing developers and other planners to work together at an appropriate strategic scale.

Interventions will be undertaken at a variety of scales (site/development specific, local authority/operational catchment, regional/supply zone) and require different levels of collaboration.

We need an overarching, strategic approach (coordinated/system integration) or framework to ensure we maximise opportunities for synergies that design standards and market incentives alone could miss.

Key message: an OxCam IWM framework should specify improved linkages between existing planning programmes, as well as define the interface between prescriptive design requirements for environmental betterment, market incentives, and strategic optimisation of infrastructure.

5. Implementing the IWMF

Potential operation/scope of IWMF

The integration of water systems will require an active effort to bring workstreams together to create the synergies that are there to be realised. We propose the following outline of activities for the operation of the IWMF:

1. **Coordinate opportunities for co-development and co-funding of options with multiple benefits.**

Using the method set out in Section 3, the following key tasks would enable the selection of integrated option portfolios with benefits across all four planning frameworks.

- Promotion of a common set of planning assumptions.
- Modelling sets of options at appropriate times to inform stakeholders of opportunities that exist to create mutually beneficial option portfolios.
- Negotiate collaborative development of portfolios that reflect system synergies.

2. **Coordinate development of options that have in-combination effects,** such as environmental flow and water quality benefits that enhance availability of water resources in drought conditions.
3. **Identify conflicting strategies** and opportunities to mitigate disbenefits of options.
4. **Coordinate policy recommendations** such as developer requirements for environmental neutrality or enhancement.
5. **Provide a common voice for water in wider system integration** with, for example, transport and energy system planning.

Role of modelling within the IWMF

An integrated model would allow the different planning frameworks to be informed by:

- A live set of options under consideration across the other planning frameworks
- A high-level view of the potential synergies across subsystems.

It would also enable collaborative development of combining options.

The modelling will identify in-combination effects of different options. For example, low flow and water quality measures that combine to enhance water resource availability and environmental benefits; or negative impacts that could be mitigated through collaborative working.

This could be informed by testing best value subsystem portfolios in the integrated model, and reviewing high-level performance indicators. Performance targets and thresholds need to be set on the basis of modelling and collaboration with local area experts and stakeholders.

A coordinated and centralised high-level approach to modelling options would enable the efficiencies of multi-benefit options to be realised at scale. This approach would identify the cross system synergies and where effort is needed to realise these opportunities.

It would be more efficient to develop this high level-overarching view of the synergies than to rely on each planning framework to develop its own approach to interacting with all of the other system frameworks.

Stakeholders consulted

Phase 1 was undertaken with stakeholder collaboration throughout.

- Systems mapping was undertaken via ten Focus Group meetings across water resources, wastewater, habitats and natural capital, landscape and agriculture, flood risk and the environment and development interface.

554 Comments received

From **40** people

Across **13** organisations

Via **5** technical group meetings

Responses to **6** technical notes

Organisations consulted:

Affinity Water
Anglian Water
Central Bedfordshire LLFRA
Defra Group
Environment Agency
Homes England
Natural England
Oxford University
South Staffs Water
Thames Water
Waterwise
Water Resources East
Water Resources South East