MOTT MACDONALD

Subregional integrated water management strategy

East London

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Subregional integrated water management strategy

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July 2023

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Glossary

AfW	Affinity Water
AMP	Asset Management Period
BSI	British Standards Institution
CP	Climate Projections
EA	Environment Agency
GLA	Greater London Authority
ICL	Imperial College London
LIWMS	Local Integrated Water Management Strategy
NBS	Nature Based Solutions
NPPF	National Planning Policy Framework
OA	Opportunity Area
ONS	Office for National Statistics
PCC	Per Capita Consumption
PMP	Progressive Metering Plan
RCP	Representative Concentration Pathway
SESRO	South East Strategic Reservoir Option
SIWMS	Sub Integrated Water Management Strategy
STW	Sewage Treatment Works
SuDS	Sustainable Urban Drainage Systems
TE2100	Thames Estuary 2100

TfL	Transport for London
TW	Thames Water
WFD	Water Framework Directive
WINEP	Water Industry National Environment Programme
WRSE	Water Resource South East
WRZ	Water Resource Zone
WSIMOD	Water Systems Integration Modelling Framework

Executive summary

Context and introduction

This document is the result of the development of the Subregional Integrated Water Management Strategy (SIWMS) for the Lower Lea. The project was delivered in partnership between GLA, EA, Thames Water, Natural England, Enfield, Waltham Forest, Hackney, Haringey, Tower Hamlets, Newham and City of London.

The analysis undertaken in support of this strategy has found a number of significant strategic water related risks under different growth and climate change scenarios. To address these risks the analysis has validated and significantly reinforced the need for many activities and interventions currently being undertaken (such as demand management and delivery of SuDS). Additionally, the analysis has also shown that delivery of isolated programmes will not be enough to entirely offset the identified risks and enable the delivery of desired economic growth, climate resilience and environmental improvements. To do this will require a significant increase in the level of coordination in planning, delivery and action across project partner organisations and in some cases beyond the boundaries of this strategy.

Objectives

This strategy provides decision makers and policy makers in project partner organisations with the following:

- An understanding of water related risks in the subregion under different growth and climate change scenarios.
- Interventions and measures needed to ensure sustainable growth in response to identified risks.
- Clarity on the delivery levers and mechanisms to implement identified interventions and measures.
- Adaptive capacity, enabling the strategy to change course under changing circumstances.

Study approach and scenarios

The analysis to inform strategy recommendations was performed by modelling the Upper and Lower Lea operational catchments using Imperial College London's WSIMOD software. This allowed for quantitative assessment of key outcomes in relation to water quality and quantity under different future scenarios.

Two main future scenarios were modelled: ‘City Living’ and ‘Country Life’. The scenarios represent different plausible futures built up from a series of factors covering population growth, economic growth and spending, urbanisation, environmental ambition, and water demand. Each scenario was modelled under different climate change projections. In this report, we focus on results for the RCP 2.6 climate change scenario.

City Living – This scenario represents a future in which there is high urbanisation within central London and the commuter belt. There is also some focus on environmental protection as a result of high urbanisation and medium economic growth.

Country Life – In this scenario rural urbanisation is high whilst growth in central London has not increased as projected, with water demand reducing in the subregion. Additionally, there is a high level of focus on environmental protection and economic growth is moderate.

The impacts of both scenarios on water quantity and quality were modelled against the baseline (current position). This provided a clear picture of the changes in risks and impact to water quality and quantity under each scenario. Subsequently, each scenario was remodelled with the inclusion of different ‘options’ (measures and interventions identified in existing plans and strategies) to mitigate impacts to water quantity and quality. Doing so provided insight into the effectiveness of different options to mitigate risks and impacts under both scenarios. Furthermore, this also provided visibility of which options delivered multiple benefits to different aspects of water quality and quantity and where there were significant trade-offs associated with certain options.

Model findings

Water quantity

Fluvial flood risk is likely to worsen due to a combination of climate change impacts and proposed WINEP abstraction reductions in the upper catchment (outside of London) for sustainability reasons. This risk poses a challenge to resilience of existing communities and economies from flooding as well as potentially affecting the viability of land for development in the subregion.

SuDS are an effective measure to help address this flood risk however the current volumes earmarked for delivery in existing plans are not enough to entirely address the increase in risk in isolation. Furthermore, SuDS delivered in upper boroughs will benefit downstream boroughs as well as having most impact on the smaller rivers (tributaries of the Lea).

Water quality

There are water quality issues in the catchment which constrains the ability of the watercourse to support a flourishing natural ecosystem and provide enhanced levels of access to quality green space for residents. Furthermore, nitrate concentrations in the catchment affect resilience of water supply across the London Water Resource Zone. Abstraction reductions under City Living and Country Life scenarios improves water quality thresholds in some sub-catchments (located in Enfield, Waltham Forest, Hackney, Newham and Tower Hamlets). However, the high levels of phosphate and nitrate may impact on the reliability of water supply for existing and future demand without scope to mitigate it.

Proposed WINEP investments at sewage treatment works in the upper catchment (outside of London) are not enough to change WFD classifications across the catchment in relation to phosphate concentrations. Further investigations are required to understand the potential for land management interventions in the upper catchment (outside of London) to deliver further water quality improvements. The relationship between PCC in the Beckton drainage catchment and the salinity concentrations in the Thames also requires further investigation to understand its impact.

Water stress

Without investment in additional supply, sustainability reductions, population growth and climate change are likely to drive a very significant increase in future water stress in the subregion (165% increase in City Living 312% increase in Country Life). If left unaddressed this may constrain future growth by reducing availability of supply. Furthermore, it may impact resilience of existing communities and economies by increasing risk of supply disruptions and temporary use restrictions.

The major planned supply side interventions in WRSE's regional plan and Thames Water's WRMP provide around 40-45% of the water resource benefits in City Living, but not as much benefit in Country Life. Increased reliance on water from outside the Lea catchment will be necessary which may constrain future growth across wider London. PCC reductions and metering initiatives are also likely to reduce water stress effectively, with their impact potentially being as high as 35%-40%, depending on other factors. However, there are trade-offs and potential disbenefits to account for with PCC reduction efforts. For sub-catchments draining to Deephams STW, PCC reductions negatively impact water quality and low flows in the Lea.

Planning and governance

Modelling has shown that delivering SuDS and leakage reductions contributes effectively to addressing current and future challenges in the catchment without any significant disbenefits or trade-offs (apart from cost). Therefore, these two options are considered 'least regrets' and efforts should be made to accelerate their implementation and delivery in the short term.

In addition, the modelling has also found that major planned supply side interventions and PCC reductions have very significant impact in mitigating some of the biggest risks identified in the modelling but have significant trade-offs which need to be managed. Therefore, these options should also be delivered, whilst managing or mitigating any negative impacts.

Based on these results, we recommend a portfolio of options:

- Least-regret options which provide multiple benefits across the subregion with no identified trade-offs. These options include SuDS and leakage reduction, as well as wider enabling options such as engaging communities.
- Principal options which mitigate the biggest risks identified from the scenario analysis but have trade-offs that need to be managed. These options include Deephams reuse, London WRZ options and metering options.
- Other options need consideration as part of the SIWMS adaptive planning but do not mitigate the biggest risks from the scenario analysis. These include natural capital options and misconnections.

Strategy recommendations

To address the challenges and risks identified by the modelling effectively, we have identified a number of recommendations for the GLA and project partner organisations to implement. These have been developed based on current levels of maturity within the group’s organisations and existing programmes of action.

Flood risk

1. Engage with EA and abstraction operators in upper catchment to investigate impact of groundwater abstraction regime on base flows.
2. Deliver planned SuDS programmes within the study area to partially mitigate impacts by retrofitting SuDS in attenuation spaces for up to 5% of the total borough areas and disconnecting surface water sewers for up to 5% the total borough areas.
3. Explore disconnection opportunities (e.g. permeable paving, water butts, green roof areas) in Lower Lea Boroughs Newham, Tower Hamlets and City of London in line with the findings from the TW DWMP.
4. Implement and enforce Schedule 3 of the Flood and Water Management Act (2010)[1].
5. Review current plans for SuDS delivery and develop more ambitious plans to achieve the targets set out in recommendation 2.

[1] The review for implementation of Schedule 3 to The Flood and Water Management Act 2010 (publishing.service.gov.uk)

6. Investigate mechanisms to enable co-funding of SuDS in strategic upstream locations which deliver shared benefits to multiple boroughs.

Water quality:

7. Engage with stakeholders in the upper catchment to understand sources of pollution outside of wastewater treatment works.
8. Investigate land management / natural capital options to reduce Phosphate pollution in the catchment.
9. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment.
10. Engage with TW and other stakeholders to further investigate / address Pymmes Brook misconnections issue.

Water stress:

11. Deliver London WRZ options and investigate Deephams Reuse further.
12. Implement LA PCC target of 105 l/p/d or less for new developments.
13. Implement progressive metering plan in line with WRMP.
14. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment.
15. Investigate the possibility of reducing PCC in the Beckton catchment without impacting Thames salinity.

Planning and governance:

16. A clear governance structure and approach (supported by tools) will need to be developed and implemented to manage the trade-offs and multi-agency coordination required as part of an effective strategy for the subregion.
17. 'Least regrets' options of SuDS and leakage reductions should be delivered immediately as they mitigate current and future risks without any significant trade-offs.
18. Trade-offs related to ‘principal’ options should be investigated and actively managed as these options progress through delivery. These include London WRZ options, Deephams Reuse and PCC reductions.

Delivery recommendations

To support the strategy recommendations and ensure the risks identified through the study are addressed, a number of key delivery recommendations have been identified. The objective of these delivery recommendations is to:

- Align action across organisations to enable impactful action and progress against challenges identified in the strategy which pose a collective risk to the strategy area.

- Ensure efficiency in actions, reducing workload for organisations and ensuring that actions are complementary (not counterproductive).
- Set in motion delivery of strategy recommendations and provide opportunity to monitor and track progress.

We have organised our recommendations into ‘90 day’ actions and longer-term activities. The ‘90 day’ actions are designed for different organisations to undertake immediately (in the next 90 days) to begin implementation of the strategy recommendations. Longer-term activities are designed to enable more effective cross-organisational collaboration going forwards. These will be essential to ensure that future trade-offs are managed effectively, and that action is effectively aligned across different actors in the subregion, supporting growth, sustainability and decarbonisation objectives.

1 Introduction

Mott MacDonald (MM) has been commissioned by the Greater London Authority (GLA) to develop a Subregional Integrated Water Management Strategy (SIWMS) as a pilot region in East London.

The aim of this project is to integrate planning and infrastructure across water resources, wastewater, water quality and flooding to create a Subregional Integrated Water Management Strategy (SIWMS). This is a non-statutory, dynamic, planning level framework which remains responsive to changing conditions, as opposed to the delivery of a static plan. It provides a coordinated strategy to support cross-organisational collaboration to deliver sustainability across the subregion.

1.1 Background

East London is earmarked for significant growth focused around opportunity areas that will be supported with infrastructure and investment to create vibrant hubs for new social and economic development. However, this will create complex interactions with the water environment against the background of climate change. Management around de-risking growth requires a collaborative approach that remains agile to respond to future uncertainties.

The preparation of a SIWMS seeks to address some of the challenges that cannot be resolved by undertaking a Local Integrated Water Management Strategy (LIWMS). These include creating a platform for stakeholders to engage earlier on strategic matters and to align objectives, create a shared evidence base and identify opportunities for collaborative commissioning of more detailed studies based on the findings of the SIWMS.

Whilst this is a pilot, the project is being undertaken in a changing wider context, that is characterised by an increased regulatory focus on strategic water planning and proposed changes to the land use planning system.

The project was delivered in partnership between GLA, EA, Thames Water, Natural England, Enfield, Waltham Forest, Hackney, Haringey, Tower Hamlets, Newham and City of London.

1.2 Project approach

We set out a shared vision for 2050 – informed through a review of planning documents and steering group workshops – for the subregion. We present a spatial representation of the challenges and opportunities that might be created through the implementation of this vision. The pilot project:

- Assesses the baseline of the water system in East London taking the Lea Valley as the study area
- Identifies a method by which an integrated perspective across planning frameworks for water resources, wastewater, flooding and environment can be achieved
- Applies the method to create an integrated and adaptive strategy for the pilot area
- Discusses delivery mechanisms for the strategy

The overall workflow of the project is outlined in Figure 1.1. Task 1 involved a holistic and comprehensive baseline understanding of the current water quality, water quantity and water resource issues in the subregion. This helped inform the collective ambition for the SIWMS which was agreed with the steering group (Task 2). Outputs from these tasks are discussed in the Baseline Report and summarised in Section 2 of this report.

This report focuses on the analysis from Tasks 3-6. Future scenarios are created based on a different projection of factors (such as climate change, level of water demand, level of urbanisation) to understand key risks related to future uncertainty (Section 3). Proposed intervention options are analysed at the sub-catchment scale to unlock their wider benefits beyond the area in which they are implemented (Section 4). Different options required to mitigate emerging risks from the scenario analysis are proposed as a portfolio of options, and how the trade-offs can be effectively managed through a collaborative strategy (Section 5). To support the strategy recommendations several key delivery recommendations have been identified. We have organised our recommendations into ‘90 day’ actions and longer-term activities (Section 6). The development of the SIWMS has been informed by expertise from the steering group. The steering group consists of the GLA, EA, Thames Water, Natural England, Enfield, Waltham Forest, Hackney, Haringey, Tower Hamlets, Newham and City of London. We have had five steering group meetings throughout the project to share and discuss preliminary findings, and incorporated feedback to inform the deliverables for this report.

The data viewer investigation report (Task 7) is included in Appendix G and the Close out report (Task 8) is a separate report.

Figure 1.1: Overview of project objectives and deliverables

Task	Objective	Deliverables	Steering Group Meeting
0. Discovery phase	To collate and confirm the information and data inputs from disparate sources for project delivery	Summary report with proposed approach and resourcing	
1. Baseline of current subregional situation	To develop a holistic and comprehensive baseline understanding of the current sub-regional situation in relation to water.	Baseline report	
2. Set collective ambition	To set a collective ambition for the SIWMS across project stakeholders		Steering Group Meeting
3. Scenario analysis	To provide an understanding of different future scenarios related to growth and water.	Subregional Integrated Water Management Strategy report	Steering Group Meeting
4. Option identification and analysis	To identify planning options which could have an impact on the catchment's water system and model their impacts on different water metrics in the baseline and future scenarios		Steering Group Meeting
5. Planning, timing and sequencing	To create an integrated plan of options to take forward for delivery.		Steering Group Meeting
6. Delivery strategy	To create a strategy to support the integrated delivery of the plan.		
7. Data viewing platform	To assess the availability of data and to document requirements for a SIWMS data viewing platform.	Data viewer investigation report	Steering Group Meeting
8. Close out report	To capture and reflect on the lessons learned from this study to inform future SIWMS studies.	Close out report	

2 Summary of baseline findings

2.1 Purpose of the baseline report

The Baseline Report documents all the activities undertaken in the baseline analysis. These activities included:

- System mapping – used to identify key interlinkages and interdependencies across water and urban planning systems. It also provided a means to validate the metrics used in the multi-criteria analysis to inform the option screening process in this report.
- Data collection – reviewed existing data related to the catchment, including spatial boundaries and existing plans from different water companies and local Boroughs.
- Baseline modelling – WSIMOD modelling of the baseline, including model calibration and validation.

This developed our understanding of the proposed growth plans (such as the London Plan Opportunity Areas) and planned options to meet this demand.

2.2 System mapping

Table 2.1 outlines the key metrics from the Baseline Report informed by the systems mapping exercise. It highlights which metrics are taken forward for modelling and option screening in this SIWMS report.

Table 2.1: Metrics identified from Baseline Report and metrics taken forward for SIWMS

Criteria	Metrics	Source	Taken forward for SIWMS
Flood protection	Properties at risk of flooding (includes sub metrics for wastewater, surface water and fluvial flooding)	Environment Agency, LLFA and TW DWMP Flood Risk Maps	No
Flood placemakin g	Q5 QMED flow R-B Index	IWM Modelling	Q5 as a modelled metric for high flows as an indicator for flood risk
Water quality	Water Framework Directive (WFD) status	IWM Modelling	WFD status as a modelled metric for

Criteria	Metrics	Source	Taken forward for SIWMS
	Protected site status Phosphate and ammonia concentrations		ammonia, phosphate and nitrate
High flow water quality	99 percentile BOD Phosphate and ammonia concentrations	IWM Modelling	No
Environmental flow	Q95 flow deficit	IWM Modelling	Q95 as a modelled metric for low flows as an indicator for drought risk
Water resources	Dry year supply demand balance benefit (Ml/d)	IWM Modelling	Number of days where water resources are not at their ideal storage range as a modelled metric
Morphology	Water Framework Directive (WFD) status	Assessed for each option (WFD risk status)	Used for option screening
Invasive Non-Native Species (INNS)	INNS WFD pressure status	Assessed for each option (WFD risk status)	Used for option screening
Carbon sequestration	Tonnes carbon equivalent	Calculated for each option	Used for option screening
Embodied carbon	Tonnes carbon equivalent (embodied)	Calculated for each option	Used for option screening
Operational carbon	Tonnes carbon equivalent (operational)	Calculated for each option	Used for option screening
Biodiversity	Biodiversity net gain	Calculated for each option	Used for option screening
Soil health	Soil health and erosion risk metrics	Calculated for each option	Used for option screening
Mental health	Weighted score based on increased access to	Calculated for each option	Used for option screening

Criteria	Metrics	Source	Taken forward for SIWMS
	green/blue space for recreation		
Physical health	Weighted score based on increased access to green/blue space for recreation	Calculated for each option	Used for option screening
Urban heat	Weighted score based on increased access to green/blue space for recreation	Calculated for each option	Used for option screening
Air quality	Weighted score based on increased access to green/blue space for recreation	Calculated for each option	Used for option screening
Social connectivity and networks	Local connectivity impacts and stakeholder networks	Calculated for each option	Used for option screening

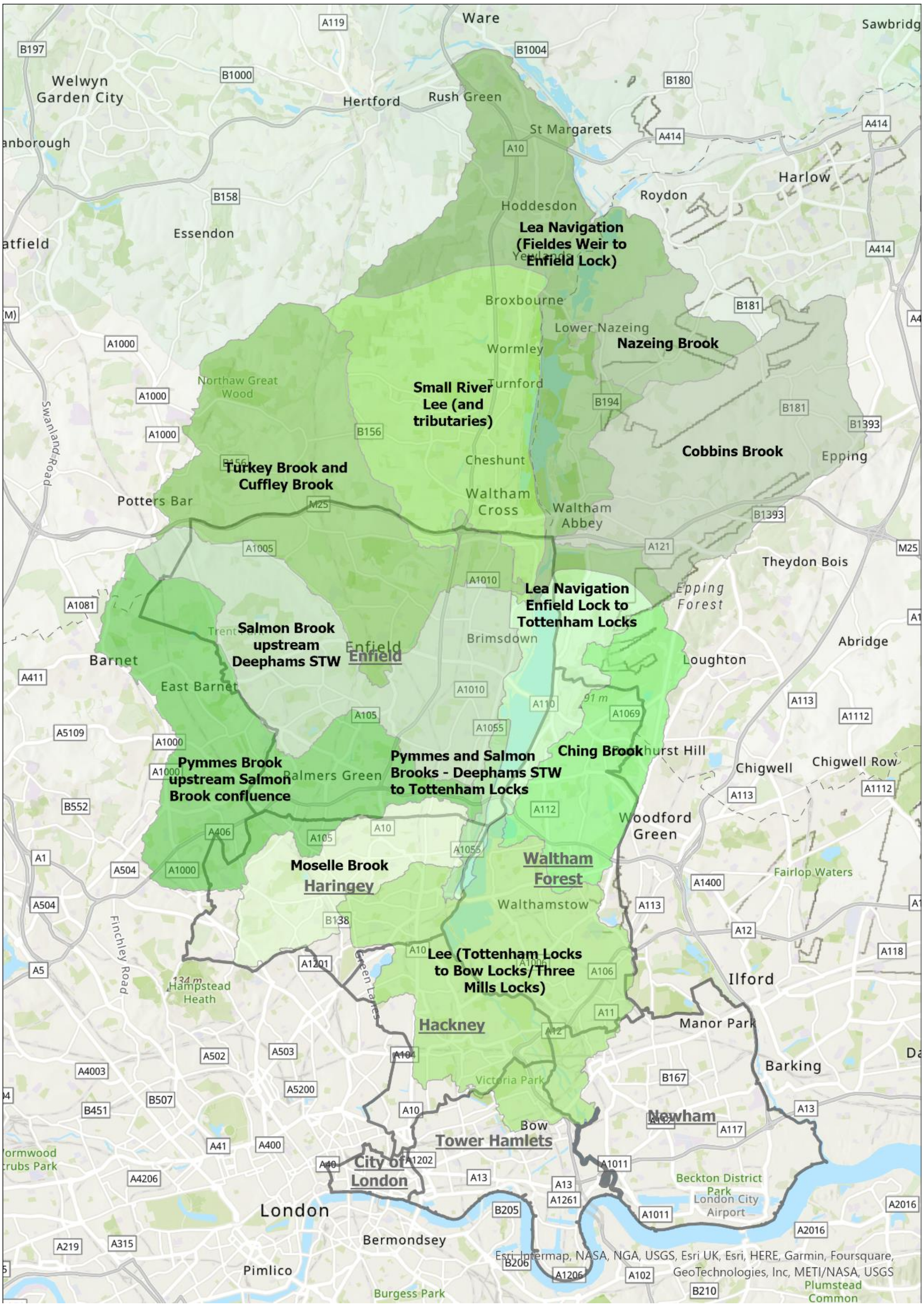
2.3 Data collection

Key baseline findings are discussed in this section. They provided insight into the water problems within the region, along with future constraints that have been highlighted by planning authorities. Opportunities were also identified to improve various water management issues, which influenced the scenario development in Section 3 and option development in Section 4 of this report.

2.3.1 Spatial scale of study area

To identify the appropriate spatial scale for the study, the planning scales of the water sub systems were compared. Water quality and flooding plans are both targeted at the river catchment scale. The River Lea catchment extends beyond the Greater London Authority (GLA) area of responsibility. Water resources are managed at a much larger scale across the Thames Water London Water Resource Zone (WRZ), making it difficult to scale down options to the subregion. Sewer networks are also not aligned with the river catchments or Borough boundaries, as they are managed in drainage area catchments. The difference in areas the plans work across made it challenging to determine the appropriate scale for the project. Figure 2.1 highlights the subregion area covered by the SIWMS and the 12 sub-catchments within the study area.

Figure 2.1: 12 Sub-catchments where results will be presented for the SIWMS study area



Source: Environment Agency. Based on the Ordinance Survey Map with the Sanction of the Controller of H.M Stationery Office License Number:-100019345

Table 2.2: Sub-catchments and overlapping London boroughs

Lower Lea sub-catchments	Overlapping London boroughs included in the study
Pymmes and Salmon Brooks - Deephams STW to Tottenham Locks	Haringey, Enfield
Moselle Brook	Haringey, Enfield
Ching Brook	Waltham Forest
Pymmes Brook upstream Salmon Brook confluence	Haringey, Enfield
Lea Navigation Enfield Lock to Tottenham Locks	Haringey, Enfield, Waltham Forest
Salmon Brook upstream Deephams STW	Enfield
Turkey Brook and Cuffley Brook	Enfield
Cobbins Brook	No Boroughs overlap
Small River Lea (and tributaries)	Enfield
Nazeing Brook	No Boroughs overlap
Lea Navigation (Fieldes Weir to Enfield Lock)	Enfield
Lea (Tottenham Locks to Bow Locks/Three Mills Locks)	Haringey, Hackney, Newham, Tower Hamlets, Waltham Forest

2.3.2 Baseline: Water quality

The Water Framework Directive (WFD) water quality data within the catchment shows that there are significant issues with poor water quality within many of the sub-catchments caused primarily by phosphate concentrations, while some areas fail in their chemical status due to other chemicals within the rivers. However, it is important to note that there are wider physico-chemical issues that contribute to not achieving good water quality status which are interdependent with other sectors such transport or other industrial activity.

While most of the study area is urbanised, there are large areas of natural capital stock in the north of the study area as well as the Upper Lea catchment. Natural capital has positive impacts on the water quality in the lower catchment.

Population increases cause a rise in water demand and place more pressure on the wastewater network. This impacts the capacity to treat sewage effectively and discharge to the watercourse, impacting water quality. To cope with the increased flows caused by the predicted urbanisation, Beckton Sewage Treatment Works (STW) is being upgraded in 2023 and is likely to need further improvements, while Deephams STW is still working within its consent.

We know from the site visit to Coppermills WTW that levels of nitrate in the River Lea can affect water supply resilience. When nitrate levels are high, additional water from West London is required to blend the water supply.

2.3.3 Baseline: Water quantity

The Baseline Report identified different sources of flood risk in the study area. Figure 2.2 highlights areas of the study region at risk of river and tidal flooding. In the River Lea flood risk area, the Environment Agency have identified 71,176 people and 581 services to be at risk of flooding. Figure 2.3 to Figure 2.6 show that a significant projected increase in the risk of sewer flooding by 2050, with more downstream Boroughs (Newham, Hackney and Tower Hamlets) exposed in 2050.

The Environment Agency (EA) plan to reduce abstractions in the Upper Lea catchment so that flows in chalk streams can be restored. This will cause changes in the flow regime along the River Lea.

Figure 2.2: Extents of flood risk from rivers and tidal flooding

Source: Environment Agency

Figure 2.3: Properties at risk of internal sewer flooding 2020

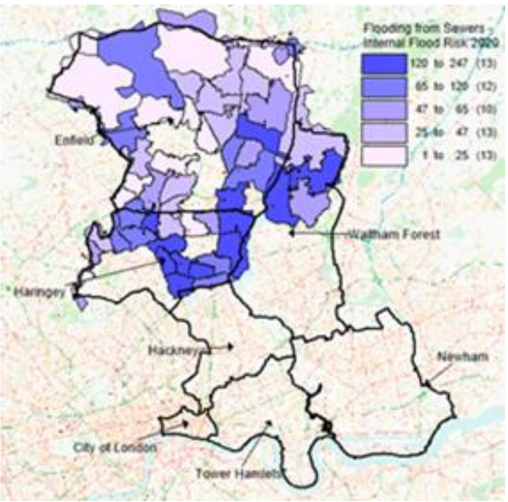


Figure 2.4: Properties at risk of internal sewer flooding 2050

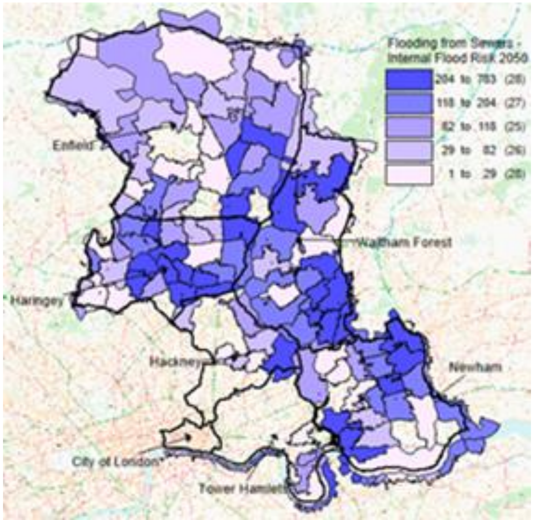


Figure 2.5: Properties at risk of external sewer flooding 2020

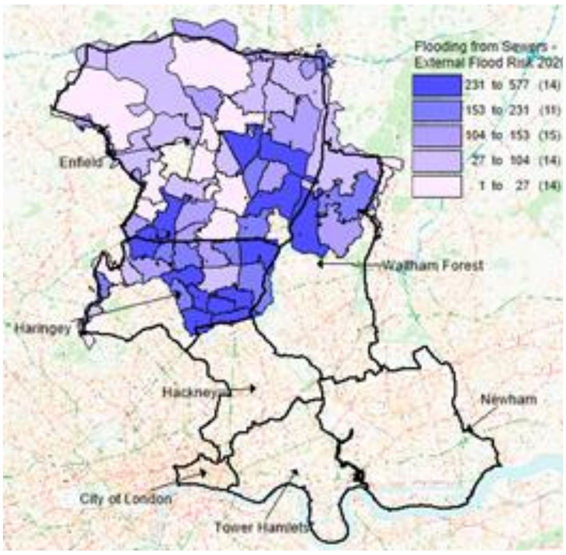
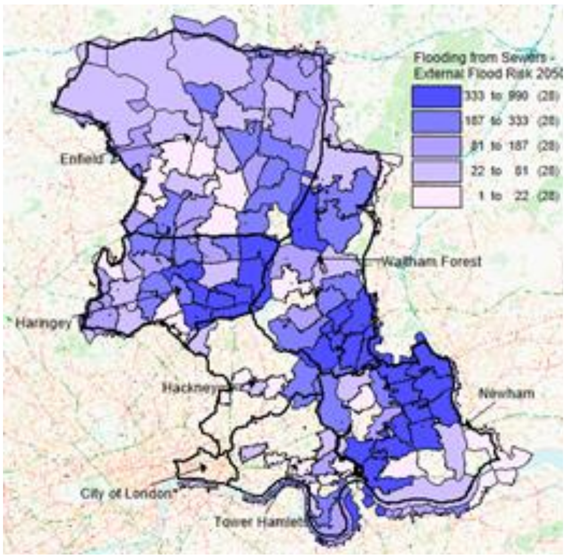


Figure 2.6: Properties at risk of external sewer flooding 2050



2.3.4 Baseline: Water resources

Water resources across London are managed as part of the London Water Resources Zone. Raw water is taken from the Thames (West London) and the River Lea which can then be managed to ensure supply across the whole city. Alterations to water resources in the River Lea catchment are expected to emerge due to increased environmental ambition for the catchment by regenerating chalk streams in the river by reducing abstractions from aquifers in the Upper Lea. This will have implications on water resources in the catchment as well as impact other metrics. The baseline findings suggest that increased water stress is to be expected.

2.3.5 Baseline: Planning and governance

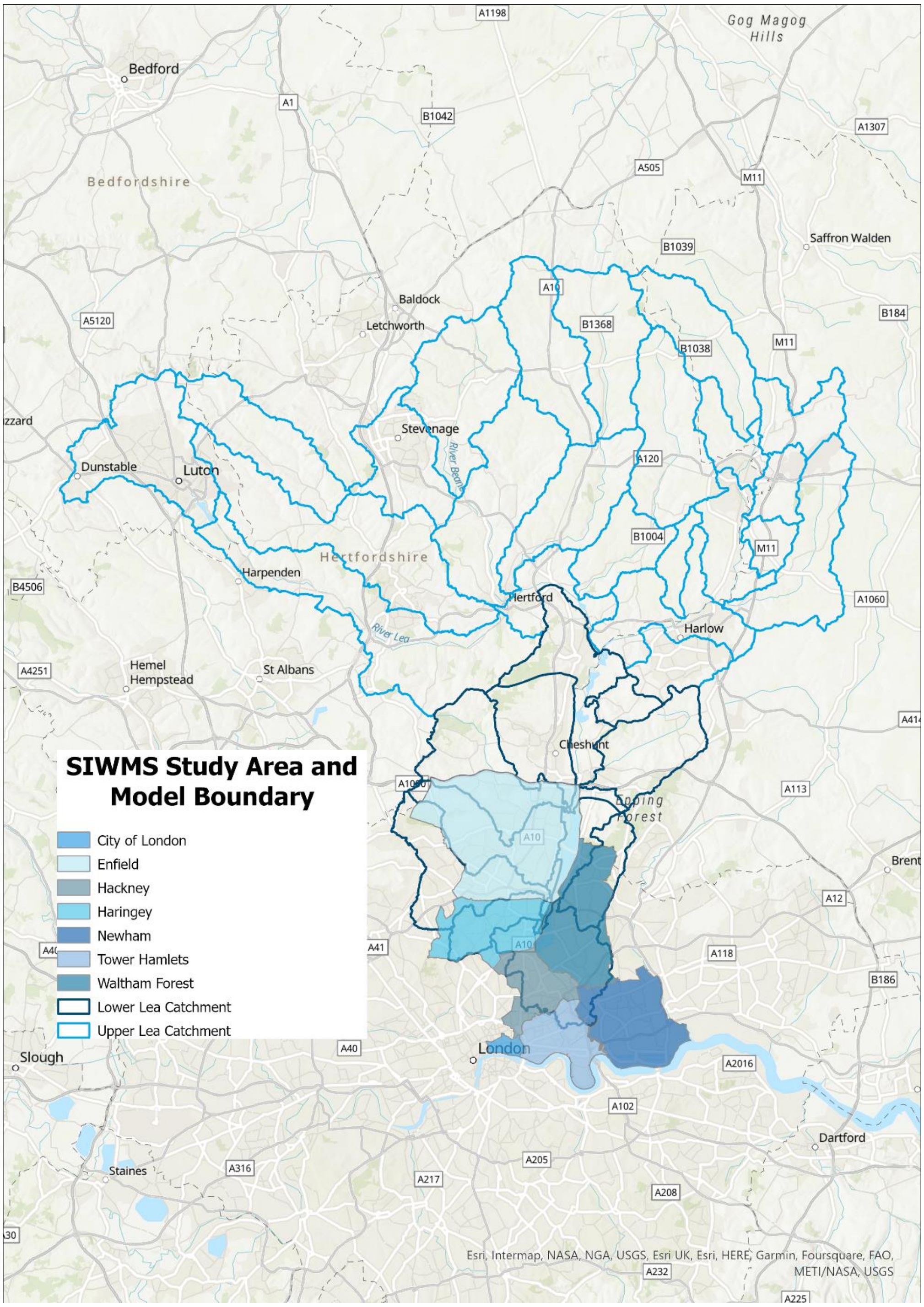
The boroughs within the study all had differing approaches to water use policies and surface water management strategies which are tailored to their own risks. There is potential to align these plans going forward so that they are coordinated in their approach, providing benefit as the actions of individual boroughs can indirectly impact others downstream. The future constraints and opportunities related to growth and water management identified in the baseline informed the scenario analysis in Section 3.

2.4 Baseline modelling

Figure 2.7 highlights the 35 sub-catchments in the River Lea catchment modelled in the Water Systems Integration Modelling Framework (WSIMOD) which was used for this study. As changes in the upper sub-catchments outside of the study scope could impact the water systems across the subregion, the

Upper Lea has been modelled. However, only the results for sub-catchments within the subregion are included in the SIWMS. The model boundary selection process is detailed in Appendix F Model Boundaries.

Figure 2.7: Modelled area showing Upper Lea and the SIWMS study area (Lower Catchment) with local boroughs



Source: Environment Agency[3], Greater London Authority[4]. Based on the Ordinance Survey Map with the Sanction of the Controller of H.M Stationery Office License Number:- 100019345

The WSIMOD software used for modelling is an open-source software package developed by Imperial College London. Results are presented for the 12 sub-catchments in the SIWMS study area (Figure 2.1). It includes model representation of all key elements of the water cycle in both urban and rural environments. These modelled elements are designed to interact with each other, allowing for flexible representation of the water cycle to accommodate different built and natural infrastructure configurations. This allows for an integrated assessment of the impacts of planning, development, and intervention scenarios on various environmental indicators such as water quantity, quality and resources for the subregion. Appendix D outlines more detail on the WSIMOD model and how it has been applied for this project.

The Baseline Report provided model calibration and validation. Calibration of the model has been undertaken using open-source water quality and flow data to demonstrate that the model represents key processes within the River Lea. As Beckton discharges to the River Thames and Deephams discharges to the River Lea, our modelling is more sensitive to Deephams STW. Our time series model matches well with reservoir levels in low flows, but less so in high flows. This is likely because we have not modelled the whole Water Resource Zones and the transfers from Thames Lea Tunnel are assumed in our model. This was discussed and agreed with the steering group as low flows are more critical for assessing water resource availability and impact on water stress. Where there are discrepancies, assumptions may have been added to the model (e.g. Pymmes Brook misconnections) to be more representative of our calibration data. We agreed with the steering group that we could continue with the current level of calibration.

[3] Lee Lower Rivers and Lakes Operational Catchment | Catchment Data Explorer

[4] Statistical GIS Boundary Files for London - London Datastore

3 Scenario analysis

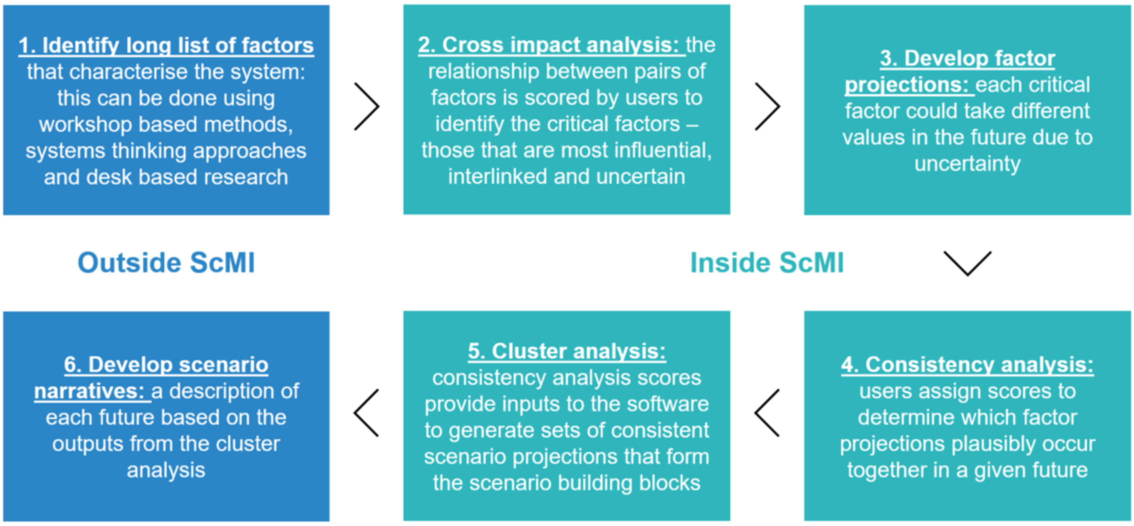
3.1 Scenario overview

East London is earmarked for significant growth which will have complex feedbacks on water management in the area. Future scenarios related to growth, water and climate change have been developed to inform a strategic understanding of future risks, issues and opportunities. External factors such as climate change, the economy, environmental policy, consumer activities and technology create future uncertainties around the interaction between growth and water. These factors will drive uncertainty around outcomes for people and the environment. Systems mapping (see Baseline report) and an internal workshop using expert knowledge identified the factors used to inform the pilot SIWMS. Each scenario developed is a projection of factors which could easily occur together and are therefore considered plausible future states. However, it is important to note that there is variance within each scenario and some, or all, of these factors may not happen. The planning horizon selected for the future scenarios was to 2050, as this aligns with the Thames Water planning horizons. The growth projections for the 2050 planning horizon extends beyond the 2041 growth projections stated in the London Plan where there is reasonable confidence. To understand how these future scenarios interact with the water environment, they were applied to the WSIMOD model.

3.1.1 Scenario method

A structured scenario development methodology was used to create plausible future scenarios. An overview of the method is provided in Figure 3.1, and Appendix A Scenario approach outlines the method in more detail.

Figure 3.1: Steps in the scenario development using a Scenario Manager software developed by ScMI[5]



3.1.2 Scenario factors

We used the following factors (informed by the baseline analysis) in the development of scenarios:

- Opportunity areas – includes targeted projections for housing and job growth linked to defined opportunity areas (confirmed only);
- Urbanisation (city) – includes the level of urban growth based Greater London Authority (GLA) growth figures for the catchment;
- Urbanisation (rural) – includes the level of growth in the upper Lea catchment, based on Office for National Statistics (ONS) and the increase in runoff area assuming developed land to accommodate future growth is greenfield;
- Adaptation[6] – includes the level of cultural shift towards environmental enhancement in the Upper Lea, and relates directly to uptake of SuDS features in the upper Lea and environmental enhancements due to improve water quality such as the WINEP programme and reduction in spills from combined sewer overflows to the river;
- Upstream abstraction regime – includes licence changes set by the Environment Agency to reduce the amount of abstraction permitted in the chalk streams;

[5] https://www.scmi.de/en/software/scenario-manager%E2%84%A2

[6] (WINEP changes to sewage treatment plants were from the initial position for WINEP at the time of the study. These are known to have been developed since)

- Level of demand for water – based on different per capita consumption (PCC) projections;
- Climate change – includes historic and future climate projections for each scenario.

A combination of factor variables that are likely to occur together then influenced each scenario output.

3.1.3 Scenario outputs

The scenario methodology created five possible future scenarios: City Living; Unrealised Urbanisation; Country Life; Prosperous Growth; and Environmental Priority. These scenario narratives are outlined below, and Appendix A Scenario approach provides more detail on all five scenarios along with all the modelling assumptions. The upper and lower Lea boundaries (see Figure 2.7) were used to differentiate growth in rural and urban areas, respectively.

Country Life

In this future scenario more people have decided they want to live in the countryside rather than the city. Therefore, rural urbanisation has increased, while city growth in the lower river Lea catchment has not increased as projected. Opportunity areas have only achieved 50% of their potential and water demand in the subregion drops. As people are living in the countryside, they place more importance on the environment and this results in a large number of adaptations such as nature-based solutions, and pressure to restore chalk streams in the upper Lea. As economic growth has been moderate, they have the money to spend on these environmental enhancements.

Modelling assumptions summary:

- Opportunity areas – projected growth in opportunity areas assumed at 50% of total estimated occupancy and population updated in the respective sub-catchments to reflect localised impact
- Urbanisation (city) – projected growth in subregional study area (i.e. within GLA boundary) is low and population is updated to reflect a low growth scenario
- Urbanisation (rural) – projected growth in upper Lea catchment is high and population is updated to reflect high growth scenario; development is assumed to take place in greenfield areas therefore additional impermeable areas have been added to represent increase in roof and paved areas in the upper Lea catchment. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year

- Adaptation – This scenario assumes a high uptake in SuDS in the upper Lea catchment, with a reduction in impermeable area of 20%; all proposed WINEP schemes to address water quality at sewage treatment works draining to the upper Lea are realised
- Abstraction regime changes– Enhanced sustainability reductions, including a reduction of 82% in the Thames Water abstraction zones.
- Level of demand for water – New growth areas achieve a reduced PCC of 90l/p/d and existing housing stock PCC reduces by 15l/p/d.

City Living

In the City Living scenario more people choose to live as close to the centre of London as they can afford, and therefore opportunity areas are very successful. There’s high urbanisation within the London boroughs as well as increased urbanisation in the commuter belt. Impacts to the environment in central London, caused by increased population, result in some focus on environmental protection which is supported by a moderate economic growth.

Modelling assumptions summary:

- Opportunity areas – projected growth in opportunity areas assumed at 100% of total estimated occupancy and population updated in the respective sub-catchments to reflect localised impact
- Urbanisation (city) – projected growth in subregional study area (i.e. within GLA boundary) is high and population is updated to reflect a high growth scenario, outside of the opportunity areas. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of 4m^2 per year. New properties are assumed to be predominantly built on brownfield sites, so net change in impermeable area is zero.
- Urbanisation (rural) – projected growth in upper Lea catchment is high and population is updated to reflect high growth scenario; development is assumed to take place in greenfield areas therefore additional impermeable areas have been added to represent increase in roof and paved areas in the upper Lea catchment. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of 4m^2 per year
- Adaptation – This scenario assumes a low uptake in SuDS in the upper Lea catchment, with a reduction in impermeable area of 1%; proposed WINEP schemes at selected sewage treatment works draining to the upper Lea are realised (East Hyde, Rye Meads and Harpenden only)

- Abstraction regime changes – Moderate sustainability reductions, including a reduction of 57% in the Thames Water abstraction zones
- Level of demand for water – PCC remains high or increases further up to 160l/p/d.

Unrealised Urbanisation

In the Unrealised Urbanisation scenario, economic growth has been low. This has meant that Opportunity Areas have seen low growth and success, as people couldn't afford to move to the city. Attempts at building infrastructure to allow for growth have taken place, leading to increased urbanisation, which is not being utilised to its full extent. There is no spending on environmental adaptations, such as nature-based solutions, as finances have been required elsewhere on social benefits. There are baseline sustainability reductions with regards to upstream abstraction regime alterations and the demand for water remains the same as the baseline.

Modelling assumptions summary:

- Opportunity areas – projected growth in opportunity areas assumed at 50% of total estimated occupancy and population updated in the respective sub-catchments to reflect localised impact
- Urbanisation (city) – projected growth in subregional study area (i.e. within GLA boundary) is moderate and population is updated to reflect a moderate growth scenario. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year. New properties are assumed to be predominantly built on brownfield sites, so net change in impermeable area is zero.
- Urbanisation (rural) –projected growth in upper Lea catchment is low and population is updated to reflect low growth scenario; development is assumed to take place in greenfield areas therefore additional impermeable areas have been added to represent increase in roof and paved areas in the upper Lea catchment, but fewer houses are built overall. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year.
- Adaptation – As the environment is not a priority, only 1% of impermeable area in the upper Lea is replaced with SuDS. No WINEP schemes are promoted for future scenarios.
- Abstraction regime changes – As the environment is not a priority, there are no proposed changes to abstraction licences
- Level of demand for water – PCC is assumed to remain as current (ranging from 140-160l/p/d)

Prosperous Growth

The leading factor in Prosperous Growth is that there has been high economic growth and therefore spending. Opportunity areas are successful, there's high urbanisation in the city and rural areas, and this spending also benefits the environment. Increased environmental protection measures are implemented such as nature-based solutions, flood resilience and digital technology, resulting in the need for water being low per capita. It's important to understand that the difference in this scenario is that the culture towards the environment has not changed as a whole, it's simply that prosperity encourages funding of the measures that environmental protectors deem necessary.

Modelling assumptions summary:

- Opportunity areas – projected growth in opportunity areas assumed at 100% of total estimated occupancy and population updated in the respective sub-catchments to reflect localised impact
- Urbanisation (city) – projected growth in subregional study area (i.e. within GLA boundary) is high and population is updated to reflect a high growth scenario. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year. New properties are assumed to be predominantly built on brownfield sites, so net change in impermeable area is zero.
- Urbanisation (rural) –projected growth in upper Lea catchment is high and population is updated to reflect high growth scenario; development is assumed to take place in greenfield areas therefore additional impermeable areas have been added to represent increase in roof and paved areas in the upper Lea catchment. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year.
- Adaptation – This scenario assumes a high uptake in SuDS in the upper Lea catchment, with a reduction in impermeable area of 20%; all proposed WINEP schemes to address water quality at sewage treatment works draining to the upper Lea are realised
- Abstraction regime changes – Moderate sustainability reductions, including a reduction of 57% in the Thames Water abstraction zones.
- Level of demand for water – PCC is assumed to reduce to 105l/p/d

Environmental Priority

The Environmental Priority scenario is the opposite to that of Prosperous Growth. The culture towards the environment has ultimately changed within the population such that the public have a high ambition for the environment, enhanced adaptations and enhanced sustainability reductions for upstream abstractions are undertaken. Digital technology and environmental groups become more popular through education, and the level of demand for water is low per capita because of this. The change in culture is supported by moderate economic growth, which supports the opportunity areas which are successfully increasing urbanisation in the city.

Modelling assumptions summary:

- Opportunity areas – projected growth in opportunity areas assumed at 100% of total estimated occupancy and population updated in the respective sub-catchments to reflect localised impact
- Urbanisation (city) – projected growth in subregional study area (i.e. within GLA boundary) is high and population is updated to reflect a high growth scenario. Urban creep has also been allowed for as people extend their driveways and homes, at a rate of $4m^2$ per year. New properties are assumed to be predominantly built on brownfield sites, so net change in impermeable area is zero.
- Urbanisation (rural) –projected growth in upper Lea catchment is moderate and population is updated to reflect moderate growth scenario; development is assumed to take place in greenfield areas therefore additional impermeable areas have been added to represent increase in roof and paved areas in the upper Lea catchment, although this is lower than in other scenarios as we aspire to protect green spaces. People are aware of their impact on the environment and therefore no creep has been allowed for.
- Adaptation – This scenario assumes a high uptake in SuDS in the upper Lea catchment, with a reduction in impermeable area of 20%; all proposed WINEP schemes to address water quality at sewage treatment works draining to the upper Lea are realised
- Abstraction regime changes – Moderate sustainability reductions, including a reduction of 57% in the Thames Water abstraction zones.
- Level of demand for water – PCC is assumed to reduce to 105l/p/d

Each scenario has been modelled under different climate change projections based on the pathways referred to as “Representative Concentration Pathway” or RCP: RCP 2.6 (“best-case” scenario), RCP 8.5 (“worst-case” scenarios) and RCP 2.6 with unseasonable changes. The impact is to affect the rainfall and evaporation processes used in the modelling. However, there was not much variance in the results because of the dominance of the abstraction licence changes. We therefore report the results from the RCP 2.6 climate change scenario.

3.1.4 Identifying scenario risks

Scenarios were modelled to identify changes across the river metrics (informed by the baseline analysis - see Section 2.2) for the subregion. Threshold classifications for river metrics have been used to identify key risks from the scenario analysis (Table 3.1). Any changes to these metrics help to inform the action required for the SIWMS. Water quality thresholds are based on a Water Framework Directive (WFD) report[7]. Water quantity thresholds are based on relative change from baseline as the impacts from high and low flows are dependent on local conditions. Changes to high flows are used as a proxy for flood risk, and changes to low flows are used as a proxy for drought risk. Water stress is measured separately based on availability of water at Coppermills STW. Water stress is informed by the metric ‘days of water stress’, which is the number of days that the reservoir is not in their ideal storage range (see Appendix D for more detail).

Table 3.1: Thresholds used to classify river metrics. Ammonia, Phosphate and Nitrate units are mg/l. Drought and flood risk units are % change relative to baseline, where no change would be 0%.

Metric	High	Good	Moderate	Poor	Fail
Ammonia	<0.3	<0.6	<1.1	<2.5	>2.5
Phosphate	<0.05	<0.12	<0.25	<1	>1
Nitrate	<5	<8	<10	<40	>40
Drought risk (Q95)	>50	>10	>-10	>-50	<-50
Flood risk (Q5)	<-20	<-5	<5	<20	>20

3.2 Scenario modelling results

This section provides an overview of the modelling results for future scenarios. Full results can be found in Appendix D. It should be noted that the results and interpretations are subject to modelling limitations which are also outlined in the Appendix. Appendix A provides more detail on all five scenarios along with the modelling assumptions.

3.2.1 Summary results

Figure 3.2 highlights the relative change for each metric in future scenarios compared to their baseline value. The percent changes are aggregated for the subregion and therefore provides a high-level summary of the water quantity and quality changes under future scenarios. In summary:

- Flood risk increases due to more water in the system from reduced abstractions

[7] https://www.daera-ni.gov.uk/sites/default/files/publications/doe/UKTAG-environmental-standards-and-conditions-phase-1.PDF

- Ammonia decreases by a small amount in City Living
- Ammonia decreases more in Country Life and Environmental Priority due to increased dilution from more significant abstraction limits
- Ammonia increases in Prosperous Growth
- Drought risk reduces in Country Life, Environmental Priority and Prosperous Growth. This is because low flows are replenished by upstream effluent in Prosperous Growth, Country Life and Environmental Priority through abstractions.
- There are reductions in nitrate with the exception of Prosperous Growth
- Phosphate levels are also reduced which are driven by WINEP changes

Figure 3.3 highlights the results from the scenarios across the water quality and water quantity with climate change RCP 2.6 scenario based on threshold classification changes in each sub-catchment. It provides more spatial variance across the sub-catchment compared to Figure 3.2. Threshold classification changes were used to select which scenarios to pursue for the pilot study. Modelling results at the threshold level (as opposed to relative value changes) suggested that the Baseline and Unrealised Urbanisation are similar, City Living and Prosperous Growth are similar, and Country Life and Environmental Priority are similar. This was investigated and it was found that the planned abstraction licence changes were so significant that they outweighed the other scenario factors. Therefore, we decided to focus on two scenarios, the Baseline, City Living and Country Life, to demonstrate the proof of concept for the SIWMS. This reduces the complexity in the results whilst demonstrating the value of an integrated approach at the subregional level in this pilot project. The results for each focus areas are discussed in more detail in the following sections.

Figure 3.2: Percent change in Baseline value for each metric under future scenarios and climate change

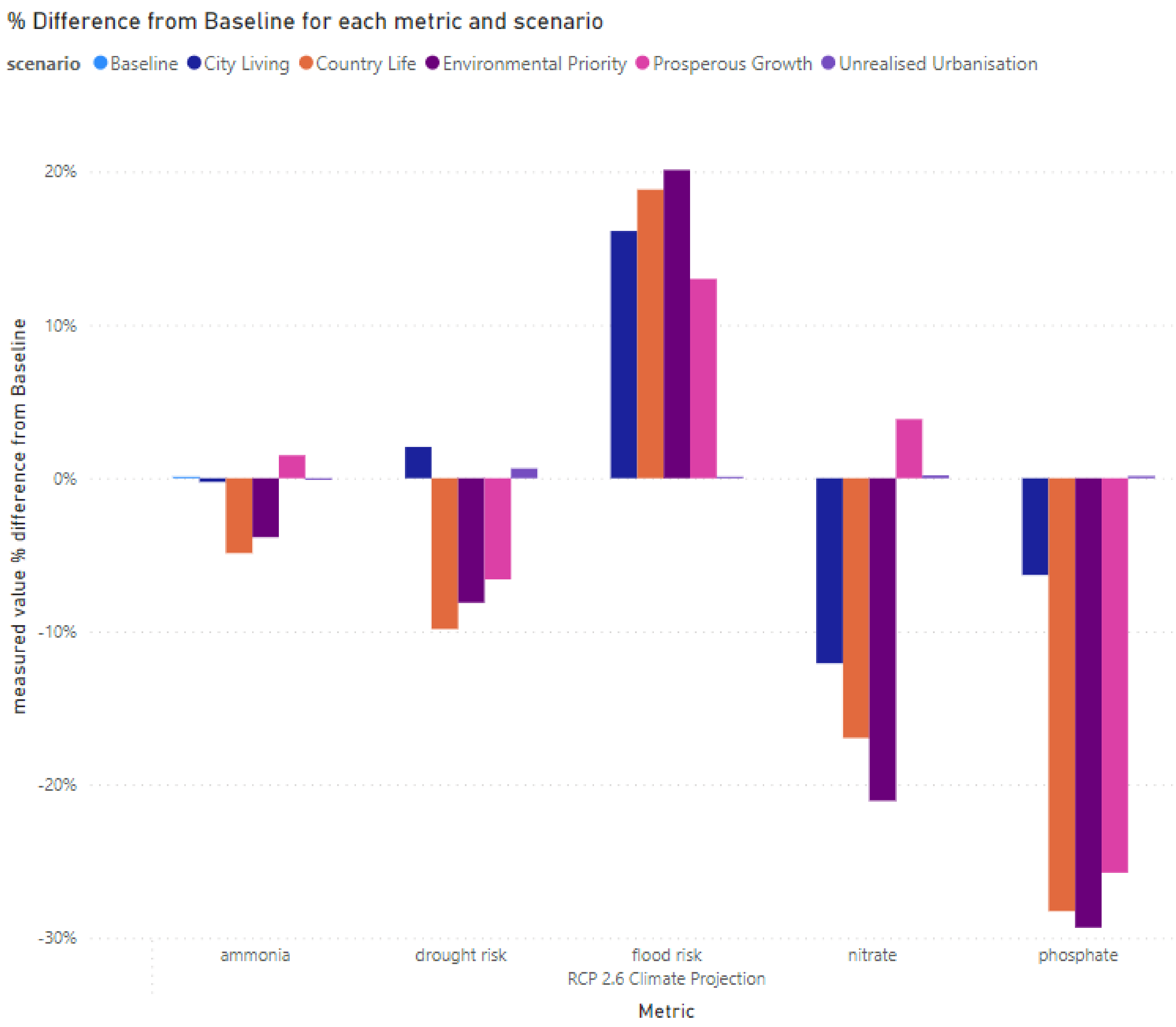
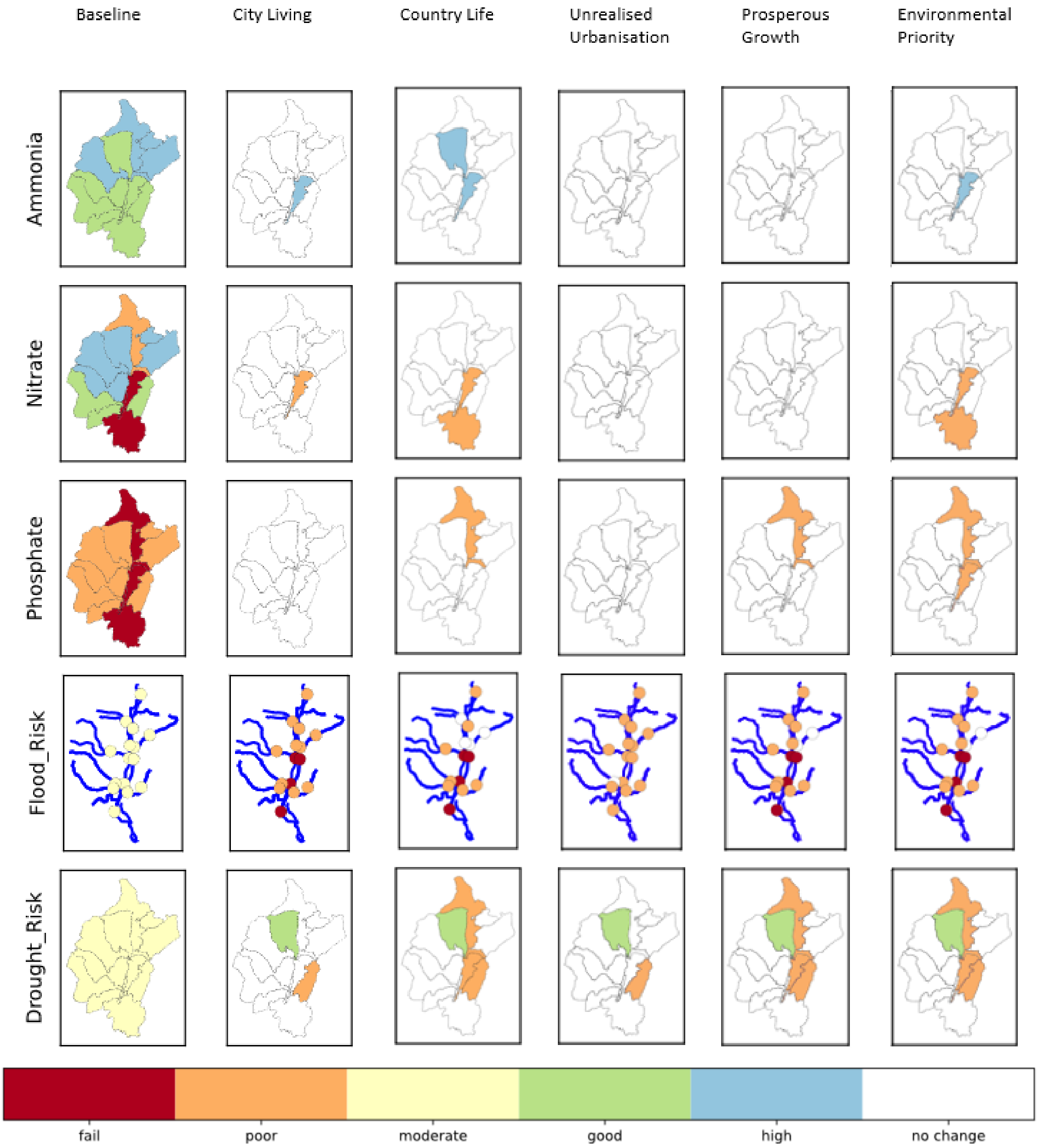


Figure 3.3: Scenario impacts with climate change RCP 2.6 scenario.



3.2.2 Water quality

Water quality is measured using nitrate, phosphate and ammonia levels and presented in the format of the WFD classifications. We took forward Country Life and City Living scenarios for a more detailed discussion on the impacts of various water quality metrics.

Baseline

In the Baseline scenario, Figure 3.3 illustrates that phosphate levels are high, and most areas have a poor or fail WFD threshold classification. Ammonia WFD classifications are good or high, whilst nitrate thresholds vary across the subregion.

Country Life

Phosphate levels remain high in this scenario. There are some positive effects of the WINEP treatment plant improvements in reducing the amount of phosphate in the River Lea. For example, phosphate levels reduce by 28% in this scenario under climate change (see Figure 3.2). However, only one WFD classification threshold improved (see Figure 3.3). Moreover, these phosphate reductions become less noticeable as the river Lea flows downstream, primarily because the Deephams effluent also flows into it.

Ammonia and nitrate levels reduce in this scenario. Figure 3.2 shows that ammonia levels drop by around 5% and nitrate levels drop by around 17% across the subregion. In some sub-catchments, there is enough of a change from the Baseline to cause a WFD threshold improvement as illustrated in Figure 3.3. For example, two sub-catchments in Enfield and Waltham Forest improve their WFD classification of ammonia from ‘good’ in the Baseline to ‘high’ in Country Life. Two sub-catchments (located in Enfield, Waltham Forest, Hackney, Newham and Tower Hamlets) improve their WFD classification of nitrate from ‘fail’ in the Baseline to ‘poor’ in Country Life. These improvements in the main River Lea are attributable to the licence changes.

City Living

Phosphate WFD thresholds remain the same in this scenario in each sub-catchment (Figure 3.3). However, the WINEP treatment plant improvements have some positive impacts in reducing the amount of phosphate in the River Lea. Figure 3.2 shows a 6% reduction in phosphate across the subregion. These phosphate reductions become less noticeable as the river Lea flows downstream, primarily because the Deephams effluent also flows into it.

One WFD classification threshold was improved for nitrate and one improved for ammonia Figure 3.3). This sub-catchment is in Enfield and Waltham Forest. However, the high urban population growth outweighs most benefits to nitrate and ammonia attributable to the WINEP-driven licence changes in the Lower Lea south of the M25 in this scenario.

3.2.3 Water quantity

We took forward Country Life and City Living scenarios for a more detailed discussion on the impacts on water quantity metrics. Water quantity is measured using high and low flow data. A change in high flows represents a change in flood risk. A change in low flows represents a change in drought risk.

Water quantity changes in future scenarios are relative to the baseline value. Figure 3.3 highlights flood points which have been selected based on known areas of flood risk informed by the EA maps. However, in our analysis, high flows for each sub-catchment were compared to their baseline value as a proxy for flood risk within each sub-catchment. Increased high flows will likely result in increased risk to areas prone to flooding.

Baseline

Both high and low flows have a moderate status in the baseline scenario to identify key changes in future scenarios. Therefore, flood risk and drought risk start out at zero change in the Baseline.

Country Life

The primary impacts of climate change are in flood risk, with nearly every point worsening under the RCP 2.6 scenario. As Figure 3.3 shows, the most downstream flood point has an increased risk from moderate to fail in this scenario. At the Lea (Tottenham Locks to Bow Locks/ Three Mills Locks) sub-catchment, our analysis shows that high flows increase by 33%. This suggests an increased likelihood of flooding at known flood points in the downstream boroughs of in Tower Hamlets, Newham and City of London. Abstraction licence changes also worsen flood risk. In Country Life, which has no urban creep, we can see the benefits of the adaptation reductions in impervious areas through a reduction in the flood risk in many urban catchments and the main river Lea (Figure 3.3). However, Figure 3.2 shows the percentage change in high flows across the subregion, suggesting that flood risk increases overall compared to baseline flows.

Drought risk worsens in the Country Life scenario with climate change in three sub-catchments (in Enfield and Waltham Forest), whilst one sub-catchment (in Enfield) has a threshold improvement (Figure 3.3). As effluent is important in supporting low flows, the Upper Lea per capita reductions in this scenario have a negative impact on drought risk.

City Living

Flood risk worsens under the RCP 2.6 scenario in City Living. As Figure 3.3 shows, the most downstream flood point has an increased risk from moderate to fail in this scenario. At the Lea (Tottenham Locks to Bow Locks/ Three Mills Locks) sub-catchment, our analysis shows that high flows increase by 39%. This suggests an increased likelihood of flooding at known flood points in the downstream boroughs. Abstraction licence changes also worsen flood risk. The adaptation reductions in impervious area are counterbalanced by urban creep in this scenario.

Drought risk remains moderate across most areas in the subregion (Figure 3.3). However, under RCP 2.6 there is one threshold improvement in one sub-catchment (as low flows increase by 10% from baseline values) in Enfield and one threshold reduction in one sub-catchment (as low flows decrease by 11% from baseline values) in Waltham Forest in this scenario.

3.2.4 Water resources

Water stress is measured separately based on availability of water at Coppermills STW (and therefore not presented by sub-catchment). Table 3.2 shows the impact of the scenarios on water resources under City Living and Country Life. The average number of days per year when reservoirs are not in their ideal storage range increases significantly under both City Living and Country Life, causing a future risk to water resources. Therefore, the two variations on proposed abstraction licence changes (moderate reductions and severe reductions) used in the two scenarios have a significant impact on water resources.

Table 3.2: Scenario impacts on water resources

Scenario	Days of water stress/year	% of days of water stress per year
Baseline	88	24%
City Living (with climate change RCP 2.6)	234	64%
Country Life (with climate change RCP 2.6)	363	99%

In summary, the two variations on proposed abstraction licence changes (moderate reductions in City Living and severe reductions in Country Life) have far-reaching impacts, providing some water quality improvements in the Lower Lea compared to the Baseline. Water resources are a significant risk under both scenarios, but particularly under Country Life. Flood risk is also increased significantly, particularly in the City Living scenario. Phosphate levels remain high in both scenarios.

Modelling results provide insights on how the scenarios can produce multiple impacts across the four core systems of interest: water resources, wastewater, water quality/environment and flooding across the subregion. Potential intervention options to mitigate the adverse impacts of these scenarios and maximise co-benefits can also be explored in the WSIMOD model, as discussed in Option identification and analysis.

4 Option identification and analysis

4.1 Overview of option identification and selection for modelling

We reviewed planning documents from water companies, the Environment Agency and local authorities to identify planning options which could have an impact on the catchment's water system. We screened options to select those which have an impact at the subregional scale. Options which would be beneficial at a local scale were excluded because these impacts would not be seen on such a large scale for the SIWMS. Options which were taken forward were further categorised as either 'wider enabling options' which were not modelled but would have an overall catchment benefit, or 'modelled options' which were included in the WSIMOD model to assess their impact on environmental indicators across the subregion. Appendix B outlines the methodology for selecting these options.

The plans considered for option identification were:

- TW WRMP
- TW DWMP
- EA RBMP
- EA FRMP
- TE2100 Plan
- WINEP
- Newham LFRMS
- City of London LFRMS
- Enfield LFRMS
- Haringey LFRMS
- Hackney LFRMS
- Waltham Forest LFRMS
- Tower Hamlets LFRMS
- Isle of Dogs and South Poplar IWMS

4.2 Wider enabling options

The 'wider enabling' options primarily focus on improving awareness and communication between communities, planning authorities and infrastructure providers and reinforcing collaboration. Table 4.1 provides a description of the wider enabling options included. These options are important for ensuring the longevity of the SIWMS plan and to help create action on the ground.

Table 4.1: Description of wider enabling options

Option	Description	Plan
Skills through training	A programme to empower members of the community to	EA Thames RBMP

Option	Description	Plan
	effectively engage and raise issues with statutory bodies.	
Engaging communities	Engage communities through improving knowledge and understanding of the catchment and the impact of their behaviour on the water environment.	EA Thames RBMP and LFRMS’
Community partnership officer	Employment of a full-time Community Partnership Officer to further engage communities, provide volunteering opportunities, coordinate ‘friends of’ groups and river champions across the catchment in a community focused, ‘grassroots’ partnership.	EA Thames RBMP
Lea catchment website	Website for collating information on projects, news and events across the catchment and publicising them.	EA Thames RBMP
Coordination of development	Coordination of work underway to improve planting, drainage, and water quality.	The Isle of Dogs and South Poplar IWMP and LFRMS
Sustainable policy	Ensure local planning policy sets out minimum requirements for flood mitigation measures.	LFRMS’
Establish and maintain partnerships	Clarify roles/responsibilities of all risk management authorities and key stakeholders. Also includes identifying and monitoring funding sources, while reviewing resources available within the council for flood risk management.	LFRMS’
Communicate with at risk communities	Develop effective methods for communicating and sharing flood risk information with at risk communities.	LFRMS’
Supporting privately owned water assets	Establish consenting procedures to control building of structures that may affect water flow and	LFRMS’

Option	Description	Plan
	advertise consenting procedures across London Boroughs.	
Partnership approach to flood risk management	Local Boroughs will continue to actively engage in the LoDEG & Drain London Forum to contribute to a coordinated London-wide approach to flood risk management. The newly formed Strategic Surface Water Governance Group will also support collaborative approaches between the GLA, Thames Water, TFL, London Councils and the Environment Agency and political representatives from London Boroughs who are all involved.	LFRMS'
Promote flood resistance and resilience measures	Identify properties where an acceptable standard of protection cannot be achieved and promote individual property protection measures.	LFRMS'
Information sharing	Information sharing mechanisms investigated and created by the boroughs in the study area.	LFRMS'

4.3 Modelled options

Table 4.2 provides a description of the options included for WSIMOD modelling and their corresponding plans. For more detail on the modelling approach, see Appendix D.

Table 4.2: Description of modelled options

Option	Plan	Description	Limitations
Natural capital	EA Thames RBMP, WINEP and TE2100 plan	Options which improve natural capital sites (such as river and lake restoration, diffusing pollution, management of freshwater invasive species, and habitat	Existing plans around natural capital are vague so there are high assumptions around how the option could be implemented and the impact this may have on the river catchment implementation. Due to

Option	Plan	Description	Limitations
		restoration on wetland sites).	timescale limitations, modelling is based on regenerative farming to 50% of agricultural land in the Upper Lea, which increases percolation by 50% and the soil field capacity by 10%.
Deephams reuse	Thames WRMP	Implements a wastewater reuse scheme at the Deephams sewage treatment works, with a target of 46 Ml/d of water being recycled by 2061. (This figure was the most relevant at the time of modelling it has since been superseded by more recent WRMP versions)	The planned date is out with the planning timeframe used in this project (2050).
London WRZ	Thames WRMP	Improve water resources in the London Water Resource Zone (WRZ) by supplementing water via water transfers. This will contribute to providing an additional 175 Ml/d to the London WRZ.	Boundary limitations mean that potential trade-offs with other areas across the river metrics have not been identified. This is being considered by WRSE however.
Metering	Thames WRMP and Local Plans	A progressive metering plan (PMP) which aims to install a smart meter technology in 73% of homes within the London WRZ by 2030 to reduce personal consumption from 143 l/p/d to 124 l/p/d by 2045. Local planning authorities have water consumption targets of 105 l/p/d for new developments. The modelled option was set at	Results will require spatial interpretation as London Boroughs are served by both Deephams and Beckton sewage catchments which wi ll have differing impacts on the River Lea

Option	Plan	Description	Limitations
		105 l/p/d for the whole study area.	
Leakage reduction	Thames WRMP	Targets to reduce leakage by 122.4 Ml/d from 2020-2024 as well as a further 76 Ml/d leakage reduction in London across up to 2035	Difficulties in locating and fixing leaks. Improving groundwater modelling in future WISIMOD modelling could highlight river metric trade-offs worth investigating.
SuDS	Thames Water DWMP for London and LFRMS of the Boroughs within the subregion	Reduce flood risk by attenuating water and disconnecting surface water from combined sewer networks. Both disconnection and attenuation measures are considered.	SuDS have been considered at scale for the SIWMS, with 4-13% of the sub-catchment areas converted to SuDS. Modelling individual, smaller areas of SuDS does not provide reasonable evidence at the subregional scale. Modelling of SuDS as an option relates to retrofitting, rather than implementing new SuDS through developments: these are included through growth scenarios referred to in Section 3.
Reducing misconnections	LFRMS, EA Thames RBMP and Thames Water DWMP	Measures to identify and disconnect foul sewers that connect to surface water sewers to improve water quality and separate flows from sewer systems.	Due to the substantial uncertainties associated with modelling misconnections, we have separately performed an ancillary data analysis for misconnections in the Pymmes Brook in Appendix D.

Although reducing misconnections was identified as an option for modelling during the screening process, it was not taken forward due to substantial uncertainties associated with modelling misconnections. To demonstrate the potential, we did a small case study on an area we identified in the baseline (Pymmes Brook located in Enfield and Haringey) where we had to add additional polluted flow to get a good calibration. This identifies that, by locating and diverting misconnections, there is an improvement to local water quality, and subsequently, on biodiversity. We have separately performed an ancillary data analysis for misconnections in the Pymmes Brook in Appendix D.

Table 4.3 outlines the modelled combinations by scenario, option and climate change scenario. The model was run for the 12 sub-catchments in the subregion with results analysed for each water quality and water quantity metric. For water resources, the combinations remained the same, but the model was not run for each sub-catchment as discussed in Section 3.2.4. More climate change projections were also modelled for each scenario and option combination, as discussed in Appendix D.

Table 4.3: Model combinations by scenario, option and climate change projection

Scenario	Option	Climate change
Baseline	No option	No climate change
Baseline	Deephams reuse	No climate change
Baseline	Leakage reduction	No climate change
Baseline	Natural capital	No climate change
Baseline	London WRZ options	No climate change
Baseline	Metering options	No climate change
Baseline	SuDS	No climate change
Baseline	No option	RCP 2.6
Baseline	Deephams reuse	RCP 2.6
Baseline	Leakage reduction	RCP 2.6
Baseline	Natural capital	RCP 2.6
Baseline	London WRZ options	RCP 2.6
Baseline	Metering options	RCP 2.6
Baseline	SuDS	RCP 2.6
City Living	No option	No climate change
City Living	Deephams reuse	No climate change
City Living	Leakage reduction	No climate change
City Living	Natural capital	No climate change
City Living	London WRZ options	No climate change

Scenario	Option	Climate change
City Living	Metering options	No climate change
City Living	SuDS	No climate change
City Living	No option	RCP 2.6
City Living	Deephams reuse	RCP 2.6
City Living	Leakage reduction	RCP 2.6
City Living	Natural capital	RCP 2.6
City Living	London WRZ options	RCP 2.6
City Living	Metering options	RCP 2.6
City Living	SuDS	RCP 2.6
Country Life	No option	No climate change
Country Life	Deephams reuse	No climate change
Country Life	Leakage reduction	No climate change
Country Life	Natural capital	No climate change
Country Life	London WRZ options	No climate change
Country Life	Metering options	No climate change
Country Life	SuDS	No climate change
Country Life	No option	RCP 2.6
Country Life	Deephams reuse	RCP 2.6
Country Life	Leakage reduction	RCP 2.6
Country Life	Natural capital	RCP 2.6
Country Life	London WRZ options	RCP 2.6
Country Life	Metering options	RCP 2.6
Country Life	SuDS	RCP 2.6

4.4 Modelled option results

Option impacts can be identified by comparing the metric values to those in the baseline. Option impacts for future scenarios can be identified by comparing the new metric values for each scenario to the values in the scenario baseline. Option results are therefore interpreted within the context of the scenario changes. For water quality metrics, changes are based on WFD classifications. For river flow metrics, changes are based on relative change compared to the scenario baseline. For water resources, changes are informed by the number of days of water stress. See Table 3.1 for threshold bands.

The results of the options modelled against the Baseline, City Living and Country life scenarios are shown in Figure 4.1 and Figure 4.2 . The changes are aggregated for the subregion to provide an overview of the relative change in water quantity and water quality respectively. Water stress impacts are noted in Table 4.4 - Table 4.6. The modelled options are discussed in more detail from Section 0 onwards, and high-level findings are summarised here:

- SuDS have catchment-wide benefits in water quality and water quantity (Section 0)
- While Deephams reuse provides water resources in drought periods, it will naturally exacerbate problems of low flows (Section 4.4.2)
- London WRZ options reduce water stress without impact other modelled metrics (Section 4.4.3)
- Metering reduces water stress for consumers but has catchment-wide trade-offs across several metrics, such as exacerbating low flows (Section 4.4.4).
- Leakage reduction reduces water stress and does not impact other modelled metrics (Section 4.4.6)
- Natural capital is discussed in Section 4.4.5, Appendix B and Appendix D and is considered as future options to investigate in SIWMS (see Section 5.5.1).
- Misconnection option is discussed in Appendix B and Appendix D and is considered as future options to investigate (see Section 5.5.2).

Figures 4.1- 4.3 highlight the option impacts indicated by a change in threshold for each scenario for each sub-catchment in the study area. This section discusses key option results for the baseline scenario, City Living with climate change under RCP 2.6 and Country Life with climate change under RCP 2.6. Full results and assumptions are found in Appendix D. It should be noted that the results and interpretations are subject to modelling limitations which are also outlined in the Appendix.

Figure 4.1: Water quantity percent change when options are modelled against the Baseline, City Living and Country Life scenarios

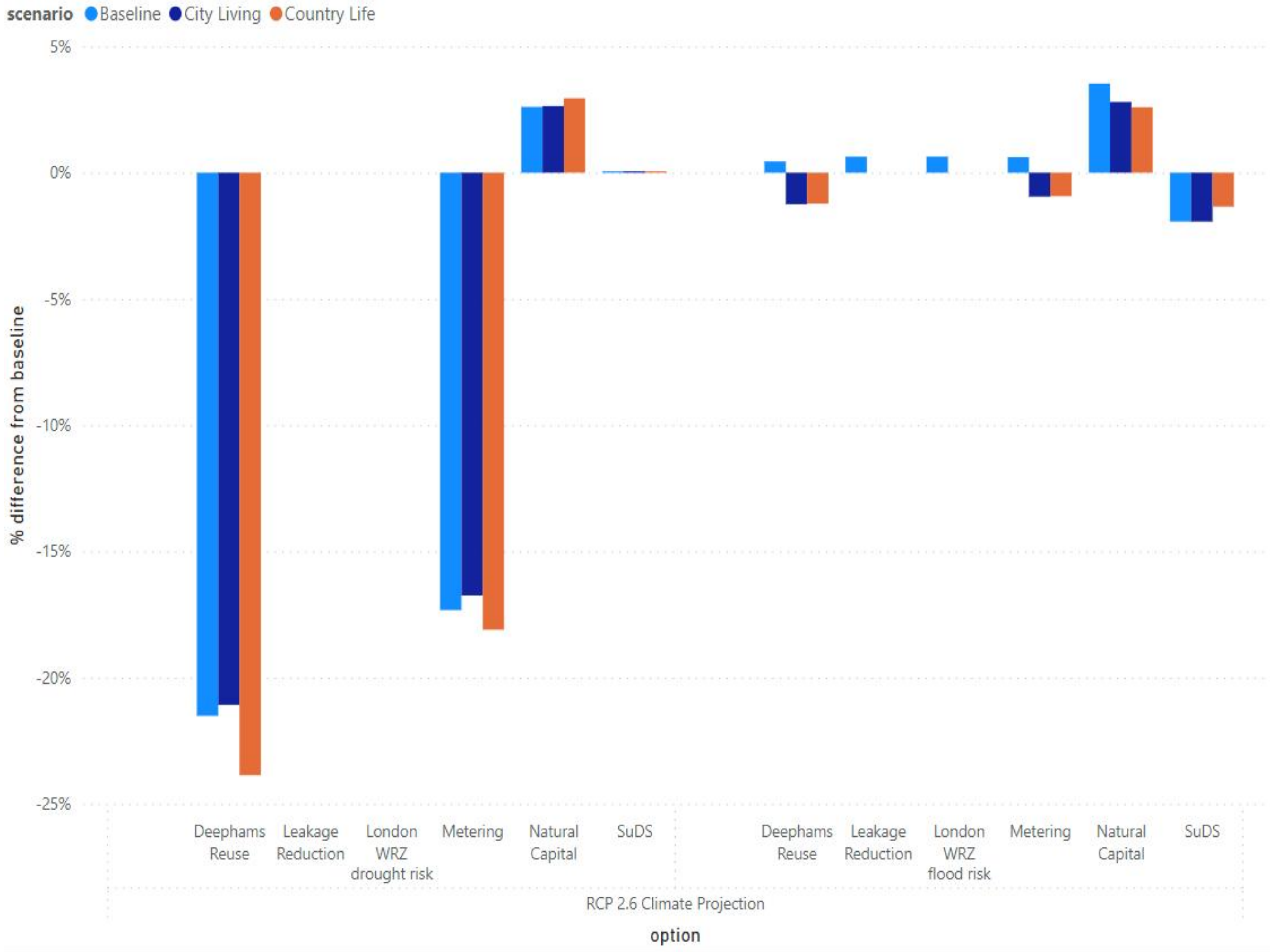


Figure 4.2 Water quality percent change when options are modelled against the Baseline, City Living and Country Life scenarios

Figure 4.3: Option impacts indicated by a threshold change in Baseline scenario with no climate change

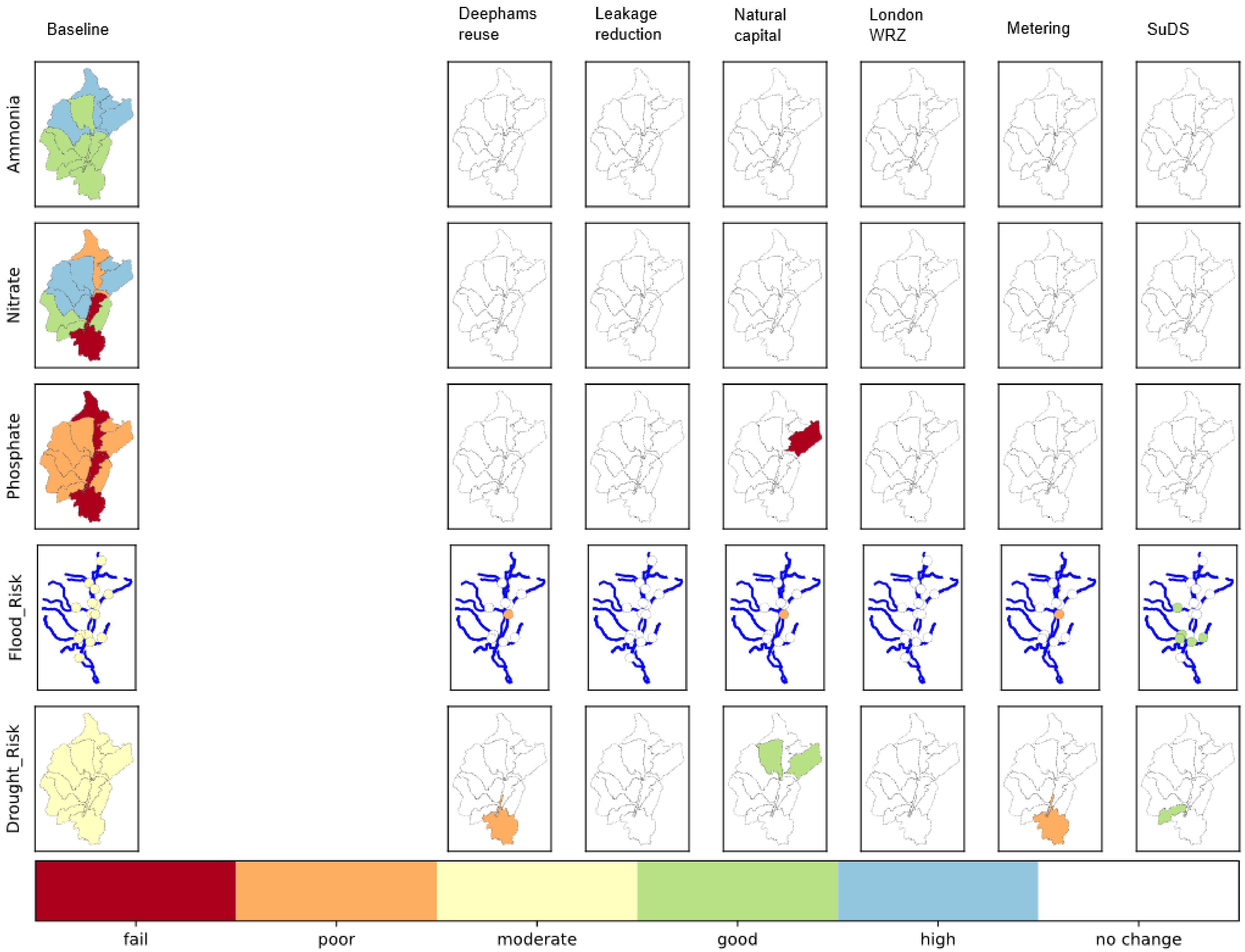


Figure 4.4: Option impacts indicated by a threshold change under City Living Scenario with climate change (RCP2.6)

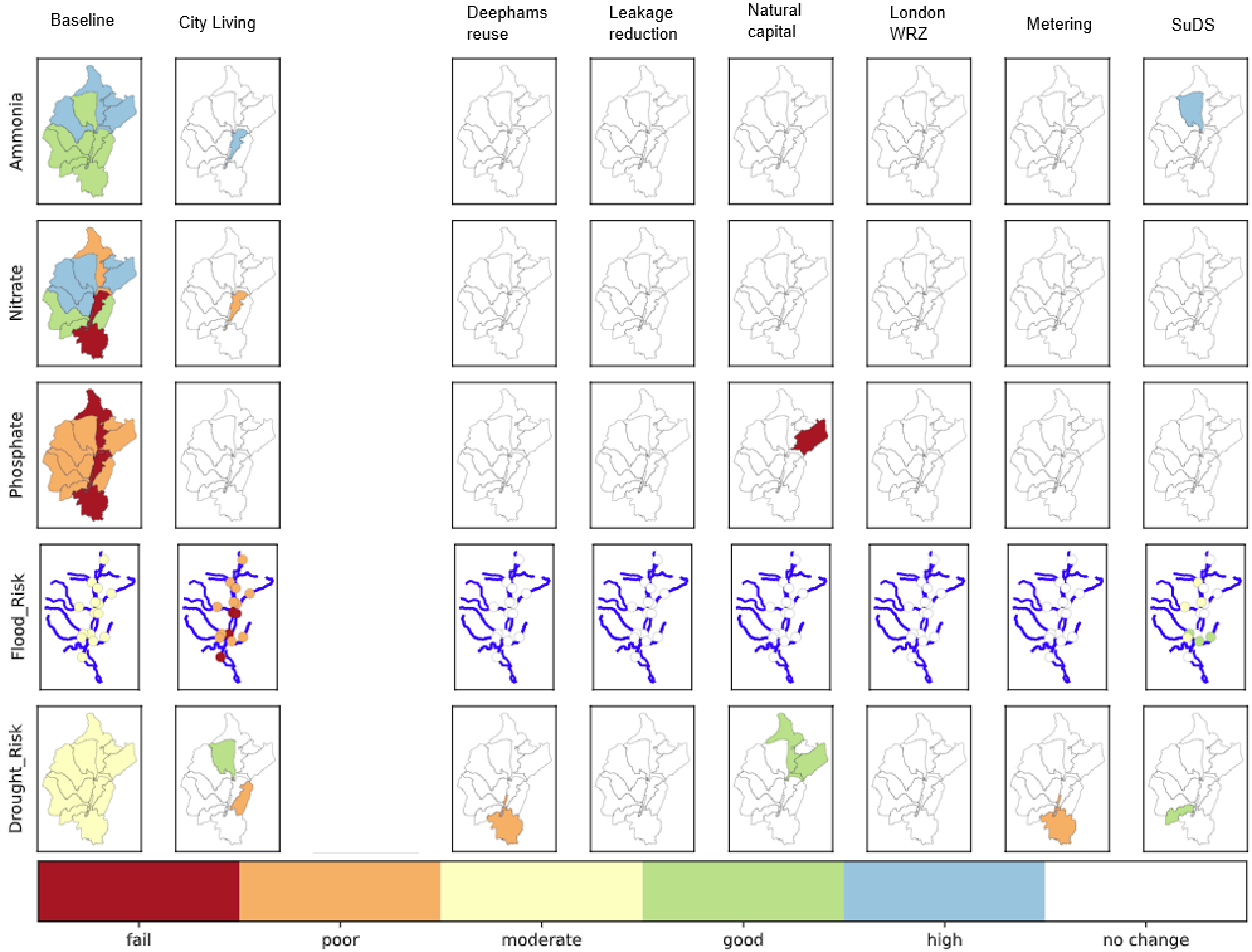


Figure 4.5: Option impacts indicated by a threshold change under Country Life with climate change (RCP 2.6)

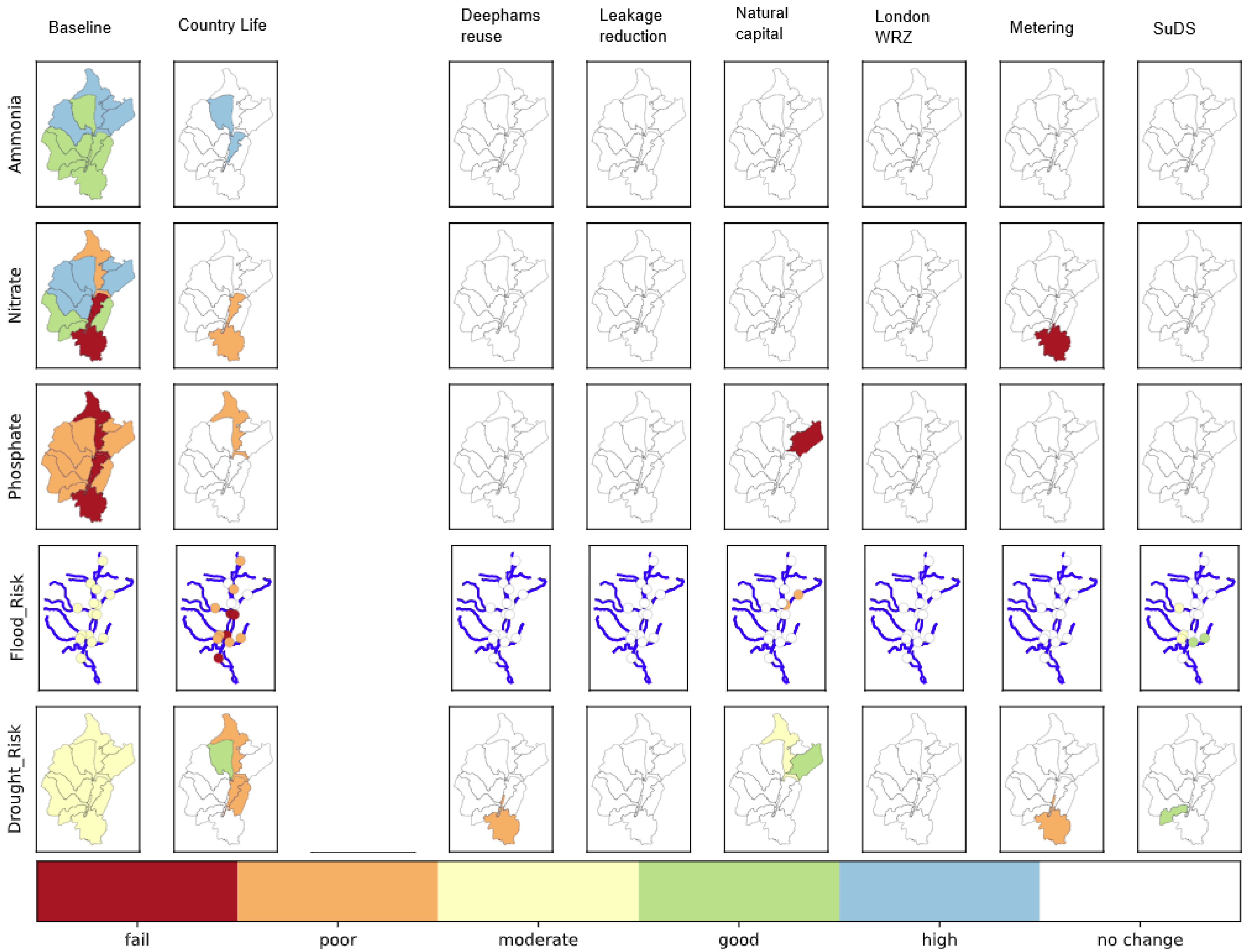


Table 4.4: Option impacts on water resources in the baseline. Option changes are calculated relative to the scenario baseline.

Option	Days of water stress/year	% change from baseline
No option	88	N.A.
Deephams reuse	48	-45%
Leakage reduction	53	-40%
Natural capital	81	-8%
London WRZ	49	-45%
Metering	54	-39%
SuDS	88	0%

Table 4.5: Option impacts on water resources in City Living (with RCP2.6). Option changes are calculated relative to the scenario baseline

Option	Days of water stress/year	% change from baseline
No option	234	+165%
Deephams reuse	134	-45%
Leakage reduction	147	-40%
Natural capital	225	-8%
London WRZ	137	-45%
Metering	150	-39%
SuDS	234	0%

Table 4.6: Option impacts on water resources in Country Life (with RCP 2.6). Option changes are calculated relative to the scenario baseline.

Option	**Days of water** stress/year	**% change from** baseline
No option	363	+311%
Deephams reuse	361	-1%
Leakage reduction	362	0%
Natural capital	363	0%
London WRZ	361	0%
Metering	362	0%
SuDS	363	0%

4.4.1 SuDS

SuDS options create infiltration which prevents surface water entering combined sewers or attenuates flow to slow runoff to reduce flood risk. To model SuDS, potential areas for attenuation and disconnection have been converted across seven sub-catchments. This provides an opportunity to show the interaction of SuDS at scale across the subregion. SuDS are provided as a case study in Appendix E Option Case Study: SuDS.

The Baseline report (see Section 2) highlighted areas within the subregion that are at risk from fluvial flooding. Future scenarios in Section 3 found that high flows increase in both scenarios as a result of climate change, abstraction licence changes, as well as from urban creep in City Living. In the Baseline, SuDS have a range of benefits in sub-catchments, reducing flood risk and increasing low flows by improving drought resilience. The water quantity benefits can be seen across both City Living and Country Life scenarios.

Figure 4.6 provides an example of the water quantity benefits from SuDS at the Pymmes Brook upstream Salmon Brook confluence. We can see that SuDS reduce flood risk by over 10% compared to the Baseline, which is enough to cause a threshold change.

Baseline findings (Section 2) indicate that there are significant issues with water quality across the catchment. The implementation of SuDS in the Baseline also resulted in water quality improvements of up to 10% (ammonia levels in Pymmes Brook in Figure 4.7) in the River Lea, however they are insufficient to improve the WFD classification. These water quality benefits hold under City Living and Country Life, with two sub-catchments with a threshold improvement in ammonia levels in City Living scenario. Other water quality benefits from SuDS include a reduction in phosphate levels in one sub-catchment (Moselle Brook) across all scenarios, and a reduction in nitrate levels in this sub-catchment in City Living and Country Life.

SuDS have most impact on smaller rivers (tributaries of the Lea). Flood risk management / SuDS programmes in upper boroughs will impact lower boroughs. It is worth highlighting that whilst fluvial flood risk has been modelled in this study, SuDS also reduce the risk of surface water flooding.

Figure 4.6: SuDS water quantity impacts in the Baseline at Pymmes Brook upstream Salmon Brook confluence

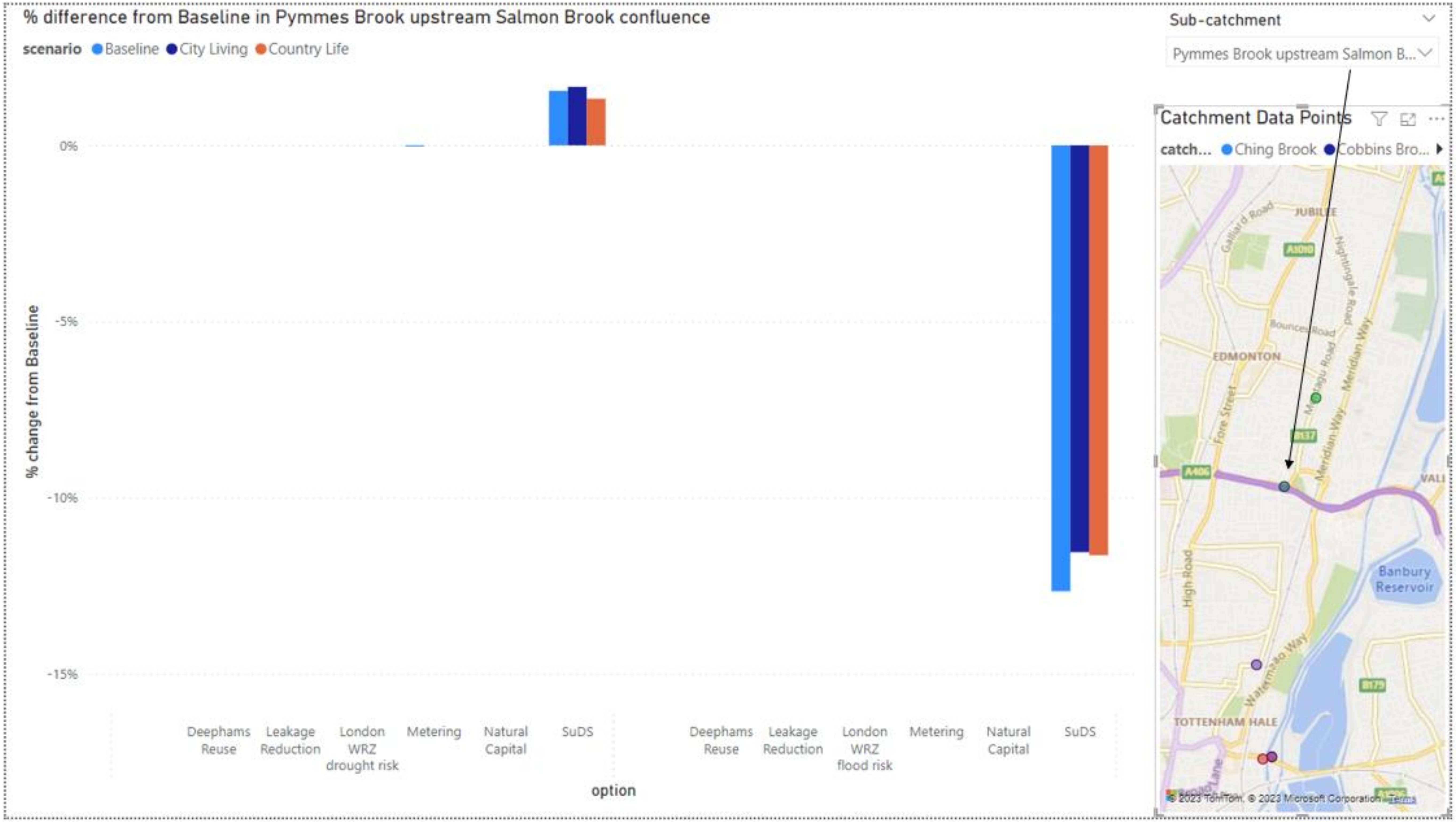
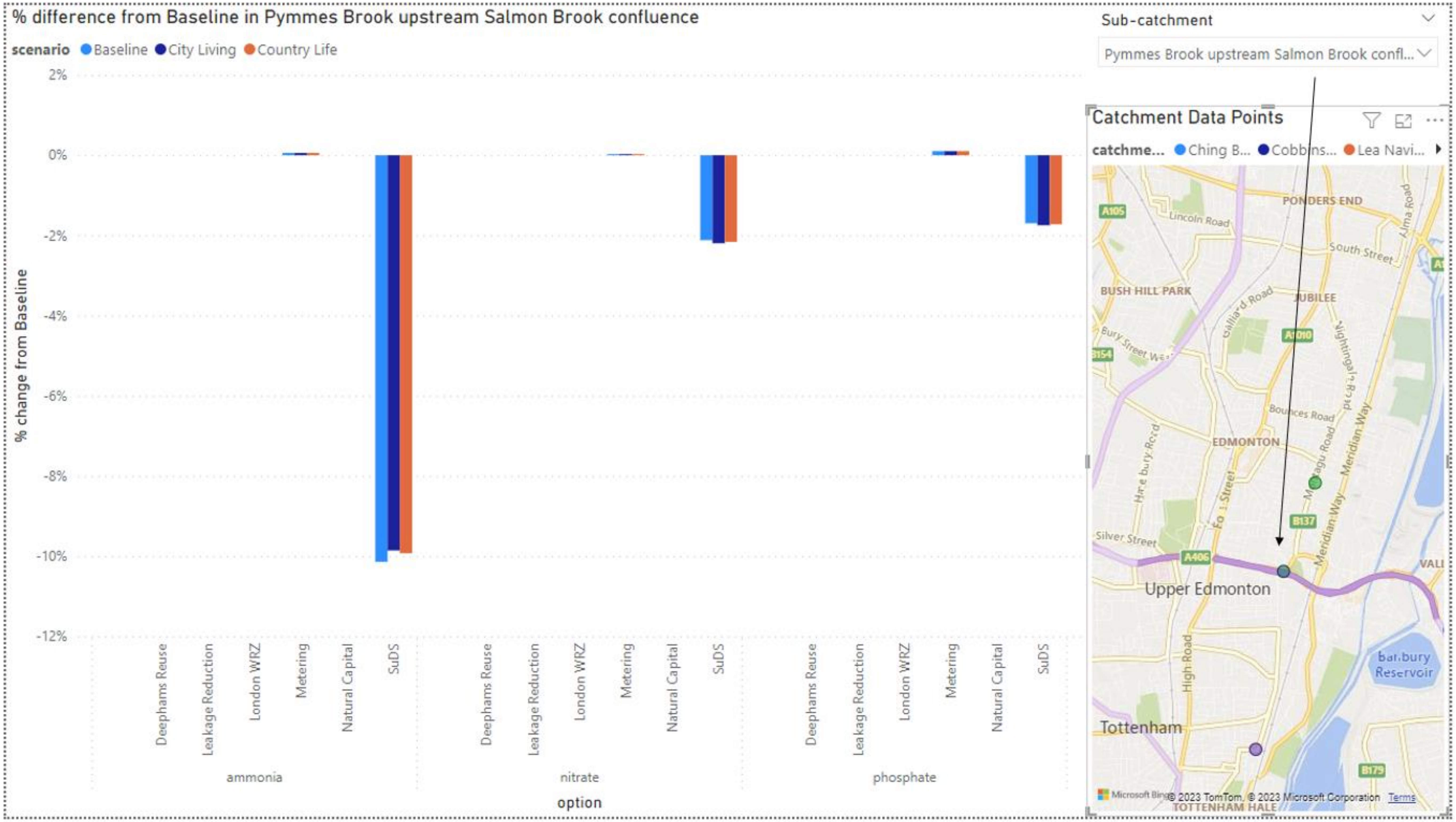


Figure 4.7: SuDS water quality impacts in the Baseline at Pymmes Brook upstream Salmon Brook confluence



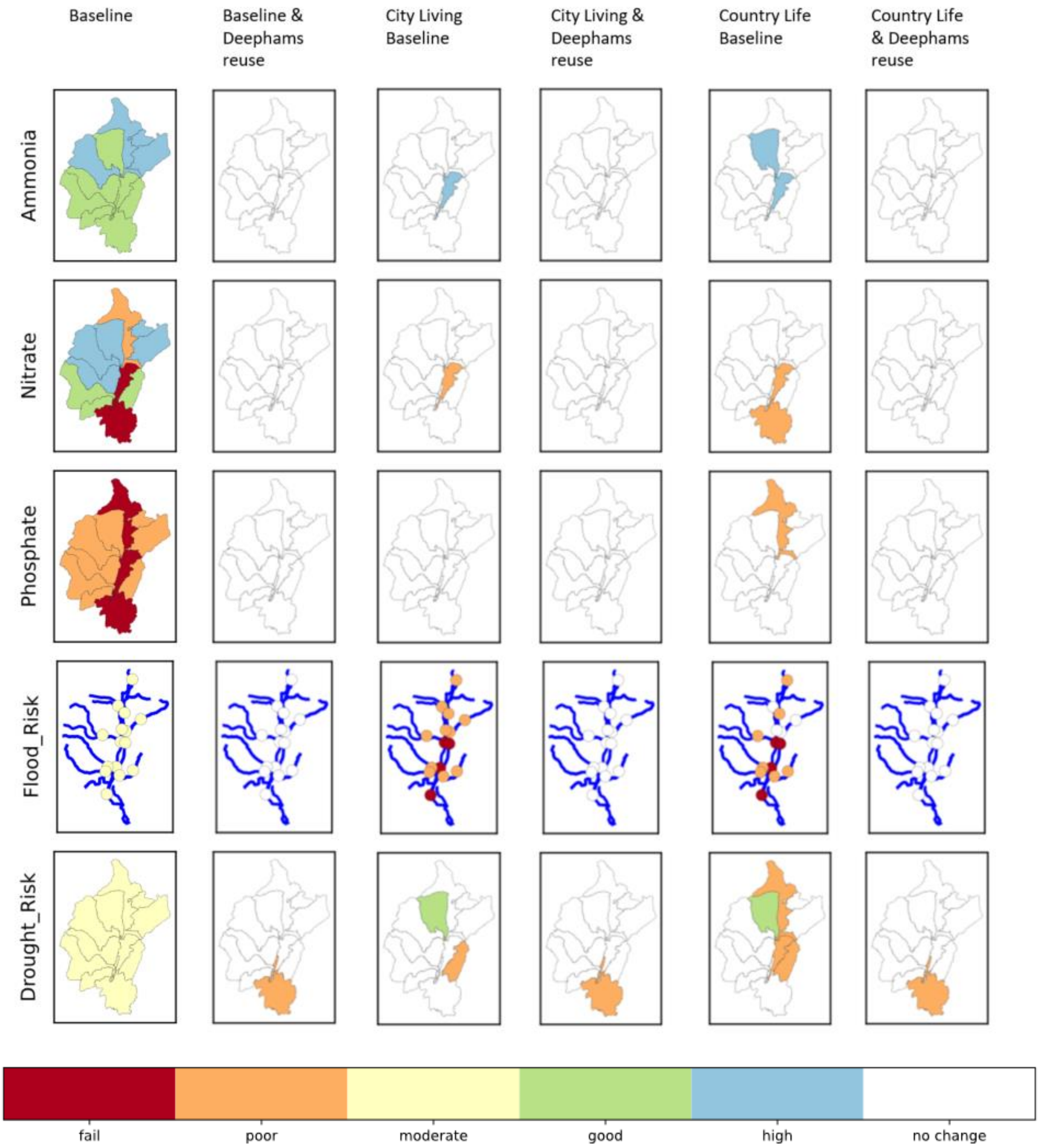
4.4.2 Deephams reuse

The Deephams reuse option is a water recycling scheme which would reduce the volume of water discharged at Deephams STW by the target volume of 46Ml/d. This value is based on WRMP19 and is subject to change in subsequent iterations of WRMP. It would discharge flows either into the King George V reservoir or into the river upstream of the reservoir intake. To model Deephams reuse, when the option is in place, the capacity is set to 46Ml/d and is prioritised over all other water resources.

When modelled, reduced effluent entering the river from Deephams results in a drop in low flows across all scenarios, reducing drought resilience (Figure 4.8) particularly close to Deephams and the lower model boundary. In the scenario baselines, flows are supplemented from abstraction licence reductions as well as Deephams effluent. By removing Deephams effluent, there is only the impact of abstractions, so there is a reduction in low flows. However, it is worth noting that under low flows condition, there is a limit on abstractions. Deephams reuse has an improvement on water resources by reducing the number of days of water stress by 45% in the Baseline and 43% in City Living (Table 4.4 - Table 4.6) However, there is no benefit to water resources in Country Life due to the severe reductions to abstraction licences in this scenario.

The Deephams reuse option also has benefits and trade-offs in water quality metrics in the baseline and future scenarios, but they are not enough to cause threshold changes. Nitrate levels are reduced in some areas across the subregion in all scenarios. In one sub-catchment under Country Life, phosphate levels are also reduced. However, it is important to note that threshold levels of ammonia have a good or high WFD classification across all scenarios whilst phosphate levels are predominately classified as fail or poor across the subregion.

Figure 4.8: Threshold changes to Baseline, City Living and Country Life Scenarios under RCP 2.6 climate change for Deephams reuse

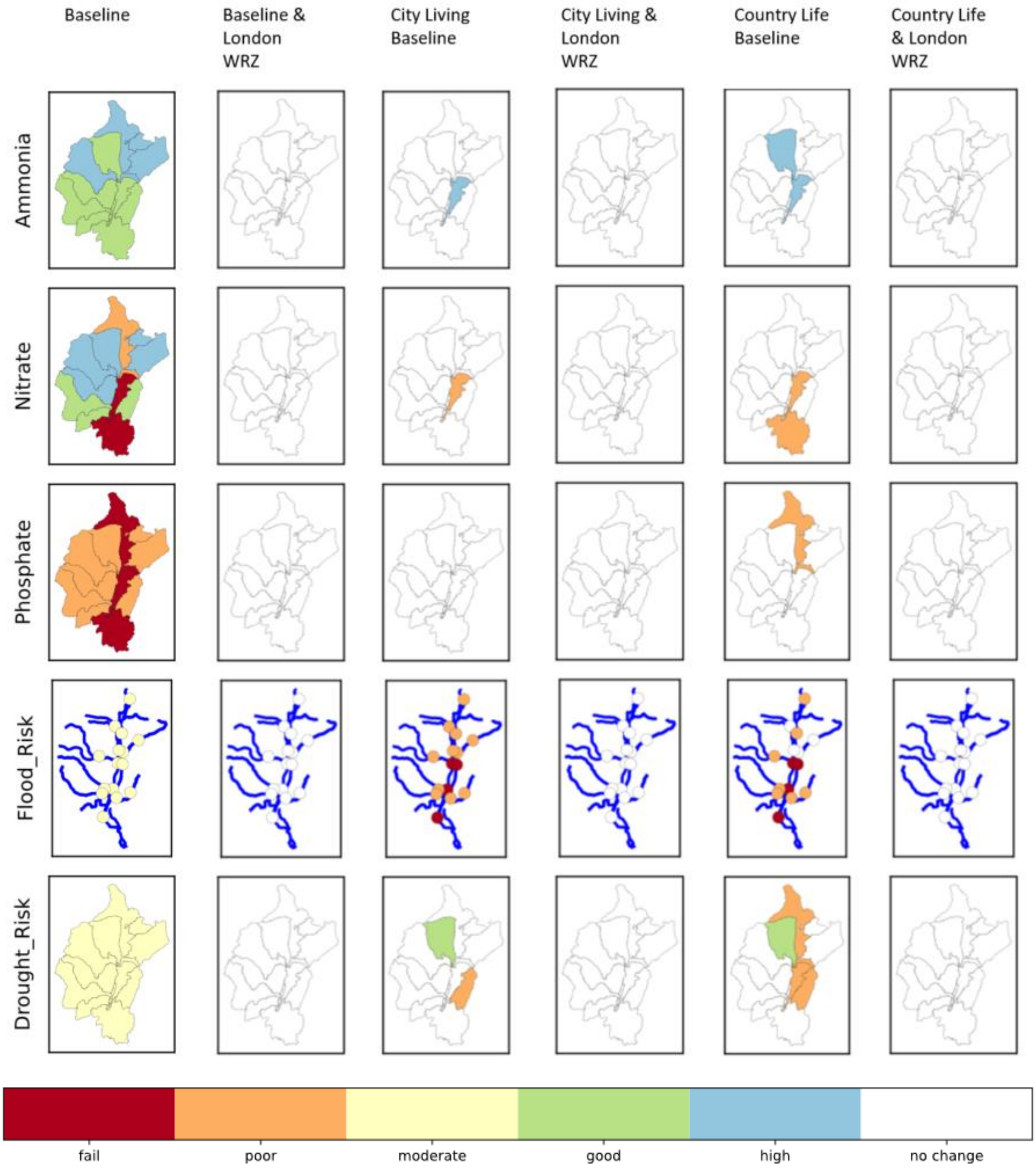


4.4.3 London WRZ

The London WRZ options are water supplement schemes and comprise the major items identified in the regional planning to meet future water demands for London. These include SESRO 150Mm^3, Oxford canal raw water transfer, reduced abstraction at Farmoor reservoir, groundwater schemes and release of network constraints. All these options could contribute to providing an addition 175Ml/d to the London WRZ. To model these options, they are conceptualised as ‘water resources only’ options since they will mainly take place outside of the modelled boundaries. Thus, they are modelled as a flat increase in water supply availability (45 Ml/d).

London WRZ options reduce the number of days of water stress by 45% in the Baseline scenario and by 42% in City Living, but there is no improvement to water resources in Country Life (Table 4.4 - Table 4.6). This option does not impact water quality or quantity metrics in the River Lea catchment modelling (Figure 4.9).

Figure 4.9: Threshold changes to Baseline, City Living and Country Life Scenarios under RCP 2.6 climate change for London WRZ options



4.4.4 Metering options

Smart metering technology aims to reduce personal consumption of water from 142 l/p/d by 2045. Each local authority also has targets to reduce consumption to 105 l/p/d or less for new developments. Metering options reduce water demand and therefore less water needs to be extracted. To model these options, per capita water use is reduced to 105l/p/d.

This option reduces effluent entering the river from Deephams, which results in a drop in low flows under all scenarios. Besides decreasing the wastewater generated, these changes have a knock-on impact to water supply, thus reducing the amount of water needing to be drawn from water resources equivalently. Modelling results show a reduction in the number of days of water stress by 39% in the baseline and 36% in City Living (Table 4.4 - Table 4.6). This option causes trade-offs with water quality metrics across all scenarios, although it does not create a threshold change. In Country Life, this trade-off is significant to cause a threshold reduction in nitrate in one sub-catchment.

Figure 4.10 and Figure 4.11 illustrate the impact of metering options at the Pymmes Brook and Salmon Brooks – Deephams STW to Tottenham Locks sub-catchment on water quantity and water quality respectively. This sub-catchment illustrates the trade-offs across the different metrics. For example, whilst this option provides a 10% reduction in high flows, and therefore reduces flood risk, it reduces low flows by almost 40%, and therefore increases drought risk. Moreover, it increases the level of ammonia by around 30%, and nitrate and phosphate levels by almost 50%.

Figure 4.10: Metering options water quantity impacts at Pymmes Brook and Salmon Brooks – Deephams STW to Tottenham Locks

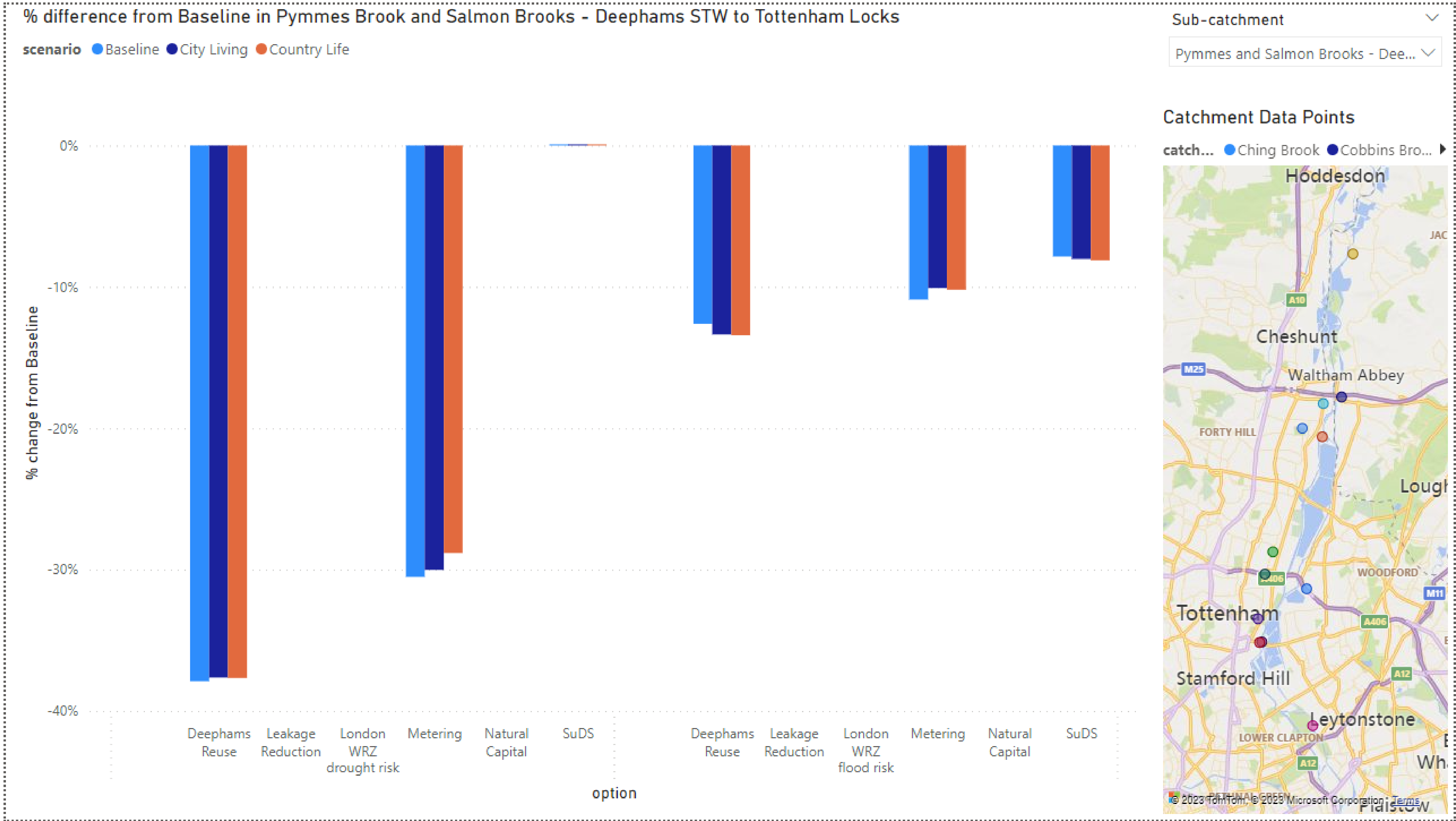
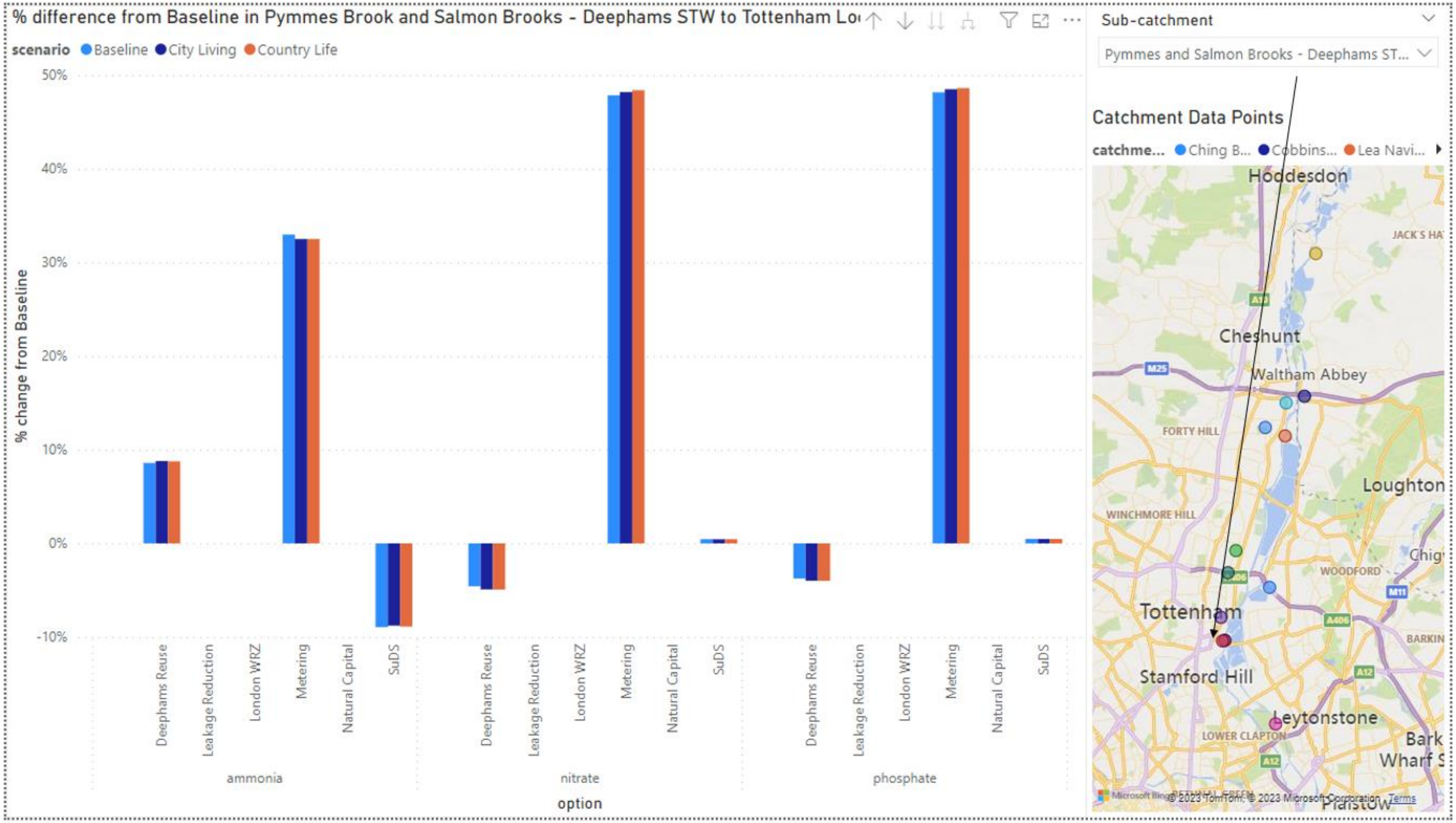


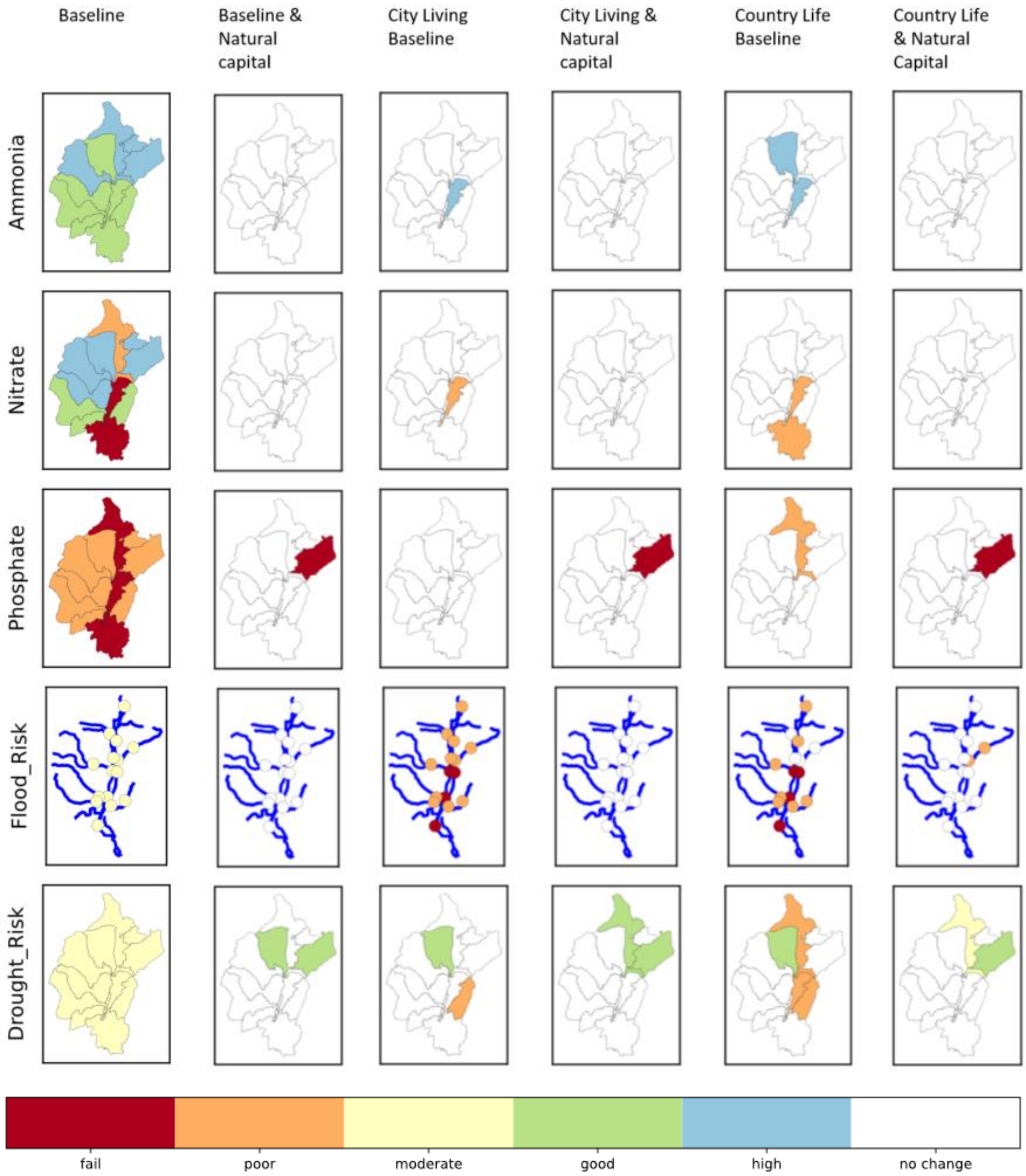
Figure 4.11: Metering options water quality impacts at Pymmes Brook and Salmon Brooks – Deephams STW to Tottenham Locks



4.4.5 Natural capital

Natural capital option implements regenerative farming techniques in all Upper Lea catchments. The way natural capital options have been modelled slows runoff, increase groundwater recharge and soil field capacity. This has local improvements to low flows in sub-catchments where it is implemented, however most of these sub-catchments are upstream of the subregion focus area. There are benefits to low flows in all scenarios in some areas, but it is not enough to create a threshold change. Natural capital options increase phosphate in some sub-catchments across the scenarios (Figure 4.12), but this is not always enough to cause a threshold change. Due to the increased baseflows resulting from Natural capital, water resources benefits can be achieved in the Baseline, but this is not significant under City Living and Country Life as these baseflows are dominated by the changes to abstractions (Table 4.4 - Table 4.6).

Figure 4.12: Threshold changes to Baseline, City Living and Country Life Scenarios under RCP 2.6 climate change for Natural capital options

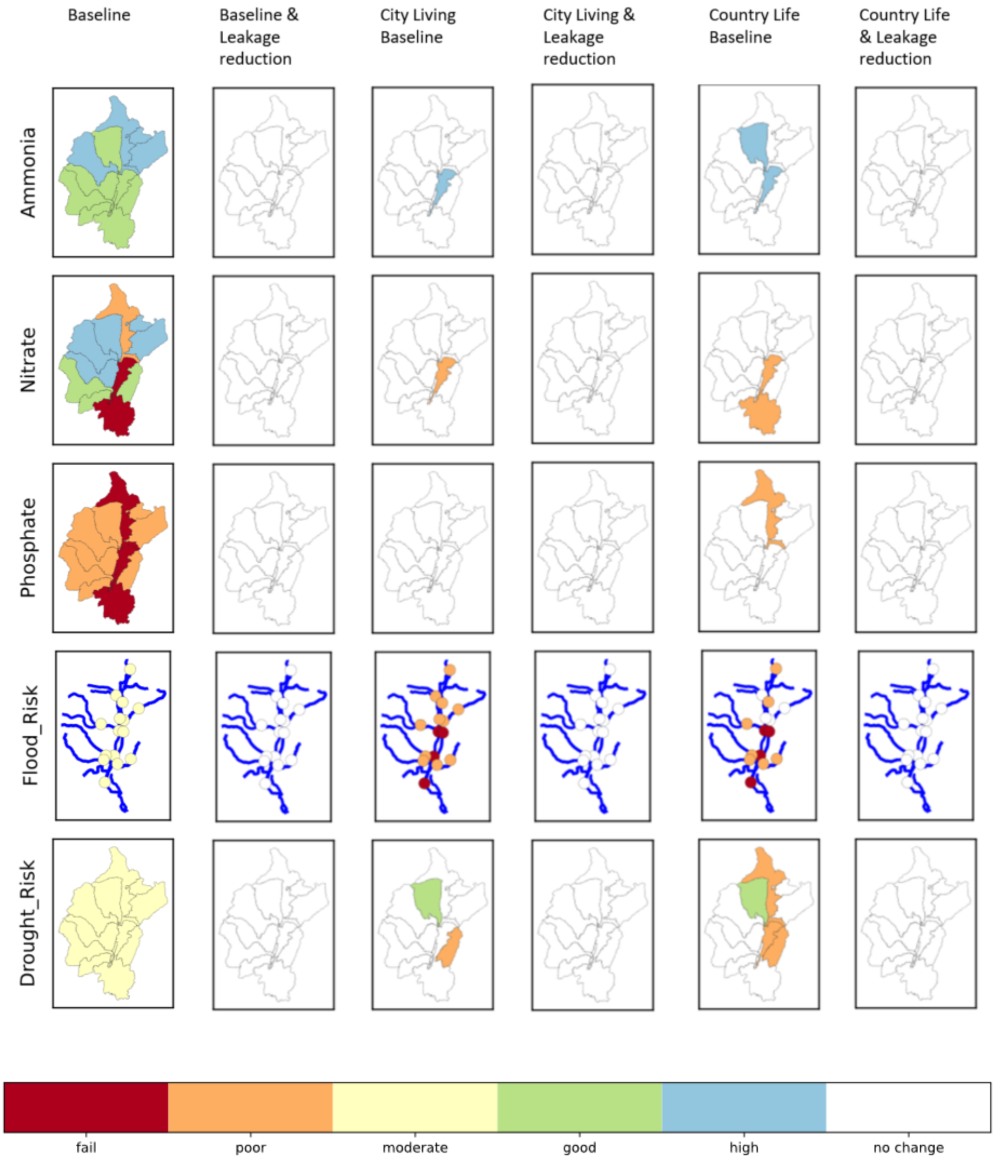


4.4.6 Leakage reduction

Leakage reduction options will be achieved through a combination of demand-side measures and mains rehabilitation in the London WRZ. To model these options, they are conceptualised as 'water resources only' options since they will mainly take place outside of the modelled boundaries. Thus, they are modelled as a flat increase in water supply availability (40Ml/d).

Leakage reduction options reduce the number of days of water stress by 40% in the Baseline and by 37% in City Living, but there is no improvement to water resources in Country Life (Table 4.4 - Table 4.6). This option does not impact water quality or quantity metrics (Figure 4.13).

Figure 4.13: Threshold changes to Baseline, City Living and Country Life Scenarios under RCP 2.6 climate change for Leakage reductions



4.4.7 Option summary

Modelling has shown that the options have impacts across the subregion on water resources, water quality and water quantity. There are no single options which fully offset current and future risks, and these options should be used in conjunction with others to set out an ambition for future water management. Section 5 discusses how these options may link together to maximise the co-benefits and mitigate the trade-offs across the subregion for the SIWMS.

5 Planning, timing and sequencing

5.1 Overview: The need for an integrated plan of options

Options required to de-risk growth in London are often either synergistic or have other impacts that need to be mitigated. Therefore, the options need to be assessed as part of an overall integrated portfolio of measures with a mutually reinforcing strategy. One option in isolation will not be enough to ensure sustainability or allow growth in the subregion. For example, Section 3 highlighted that both City Living and Country Life scenarios have significant impacts on water resources which will require a suite of multiple resource options to mitigate this risk. It is important to consider the trade-offs associated with options, as well as their benefits, across the subregion.

This section proposes an integrated plan of options to take forward for the SIWMS delivery. It outlines the methodology for assigning options as least-regret, principal or other options based on the results in Section 4. In this section, we recommend the following portfolio of options:

- Least-regret options which provide multiple benefits across the subregion with no identified trade-offs. These options include SuDS and leakage reduction, as well as wider enabling options such as engaging communities.
- Principal options which mitigate the biggest risks identified from the scenario analysis but have trade-offs that need to be managed. These options include Deephams reuse, London WRZ options and metering options.
- Other options need consideration as part of the SIWMS adaptive planning but do not mitigate the biggest risks from the scenario analysis. These include natural capital options and misconnections.

Understanding both the benefits and trade-offs of options against future scenarios can inform the timing and sequencing of their implementation. We have reviewed the principles of adaptive planning (see Appendix C Adaptive planning review and Table 5.1), and this is the approach we have followed to set out the plan below. Adaptive planning balances the need to act now whilst remaining agile to future scenarios. It enables an integrated portfolio of options to be implemented first (considered as least regret options and principal options) to offset the risks and uncertainties associated with growth opportunities and climate change. Additional options can then be implemented at a later stage as alternative future pathways, informed by continued monitoring and evaluation of the plan. This section therefore focuses on the

Term	Definition	Source
Action point	What action will be taken when the threshold is reached	Ofwat
Adaptive Pathway	Sequences of potential actions that are intended to anticipate and respond to evolving threats, risks and opportunities across multiple future scenarios. These actions are linked to specific thresholds where a change in circumstances is reached and further adaptive action may be required	Environment Agency
Decision point	Triggered when conditions change or are likely to change as they approach a threshold	Environment Agency
Driver of change	Source or driver of uncertainty	Environment Agency, Ofwat, WRSE
Threshold	Point beyond which a system is deemed to be no longer effective	BSI
Trigger point	Monitored indicator that shows conditions are approaching a threshold.	BSI
Uncertainty	The state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence or likelihood.	BSI

planning and governance of the options analysed in Section 4.

An integrated portfolio of options creates an aggregated set of benefits across the subregion that could be missed by considering options at a smaller scale and in isolation. Section 5.2 – 5.4 outlines the methodology approach for assigning options as least-regret, principal or other. Section 5.6 outlines key decision points to support the delivery of the integrated portfolio of options to ensure the plan remains adaptive. Section 5.7 provides a summary of the model findings, key implications and strategy recommendations.

Table 5.1: Glossary of key adaptive planning terminology

5.2 Risk assessment

To understand evolving risks associated with growth opportunities and climate change, modelled metrics that have a threshold classified as 'fail' or 'poor' were identified in the baseline and future scenarios (using the RCP2.6 for climate change). These include:

- River health: Phosphate levels are high across 11 out of the 12 sub-catchments modelled under baseline and future scenarios, whilst four sub-catchments have high levels of nitrate.
- Water resources: The average number of days per year when reservoirs are not in their ideal storage range increases significantly under both City Living and Country Life.
- River levels: All sub-catchments have an increase to flood risk in City Living (two sub-catchments drop to fail). One sub-catchment has drought risk classified as poor in City Living. In the Country Life scenario, six sub-catchments have flood risk classified as poor and two have flood risk classified as fail. Three sub-catchments have drought risk classified as poor.

Modelled scenario results suggest that treated effluent and non-point sources of pollution, mainly fertilisers, contribute equally to the phosphate load in the Lea. Thus, even with the significant investment made by WINEP in improving wastewater infrastructure, there is a limit to the amount of phosphate reduction that can be achieved without also addressing non-wastewater pollution sources.

A different combination of actions would mitigate these risks. Least regret options are discussed in Section 5.3, principal options are discussed in Section 5.4, and future options are discussed in Section 5.6.

5.3 Least regret options

Since the future is not certain and could follow different trajectories, we need to implement options first which address risks which are present in current and future scenarios, so that investment decisions are made wisely. This ensures flexibility and enables the SIWMS to be responsive to changing conditions. Least regret options are informed by the options which mitigate the identified risks across a more widespread area, whilst not creating trade-offs with other metrics.

5.3.1 Least regret method

To identify least regret options, four steps were followed which were informed by the risk assessment (Section 5.2):

- Step 1: Identify options which create threshold improvements in Baseline, City Living and Country Life and the sub-catchments these occur in
- Step 2: Identify which options create threshold reductions in Baseline, City Living and Country Life and the sub-catchments these occur in
- Step 3: Options which create metric benefits (whilst not enough to cause a threshold change) and the sub-catchments these occur in
- Step 4: Options which create metric trade-offs (whilst not enough to cause a threshold change) and the sub-catchments these occur in.

5.3.2 SuDS

SuDS options create groundwater infiltration and flow attenuation, reducing surface water entering combined sewers and slowing runoff to reduce flood risk. The details of the SuDS options included in the modelling are outlined in Appendix E. SuDS are included in the portfolio of least regret options as they mitigate flood and drought risk under future scenarios in some sub-catchments. They also have water quality benefits but not always enough to cause threshold improvements. As reductions to the abstraction licences in future scenarios improve water quality but increase flood risk, SuDS are a good option to offset some of these risks whilst providing further water quality benefits. They also help to reduce some of the impacts associated with high urban growth. Implementing these options first would help offset reduced abstraction licenses in future scenarios as well as mitigate other risks across the subregion.

These options do not cause trade-offs with other water-related metrics in the subregion (subject to model limitations). SuDS also have co-benefits to biodiversity, soil health, air quality, mental health, urban heat, and social connectivity. Whilst SuDS have a negative impact on embodied carbon, it is likely to be less than other hard engineering infrastructure. However, the reduction in operational carbon of sewage treatment caused by less surface water entering combined sewer systems could outweigh the embodied carbon involved in their implementation.

Modelling individual small areas of SuDS does not provide reasonable evidence at the subregional scale. SuDS options at scale therefore belong in future SIWMS to capture benefits beyond the borough boundary they have been implemented in. We recommend SuDS as a win-win option for the following benefits: future flood risk mitigation by reducing high flows; improving water quality; for health and social benefits; and for reducing carbon for water and wastewater treatment.

5.3.3 Leakage reduction

Leakage reduction options will be achieved through a combination of demand-side measures and mains rehabilitation. Modelling has shown that leakage reduction reduces water stress in the Baseline scenario and City Living, but there is no improvement to water resources in Country Life due to the severe reductions to abstraction licences in this scenario. This option does not cause a trade-off with other metrics. Leakage reduction reduces the abstraction requirements which creates a second-order impact on reduced operational carbon.

5.3.4 Implementing least regret options

Implementing least regret options requires collaboration to ensure the longevity of the SIWMS plan and to help create action on the ground. Previous barriers to SuDS implementation have been around ownership. Enfield Council have been successful in breaking down some of these barriers. The SIWMS steering group provides an opportunity for these lessons learned to be shared to support best practice across the boroughs. The Environment Agency and Thames Water can also support the construction of SuDS.

Leakage reduction options are owned by Thames Water. The Environment Agency and Local Boroughs should support Thames Water through increased communication and enabling access to locally and publicly owned areas to enable them to achieve their leakage reduction goals.

5.4 Principal options

Principal options mitigate the biggest risks identified from the scenario analysis but have trade-offs (see Section 5.3.1) that need to be managed. Scenario analysis has identified water resources to be a significant future risk. Therefore, we propose London WRZ, Deephams Reuse and Metering as principal options to mitigate this risk.

5.4.1 London WRZ options

The London WRZ options comprise the major items identified in the regional planning to meet future water demands for London. London WRZ options reduce the number of days of water stress in the Baseline and City Living scenario. These benefits are not realised in Country Life because of the severe abstraction licence changes in this scenario. Whilst London WRZ did not create any trade-offs across the modelled metrics, there are potential trade-offs across the whole London WRZ that have not been captured due to study boundaries. The development of this scheme will have second-order impacts which involve embodied and operational carbon. We acknowledge that we have not completely reviewed the system that London WRZ would impact. However, water companies are being asked to investigate these strategic water resource options by The Regulators' Alliance for Progressing Infrastructure Development (RAPID). This is a joint team made up of the three water regulators (Ofwat, the Environment Agency, and the Drinking Water Inspectorate) was set up to support this work. RAPID are overseeing more than a dozen projects across several water companies including recycling, desalination, transfers between regions and reservoirs to identify optimal regional solutions that could be started in 2025-2030. We are confident that this is a holistic, collaborative approach that does not need to be reviewed in detail in SIWMS as it is already reviewed at a national scale.

5.4.2 Deephams reuse

The Deephams reuse option is a recycling scheme which would reduce the volume of water discharged at Deephams STW by the target volume. Deephams reuse reduces the number of days of water stress in the Baseline and City Living scenarios, but there is no improvement to water resources in Country Life due to the severe reductions to abstraction licences in this scenario. Deephams reuse also has benefits in some water quality metrics in the baseline and future scenarios, but they are not enough to cause threshold changes. Nitrate levels are reduced in some areas across the subregion in all scenarios. In one sub-catchment under Country Life, phosphate levels are also reduced, likely due to the water level interaction with abstraction licence changes in this scenario.

The trade-offs around reduced drought resilience and increased ammonia levels associated with Deephams reuse will need to be managed in an integrated manner. Ammonia levels increase in some areas in all scenarios. Low flows interact with the nitrogen cycle – influencing the availability of oxygen which can reduce levels of nitrate and increase levels of ammonia (combined with less water available for dilution). However, it is important to note that threshold levels of ammonia have a good or high WFD classification across all scenarios whilst phosphate levels are predominately classified as fail or poor across the subregion.

Second-order impacts include increased embodied carbon during construction as well as operational carbon once the scheme is launched.

5.4.3 Metering options

Smart metering technology and policy targets aim to reduce personal consumption of water. Modelling results show a reduction in the number of days of water stress in the baseline and in City Living, however there is no improvement to water resources under Country Life. This option causes trade-offs with water quality metrics across all scenarios, although it does not create a threshold change. Reduced flows can create less dilution of nitrate, phosphate and ammonia. In Country Life, this trade-off is significant to cause a threshold reduction in nitrate in one sub-catchment. The second-order impacts for this option include:

- A reduction in operational carbon for water treatment due to the reduced volume of water needed in supply and wastewater treatment
- Meter installation which will result in customers spending less on water
- Meter installation also has the potential to improve cooperation with the water provider due to the positive impact the metering has on the customers. This can benefit social connectivity.

It is important to recognise the spatial implications of reducing water demand. If the sub-catchment drains to Deephams, then the impacts of reduced flows entering the River Lea may affect this dilution. If the sub-catchment drains to Beckton, such as areas of Waltham Forest, Tower Hamlets, Newham and City of London, then the demand for water can be reduced further because it will not impact the low flows in the river: these flows drain to the Thames which is more resilient in terms of low flow implications. While the Thames is more resilient to low flows, there is a need to further investigate the relationship PCC reductions in the Beckton catchment would have with the salinity concentrations in the river to determine any potential detriments. This is an important insight from SIWMS to enable a catchment perspective to improve water resources whilst reducing option trade-offs.

5.4.4 Implementing principal options

SIWMS has demonstrated that water stress is a significant risk in future scenarios. Implementing principal options requires collaboration to effectively manage the trade-offs around each option. For example, modelling results suggest that London WRZ is a preferred water resource option over Deephams reuse because no trade-offs have been identified: flows from Deephams discharge into the river replenishing the low flows and drought resilience. However, there are potential trade-offs across the whole London WRZ that have not been captured due to modelling boundaries. These boundary constraints mean we cannot demonstrate the trade-offs between implementing London WRZ and Deephams reuse. To restore water resources back to current levels, we need to implement significant measures including London WRZ options and Deephams reuse. However, how these are managed is decided strategically by WRSE and this organisation is best placed to understand both the need and mitigation measures around the trade-offs through their adaptive planning processes.

Thames Water may implement strategic water resource options, following investigations by WRSE and RAPID (Regulatory Alliance for Progressing Infrastructure Development). Thames Water and the Environment Agency should communicate on the timings related to environmental abstraction reductions. Local boroughs also need to communicate growth projections with

Thames Water to ensure these options are aligned. Additionally, Local boroughs and the Environment Agency should work collaboratively with Thames Water with options that provide a water quantity benefit.

5.5 Other options

This pilot project identified some uncertainties around natural capital options and misconnections options detailed in Appendix D. Further refinement of the modelling assumptions to reduce uncertainty related to natural capital and misconnection options in future SIWMS and more localised, targeted studies, can help understand the benefits and trade-offs of particular options to help develop a more certain business case for future investment.

5.5.1 Natural capital

The way natural capital options have been modelled in this pilot project slows runoff, increase groundwater recharge and soil field capacity. Plans which mention natural capital options did not provide enough detail to be modelled and there are currently few case studies which can be replicated at this scale. We recommend that this option is reviewed further, with respect to the model representation of the option, to better understand the impacts at scale. For natural capital options to have meaningful impacts on the waterbody, multiple landowners will need to implement options on their land, so would continue to benefit being assessed at subregional scale to support the evidence base. It requires a high-level strategic owner to direct where is most beneficial to focus efforts and the methods of natural capital enhancement. However, there are challenges around incentivising ownership.

5.5.2 Misconnections

The Local Flood Risk Management Strategies (LFRMS) of the Boroughs within the subregional strategy area, the EA Thames RBMP and Thames Water DWMP contain measures to identify and disconnect surface water sewers from existing combined sewer networks to improve water quality and separate flows from sewer systems. However, due to the substantial uncertainties associated with modelling misconnections, we have separately performed an ancillary data analysis for misconnections in the Pymmes Brook in Appendix D. Although WSIMOD simulations were utilised to identify potential areas and mechanisms of interest, the analysis presented in this study relies solely on observational data. Misconnection options are likely to provide benefits across the different river metrics. However, the exact location and extent of their impact will depend upon further investigation and surveys.

5.6 Future decision points

Future decision points are triggered when conditions are likely to change. Which future scenario unfolds depends upon factors outlined in Section 3.1.2. These factors include level of urbanisation in both city and rural areas, level of adaptation, development of opportunity areas, level of demand for water and upstream abstraction regime. Decision points have been aligned to current planning cycles which control these factors: water planning decision points are largely aligned to the Asset Management Period (AMP) cycles and Price Review planning process, and are required to be updated every five years; and urban planning decisions points (e.g. Local Plans and London Plan) every six years beginning in year 2027.

Figure 5.1: Simplified adaptive planning outlining key water and urban planning decision points aligned to their corresponding planning cycles.

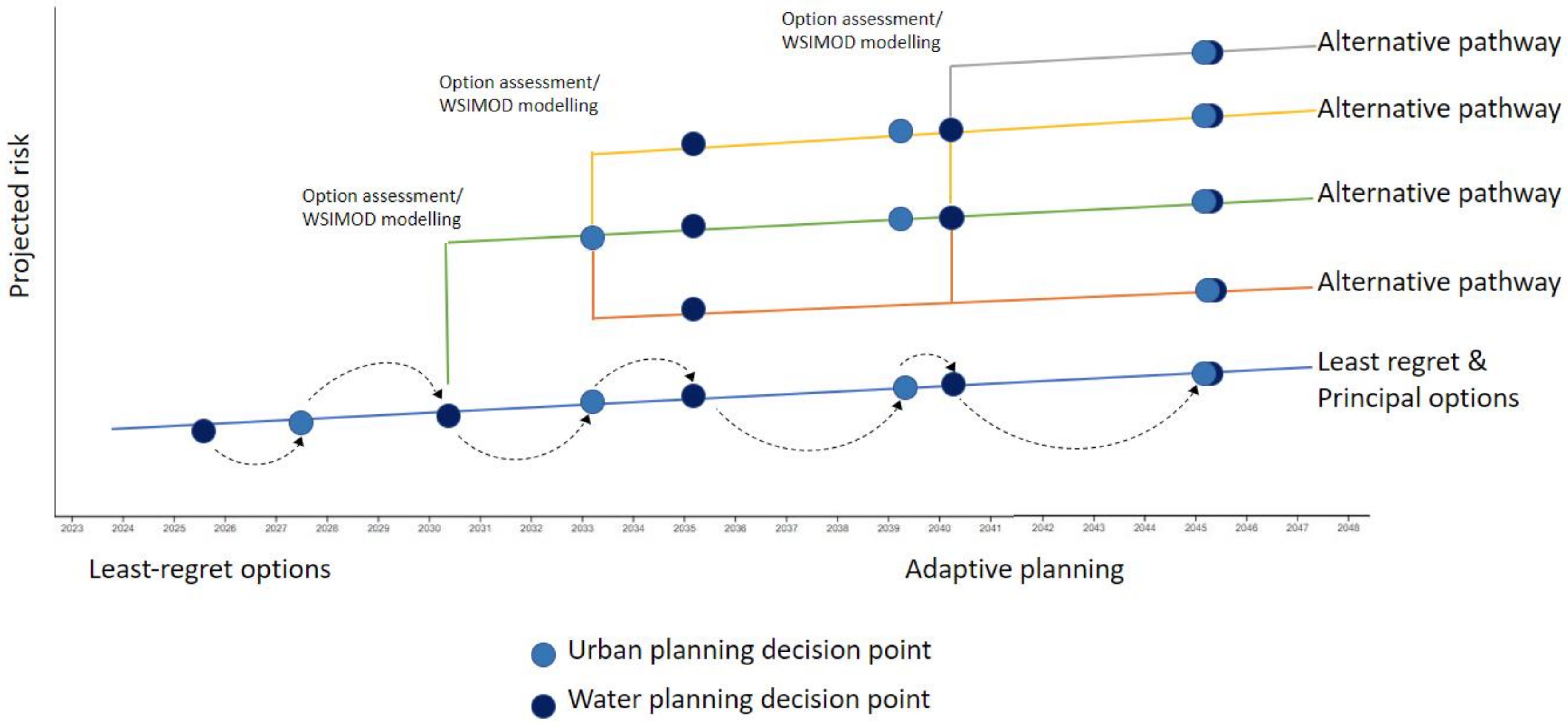


Figure 5.1 reiterates the importance for the collaboration between the water planning and urban planning contexts. The following ‘adaptive planning in action’ sets out an example where collaboration across plans can unlock future growth.

This pilot SIWMS has demonstrated the need for a coordinated approach to maximise the option benefits to de-risk growth.

There is an opportunity for future SIWMS to develop the ‘Other’ options to investigate the limitations of the modelling in this pilot project. For example, different types of nature-based solutions could be explored in a localised sub-catchment to identify the potential. Adaptive pathways around more ambitious natural capital options can then be decided. This can help organisations achieve the collective ambition of sustainability across the subregion.

The SIWMS needs to ensure a mechanism by which owners of these decision points (see Figure 5.1) can communicate with each other to evaluate when an additional option needs to be implemented and the associated feedbacks on the river metrics. These feedbacks will influence trigger points monitored in LIWMS and other adaptive plans such as WRSE and SESRO.

Adaptive planning in action

Local Plans set out the aspiration for development and growth in their boroughs, aligned with the London Plan and opportunity areas.

This will have an impact on water use, water and wastewater treatment as the number of people served by water and wastewater networks has the potential to increase.

Water planning will need to ensure this growth is factored into their plans, but also share any strategic water resource options and who they are likely to benefit in terms of unlocking growth. This is an opportunity to work collaboratively to implement water quality enhancement schemes such as SuDS to offset any trade-offs.

This will then allow Local Plans to incorporate wider growth ambitions.

5.7 Summary of model findings, implications and recommendations

Table 5.2 outlines key messages and findings from the modelling and what these findings mean for organisations in terms of risks, recommendations and actions. Table 5.3 discusses what can be done to address the findings. These tables should be read row by row from left to right. The ‘Model findings’ column summarises what the modelling work told us and the ‘Strategy implications’ column discuss what these findings mean for organisations. The ‘Recommendations’ column identify what we can do about these implications.

For example, the scenario analysis identified that upstream abstraction reductions are the biggest driver of future fluvial flood risk increases. This tells us that authorities will need to engage and work with abstractors in the upper catchment to manage future flood risk effectively. A key recommendation is for local boroughs to engage with the EA and abstraction operators in the upper catchment to investigate the impact of groundwater abstraction regime on base flows. The option analysis identified that SuDS mitigate some fluvial flood risk, but the current levels of SuDS earmarked for delivery are not enough to entirely address the increased risk. Current planned SuDS investments must be delivered to partially mitigate the impact and additional programmes should be developed. A recommendation is to investigate mechanisms to enable co-funding of SuDS in strategic upstream locations which deliver shared benefits to multiple boroughs.

Table 5.2: Model findings and potential impacts

Model findings	Evidence reference in report	Potential strategy implications	Impact type
Proposed upstream abstraction reductions are biggest driver of future fluvial flood risk increases.	3.2 3.2.2 5.2	- Focussing on flood risk management within study boundaries will not be enough to entirely mitigate impacts. - Authorities will need to engage and work with abstractors in upper catchment to manage future flood risk effectively.	Water quantity
Current levels of SuDS earmarked for delivery in plans are not enough to entirely address fluvial flood risk driven by climate change and abstraction reduction	4.4.1 Appendix E	- Current planned SuDS investment must be delivered to partially mitigate impact. - Additional programmes should be developed to make up the shortfall.	Water quantity
SuDs have most impact on smaller rivers (tributaries of the Lea). Flood risk management / SuDS programmes in upper boroughs will impact lower boroughs.	4.3 4.4.1 5.3.2	- Flood risk / SuDS programmes will deliver greater overall benefit in upper boroughs so authorities in lower stretches may be better off delivering investment outside of their administrative boundaries.	Water quantity
Proposed WINEP investments are not enough to change WFD classifications across the catchment in relation to Phosphate concentrations.	3.2.1 5.2	- To improve access / quality of the natural environment, changes in land management practices in the upper catchment are required.	Water quality

Model findings	Evidence reference in report	Potential strategy implications	Impact type
Nitrate concentrations remain an issue in the catchment and affect resilience of water supply across the London Water Resource Zone.	3.2.1	- Addressing quality of water in the Lea will also provide a resilience benefit to water supply across London, supporting long term economic and housing growth. - Within the London WRZ there is a strong dependency between water quality and the system resilience to provide drinking water.	Water quality / Water stress
Planned abstraction reductions in the upper catchment, population growth and climate change drive increases in water stress across London in the future.	3.2.3 4.4	- Additional supply sources are required to offset the impacts of multiple factors and enable planned economic and housing growth. - Reducing demand for water in existing and new housing stock will reduce the need for costly investment in new supply sources.	Water stress
There is a water quality issue in Pymmes Brook which we suspect is attributed to misconnections from the sewer system. The extent and locations are unconfirmed.	4.3 5.5.1 Appendix D	- Addressing the misconnections issue will help to significantly increase the water quality of Pymmes Brook and also help reduce pollution levels in the Lea.	Water quality
Options to reduce leakage and deliver SuDS do not result in negative impacts across any of the modelled indicators in the future scenarios.	5.3.2 5.3.3	- There are no significant trade-offs (beyond cost) related to delivering either of these options. - SuDS in particular deliver multiple benefits, beyond flood risk mitigation (including biodiversity and urban greening).	Planning and governance

Model findings	Evidence reference in report	Potential strategy implications	Impact type
Modelling has shown that no single modelled option will address current and future risks.	Executive summary Conclusions	- Multiple options will need to be delivered in conjunction to address the identified risks and challenges.	Planning and governance
Metering and changes in PCC have expected benefits relating to water stress, as well as complex trade-offs for the River Lea relating to water quality and flow in the river.	4.4.4 5.4.3	- All Local Planning Authority should aim to achieve progressively lower PCC for all new developments. - TW's progressive metering plan should be achieved across the whole catchment. - Boroughs that drain to Beckton STW should reduce PCC more than others to reduce water stress for the whole catchment whilst mitigating water flow and quality impacts in the River Lea.	Water stress

Table 5.3: Recommendations

Impact type	Recommendations
Water quantity	- 1. Engage with EA and abstraction operators in upper catchment to investigate impact of groundwater abstraction regime on base flows. - 2. Deliver planned SuDS programmes within the study area to partially mitigate impacts by retrofitting SuDS in attenuation spaces for up to 5% of the total borough areas and disconnecting surface water sewers for up to 5% the total borough areas. - 3. Explore disconnection opportunities (e.g. permeable paving, water butts, green roof areas) in Lower Lea Boroughs such as Newham, Tower Hamlets and City of London in line with the findings from the TW DWMP. - 4. Implement and enforce Schedule 3 of the Flood and Water Management Act (2010). - 5. Review current plans for SuDS delivery and develop more ambitious plans to achieve the targets set out in recommendation 2. - 6. Investigate mechanisms to enable co-funding of SuDS in strategic upstream locations which deliver shared benefits to multiple boroughs.
Water quality	- 7. Engage with stakeholders in the upper catchment to understand sources of pollution outside of wastewater treatment works. - 8. Investigate land management / natural capital options to reduce Phosphate pollution in the catchment. - 9. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment. - 10. Engage with TW and other stakeholders to further investigate / address Pymmes Brook misconnections issue.
Water stress	- 11. Deliver London WRZ options and investigate Deephams Reuse further. - 12. Implement LA target of 105 l/p/d or less for new developments. - 13. Implement progressive metering plan in line with WRMP - 14. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment. - 15. Investigate the possibility of reducing PCC in the Beckton catchment without impacting Thames salinity.

Impact type	Recommendations
Planning and governance	- 16. Governance structures and tools needed to coordinate delivery of options across stakeholders. - 17. 'Least regrets' options of SuDS and leakage reductions should be delivered as immediately as they mitigate current and future risks without any significant trade-offs. - 18. Principal options should also be delivered as they mitigate the largest risks identified in the modelling, but with some trade-offs. These include London WRZ options, Deephams Reuse and PCC reductions.

The delivery strategy for monitoring and evaluation of the SIWMS is discussed in Section 6.

6 Delivery Strategy

6.1 Need for delivery

The model findings (see Table 5.2) have highlighted risks related to water quality, water quantity and water resource availability across the different scenarios. It is imperative that the proposed least regret options (see Section 5.3) and recommendations (see Table 5.3) to mitigate these risks are delivered.

6.1.1 Water quality risks

Phosphate, nitrate and ammonia pose two main challenges to London and Londoners:

1. They reduce water resource resilience due to the need for blend supply at Coppermills. This is a constraint to London's growth plans as decreased water resource resilience reduces the capacity for new housing and economic growth. It also increases the risk of disruption of supply to London's existing business and communities.
2. Nutrient loads are a constraint to biodiversity and access to high quality green space. Nutrients increase risk of impacts such as toxic algal blooms which reduce the ability of the water course to support biodiversity and reduce the value of the water course as a recreational space.

6.1.2 Water quantity risks

Increases to flood risk has four main impacts:

1. Increase the economic disruption to residents and businesses, as well as physical and mental health impacts.
2. Reduce the attractiveness of the areas to investors, due to risk insurance premiums as well as the risk posed to their assets and activities.
3. Higher insurance premiums, placing an economic pressure on businesses and residents.
4. Land availability for development in the long term and reduce the attractiveness of land for development.

Increases to drought risks has the following impacts:

5. Reduced low flows affect water quality as there is less dilution. This has negative impacts on biodiversity.

6.1.3 Water stress risks

Water stress risks has two main impacts:

1. Increased risk of supply disruptions to residents and businesses (through temporary use bans or temporary outages)
2. Reduced deliverability of future growth plans as supply may not be able to meet new demand.

6.2 Delivery approach and key considerations

The overall objective for the delivery strategy is two-fold. Firstly, it should facilitate a more impactful action to address the significant findings of the study which pose a collective risk to all organisations. Secondly, it should reduce workload for planners and ensure that actions are coordinated (and not counterproductive) across organisations.

We have organised our recommendations into ’90 day’ actions and longer-term activities based on current levels of maturity. The ‘90 day’ actions are designed for different organisations to undertake immediately (in the next 90 days) in order to begin implementation of the strategy recommendations. Longer-term activities are designed to enable more effective cross-organisational collaboration going forwards. These will be essential to ensure that future trade-offs are managed effectively, and that action is aligned across different actors in the subregion, supporting growth, sustainability and decarbonisation objectives.

6.2.1 Immediate actions to implement the strategy recommendations

This section outlines the recommended ‘90 day’ actions. These recommendations focus on existing programmes which are already well-developed and therefore can be actioned quickly provided there is sufficient funding to do so. Longer-term actions where there is no precedent (e.g. upstream investment and engagement in the area) are discussed in Section 6.2.2.

For flooding, the following 90-day actions are recommended:

1. Engage with EA and abstraction operators in upper catchment to investigate impact of groundwater abstraction regime on base flows.
2. Deliver planned SuDS programmes within the study area to partially mitigate impacts by retrofitting SuDS in attenuation spaces for up to 5% of the total borough areas and disconnecting surface water sewers for up to 5% of the total borough areas.
3. Explore disconnection opportunities (e.g. permeable paving, water butts, green roof areas) in Lower Lea Boroughs such as Newham, Tower Hamlets and City of London in line with the findings from the TW DWMP.
4. Implement and enforce Schedule 3 of the Flood and Water Management Act (2010).

5. Review current plans for SuDS delivery and develop more ambitious plans to achieve the targets set out in recommendation 2.
6. Investigate mechanisms to enable co-funding of SuDS in strategic upstream locations which deliver shared benefits to multiple boroughs.

Table 6.1 outlines the associated actions and who should lead these.

For water quality, the following 90-day actions are recommended:

7. Engage with stakeholders in the upper catchment to understand sources of pollution outside of wastewater treatment works.
8. Investigate land management / natural capital options to reduce Phosphate pollution in the catchment.
9. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment.
10. Engage with TW and other stakeholders to further investigate / address Pymmes Brook misconnections issue.

Table 6.2 outlines the associated actions and who should lease these.

For water stress, the following 90-day actions are recommended:

11. Deliver London WRZ options and investigate Deephams Reuse further.
12. Implement LA PCC target of 105 l/p/d or less for new developments.
13. Implement progressive metering plan in line with WRMP
14. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment
15. Investigate the possibility of reducing PCC in the Beckton catchment without impacting Thames salinity.

Table 6.3 outlines the associated actions and who should lease these.

For planning and governance, the following 90-day actions are recommended:

16. Governance structures and tools needed to coordinate delivery of options across stakeholders.
17. 'Least regrets' options of SuDS and leakage reductions should be delivered as immediately as they mitigate current and future risks without any significant trade-offs.
18. Principal options should also be delivered as they mitigate the largest risks identified in the modelling, but with some trade-offs. These include London WRZ options, Deephams Reuse and PCC reductions.

Table 6.4 outlines actions for planning and governance.

Table 6.1, Table 6.2 and Table 6.3 outline the actions and who will lead the actions to mitigate water quantity, water quality, and water stress risks, respectively. For example, a recommendation is to deliver planned SuDS programmes within the study area to partially mitigate the water quantity impacts. A 90 day action is for Boroughs and the GLA to review LFRMS (in particular planned SuDS) and identify delivery challenges for shortfalls in funding. SuDS also have co-benefits to biodiversity, soil health, air quality, mental health, urban heat, and social connectivity. Improving the quality of public space strengthens the business case to implement SuDS.

Table 6.1: '90' day actions for organisations to achieve the recommendations proposed to mitigate flood risk

90-day Actions	Lead
F1 : Communicate study to relevant EA teams for the Upper Lea and maintain contact with EA Upper Lea groundwater interaction study.	EA, GLA
F2: Communicate study to Water Companies (Thames Water and Affinity Water) and identify synergies with DWMP, WRMP and PR24 delivery approach and programme.	GLA, TW, TfL
F3: Review LFRMSs (in particular planned SuDS) and identify delivery challenges or shortfalls in funding.	Boroughs, GLA
F4: Review mapped funding streams for SuDS delivery over next 2 - 3 years (circulated by LoDEG to LLFAs) and identify gaps as well as opportunities for coordination / collaboration.	GLA
F5: Support existing multi-agency programmes to unlock strategic SuDS investment (such as Prosper) and investigate the possibility of new ones. Communicate strategy findings to these programmes.	GLA, TW, EA
F6: Investigate opportunities for developer contributions to fund strategic SuDS programmes in the study area in the future.	GLA
F7: Review Schedule 3 proposals and capacity / capability to implement. Feed back findings to DEFRA consultation on impact assessment and statutory mechanisms in 2023.	GLA
F8: Investigate potential guidance and support to ensure strategy findings and recommendations are fed in to SFRA refreshes.	GLA
F9: Communicate study to LLFAs and other flood risk stakeholders working in Upper Lea.	Boroughs
F10: Coordinate engagement with the EA, Affinity Water and Thames Water in upper catchment to investigate impact of groundwater abstraction regime on base flows and flood risk.	GLA

Table 6.2: '90' day actions for organisations to achieve the recommendations proposed to mitigate water quality risks

90-day Actions	Lead
Q1 Communicate study findings with EA and water companies and understand wider pollution sources and drivers in the Upper Lea as well as any existing programmes.	GLA
Q2: Identify good practice potential mechanisms to enable funding of upstream water quality work.	GLA, EA, Natural England
Q3: Communicate study findings with TW and Thames21 to better understand Pymmes Brook potential misconnection.	GLA, Haringey, Enfield

Table 6.3: '90' day actions for organisations to achieve the recommendations proposed to mitigate water stress risks

90-day Actions	Lead
S1: Identify next opportunities to feed strategy findings into regional and London water resource planning frameworks.	EA, TW
S2: Review current local plan policy to identify whether current policies align with strategy findings for PCC.	Boroughs
S3: Identify viable options to strengthen policies outside of local plan refresh cycle - such as material considerations.	GLA
S4: Identify potential incentive based approaches to encourage PCC reduction in new developments and existing housing stock.	GLA, TW
S5: Communicate study findings to TW to take account of in leakage reduction programmes.	GLA, TW
S6: Investigate existing research and the need to commission evidence to inform more ambitious water policy targets in future London Plan iteration.	GLA
S7: Investigate potential for further PCC reductions in the Beckton catchment.	GLA, EA, City of London, Newham, Tower Hamlets

Table 6.4: '90' day actions for planning and governance across organisations

90-day Actions	Lead
P1: Further investigate potential for a digital tool enable ongoing coordination of planning and delivery.	GLA

90-day Actions	Lead
P2: Identify structures and provisions needed to facilitate integrated governance and cross-organisational coordination of planning and delivery.	GLA

6.2.2 Longer-term activities

A strategic finding from this study is that greater coordination is required across governance, planning and delivery systems to effectively address the challenges identified in the study. This is exemplified by the fact that the major influences driving negative impacts are common to the whole study area (climate change, urbanisation and abstraction reduction). Furthermore, the modelling has clearly shown that impacts of these influences cannot be addressed by individual organisations and the delivery of isolated options. The assessment of multiple benefits has also shown that certain options have potential to bring benefits to multiple stakeholders, which needs to be accounted for in delivery.

Recognising the need for greater coordination across stakeholders, work has begun in London and other parts of the UK to enable this. Examples include:

- Environment Agency Integrated Water Management work
- London Flooding Task and Finish Group
- GMCA Trailblazer Deeper Devolution Deal

Two considerations are required for effective coordination: coordinated planning and coordinated delivery.

Coordinated planning

This ensures multi-benefits and trade-offs are considered enabling outcomes to be optimised across the whole system. It also enables adaptive decision making based on best information available.

Coordinated planning entails an understanding on assumptions, data, monitoring, communication, engagement, and alignment of timescales to develop a common understanding of risk and how it evolves over time. The timings of relevant planning frameworks have been set out in Figure 6.1. The key idea in this graphic is that when the respective planning frameworks conclude their work then the portfolio of options included in the plan is recorded and the data made available to other planning frameworks. For plans to effectively link, a coordinated approach needs to be adopted. Planning metrics, data inputs and assumptions need to be aligned so that the impact is comparable across plans and therefore benefits can be shared. This may be achieved through a coordinating office to manage effective delivery of the plans.

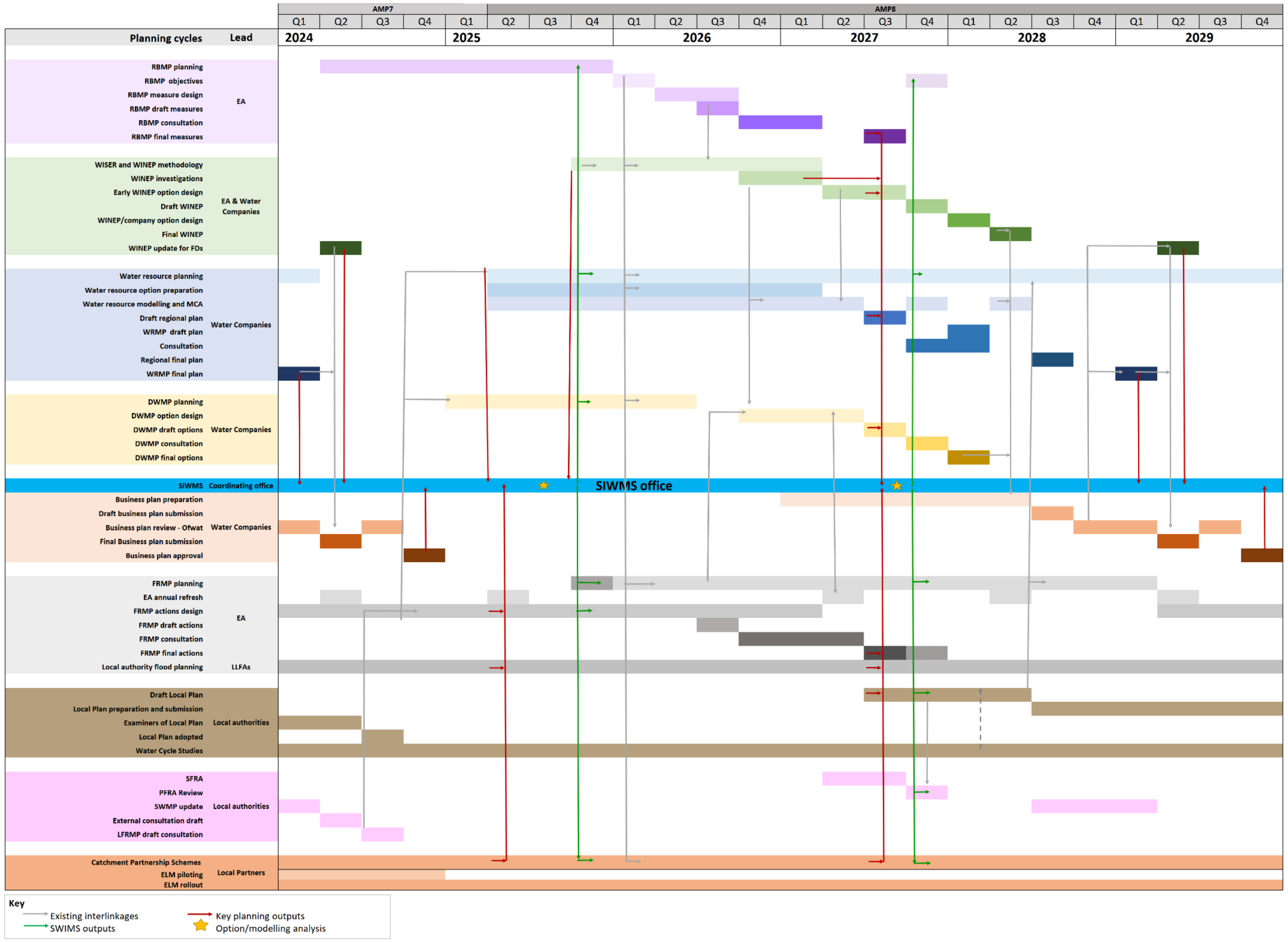
Key decision points in the proposed adaptive plan (see Figure 5.1) are aligned to water and urban planning cycles to monitor the factors which will influence future scenarios. Important factors of uncertainty for one planning framework may be influenced significantly by another framework's decisions. Table 6.5 outlines the plans which control the factors influencing future scenarios for other plans, and which plans will be impacted by the implementation. The adaptive plan decision points proposed in Section 5.6 provide an opportunity to integrate the feedbacks emerging from water and urban planning decisions, enabling environmental obligations to be effectively addressed. It should be noted that RBMP and FRMP (owned by the EA) can also drive the WINEP programme and other water quality/flood risk changes and should be reviewed in the adaptive plan.

Table 6.5: Plans which control factors in future scenarios and plans which will be impacted by the implementation to inform decision points

Plan name	Plan owner	Factor under control in plan	Direct plan impact	Plan owner
WINEP	Thames Water	Upstream abstraction regime	WRMP	Thames Water, Water Resources South East
WRMP	Thames Water, Water Resources South East	Level of demand	DWMP	Thames Water
Local Plan	Local authorities	Urbanisation (city)	DWMP, FRMP, LFRMP, WRMP	Thames Water; Environment Agency, Local Authorities, Water Resources South East
Local Plan	Local authorities	Urbanisation (rural)	DWMP, FRMP, LFRMP, WRMP	Thames Water; Environment Agency, Local Authorities, Water

Plan name	Plan owner	Factor under control in plan	Direct plan impact	Plan owner
				Resources South East
LFRMP; SWMP	Local authorities	Adaptation	Local Plan; DWMP	Local authorities, Thames Water
Local Plan	Local authorities	Opportunity areas	DWMP; WRMP	Thames Water, Water Resources South East

Figure 6.1: Planning cycles with their key interlinkages and feedbacks for SIWMS delivery



Coordinated delivery

This ensures efficiency where more outcomes can be delivered for less money invested. It also ensures effectiveness, where larger scale solutions can be unlocked with multiple stakeholders involved to address big issues (such as climate change) more effectively.

Conceptually, and in simplified form, Figure 6.2 indicates that each planning framework produces a portfolio of options with a set of corresponding benefits. These benefits are shown in Rows 1 to 4 relating to water resources, wastewater, environment and flooding. Each portfolio has principal benefits (shown in bolder colours); co-benefits relevant to other planning frameworks and then a set of notional “best value” co-benefits. In the example shown, the principal benefits for water resources are shown in column A, with co-benefits for flooding and environment shown in columns C and D. Best value benefits are shown in columns D to J. Best value benefits would include items such as social, amenity and other benefits such as carbon sequestration. The same approach is taken to representing benefits from wastewater, environment and flood planning portfolios.

The method relies on common planning assumptions and metrics – as demonstrated in the method used in this report – which then allows benefits to be summed across the portfolios as shown in Row 5. Once benefits can be summed across the frameworks then portfolios can be renegotiated and optimised for the best set of overall outcomes as shown in Row 6. With this method we believe that more cost-effective solutions for all planning objectives may be achieved. This is likely to drive down expenditure on water resources and wastewater. For environment and flood management planning we anticipate that a greater number of cost-effective interventions will be identified, and a higher overall achievement of planning objectives will be realised. (We note that the graphical representation is over-simplified in that it shows the summation of benefits only, whereas the method also allows negative impacts of options to be mitigated).

Figure 6.2: Summation of portfolio benefits and creation of integrated portfolios

Source: The Environment Agency: OxCam Integrated Water Management Framework[8]

Coordinated delivery entails market-based policy instruments. Examples of market-based instruments include EnTrade which creates and operates online markets for nature, making it easier for land managers to earn money from nature-based projects on their land[9]. Examples of joint funding of projects include the Community Infrastructure Levy (CIL)[10] which is payment by developers to the Boroughs to use towards upgrading infrastructure including transport, flood defences, health and social care facilities. By enhancing management, monitoring and evaluation, greater use of markets could be made in the implementation of the SIWMS strategy.

Coordinated planning and delivery can be achieved through a coordinated planning office and through a digital tool. To implement the adaptive plan in the longer-term, representatives from Thames Water, Local Authorities and the Environment Agency would communicate with a central coordinating office. The coordinating office would undertake multi-objective modelling of portfolios of options across multiple planning frameworks, and identify:

- Multi-benefit interventions that could be co-funded for the mutual benefit of multiple organisations
- Options that could negatively impact the objectives of other planning frameworks
- In-combination effects of different groups of interventions

The coordinating office would have a pro-active coordinating function to alert different planning offices of opportunities or needs for collaboration. This ensures feedbacks between water and urban planning are captured, along with environmental synergies. It also ensures a mechanism for incorporating learning into the monitoring and evaluation of the strategy.

To support the identification of synergies across the planning frameworks, the coordination office would have the following supporting functions:

- An advocacy role to create engagement with collaborative planning
- A coordination function to ensure consistency in planning assumptions such as
  - Common planning scenarios and horizons
  - Common metrics and value frameworks
  - Common cost and carbon assumptions
- Maintenance of a live and updated adaptive plan

[8] 63989ae6af0dc1468d4807a3_OxCam-IWMF-Phase-1-Report.pdf (website-files.com)
[9] Home (entrade.co.uk)
[10] Community Infrastructure Levy - GOV.UK (www.gov.uk)

A digital platform could enhance opportunities for collaborative working. We suggest that the platform should have the following functions to help implement the strategy:

- Clear and concise ways of communicating the strategy
- Support the steering group members to help inform and enhance their business case for investment and implementation
- Link assumptions and scenarios across strategies so that they are consistent
- Define roles and responsibilities
- Monitoring progress of the strategy and alignment with pathways
- Develop data management processes

We suggest the platform has the following analytical tools to aid collaborative working:

- A collaboration tool to set criteria and see who else works in these areas
- Timestamp for planning cycles
- Inform future modelling options for adaptive planning

A key outcome of the proposed platform would be to demonstrate the business case to support greater collaboration. By having a “single source of truth” the platform would be available for use throughout the timelines of the option – planning, procurement, hand-over and operation. In this way the platform could provide significant cost efficiencies for data management.

Appendix G further details the uses and requirements of a data viewing platform.

7 Conclusions

The Subregional Integrated Water Management Strategy (SIWMS) provides an opportunity to bring together water resources, flooding, wastewater and the environment into a single system for collaborative management.

To identify how future growth will influence water in the subregion, we assessed different variable factors across planning documents to identify five probable future scenarios. Two main potential futures emerged from our analysis– a higher urban growth scenario “City Living” and a higher rural growth scenario “Country Life”. These scenarios were largely dominated by the level of ambition around abstraction reductions. Results show that water stress is a significant risk in both future scenarios. Other risks include increased risk of flooding, with some areas experiencing increased risk of drought. Phosphate levels remain high across future scenarios.

Results from the scenario analysis have implications across the subregion. For example, reduced water quality is a constraint to biodiversity. It is also a constraint to London’s growth plans as it decreases water resource resilience which reduces the capacity for new housing and economic growth, as well as also increasing the risk of disruption of supply to London’s existing communities and businesses. Increased risk of flooding increases economic disruption to residents and businesses and reduces the attractiveness of the area for investment. Water stress increases the risk of supply disruptions and reduces the deliverability of future growth plans as supply may not be able to keep up with new demand.

We have identified the following recommendations:

Water quantity

1. Engage with EA and abstraction operators in upper catchment to investigate impact of groundwater abstraction regime on base flows.
2. Deliver planned SuDS programmes within the study area to partially mitigate impacts by retrofitting SuDS in attenuation spaces for up to 5% of the total borough areas and disconnecting surface water sewers for up to 5% the total borough areas.
3. Explore disconnection opportunities (e.g. permeable paving, water butts, green roof areas) in Lower Lea Boroughs Newham, Tower Hamlets and City of London in line with the findings from the TW DWMP.
4. Implement and enforce Schedule 3 of the Flood and Water Management Act (2010).
5. Review current plans for SuDS delivery and develop more ambitious plans to achieve the targets set out in recommendation 2.

6. Investigate mechanisms to enable co-funding of SuDS in strategic upstream locations which deliver shared benefits to multiple boroughs.

Water quality

7. Engage with stakeholders in the upper catchment to understand sources of pollution outside of wastewater treatment works.
8. Investigate land management / natural capital options to reduce Phosphate pollution in the catchment.
9. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment.
10. Engage with TW and other stakeholders to further investigate / address Pymmes Brook misconnections issue.

Water stress

11. Deliver London WRZ options and investigate Deephams Reuse further.
12. Implement LA PCC target of 105 l/p/d or less.
13. Implement progressive metering plan in line with WRMP
14. Investigate land management / natural capital options to reduce Nitrate pollution in the catchment
15. Investigate the possibility of reducing PCC in the Beckton catchment without impacting Thames salinity.

Planning and governance

16. Governance structures and tools needed to coordinate delivery of options across stakeholders.
17. 'Least regrets' options of SuDS and leakage reduction should be delivered as immediately as they mitigate current and future risks without any significant trade-offs.
18. Principal options should also be delivered as they mitigate the largest risks identified in the modelling, but with some trade-offs. These include London WRZ options, Deephams Reuse and PCC reductions.

We have identified immediate, or 90 day, actions (see Section 6.2.1) that can be taken to deliver the recommendations. For example, study findings can be communicated with the Environment Agency and water companies to understand wider pollution sources and drivers in the Upper Lea, as well as the Upper Lea groundwater interaction study. Other actions include a review of current local plan policy to identify whether current policies align with strategy findings for PCC.

There is also a need for transformative change. A strategic finding from the study is that greater coordination is required across governance, planning and delivery systems to effectively address the challenges identified in the study. Longer-term activities include coordinated planning and coordinated delivery. We have recommended mechanisms by which key members can communicate with each other and how more wide-reach options can be delivered for less investment by collaborating in a coordinated and targeted way. Mechanisms to achieve coordinated planning and delivery include a coordinated planning office and a digital tool.

This pilot project has set a precedent for future strategies in London, demonstrating the benefits of collaboration and systems-based thinking for de-risking growth and achieving the collective ambition for sustainability across the subregion. A systems perspective has given not just a clearer understanding on the responsibilities for risk, but how it is also necessary to represent the interconnected relationship between different scenarios, impacts and options. This is crucial to be able to have a dynamic and responsive strategy that is reflective of the complex water system which it is seeking to manage.

Appendices

Tables – Appendices

Figures – Appendices

A. Scenario approach

Project:	East London Subregional Integrated Water Management Strategy		
Our reference:	100108845 | 3.1 | C	**Date:**	05/06/2023
Prepared by:	KM LH	**Checked by:**	LB
Approved by:	RLS		

A.1 Background

The water sector is an inherently complex system. The future of the system is influenced by external factors such as climate change, the economy, consumer attitudes and technology. The future of these factors is uncertain and may be influenced by unpredictable feedback loops from within the water system. Scenario analysis is tool used to understand these types of uncertainties.

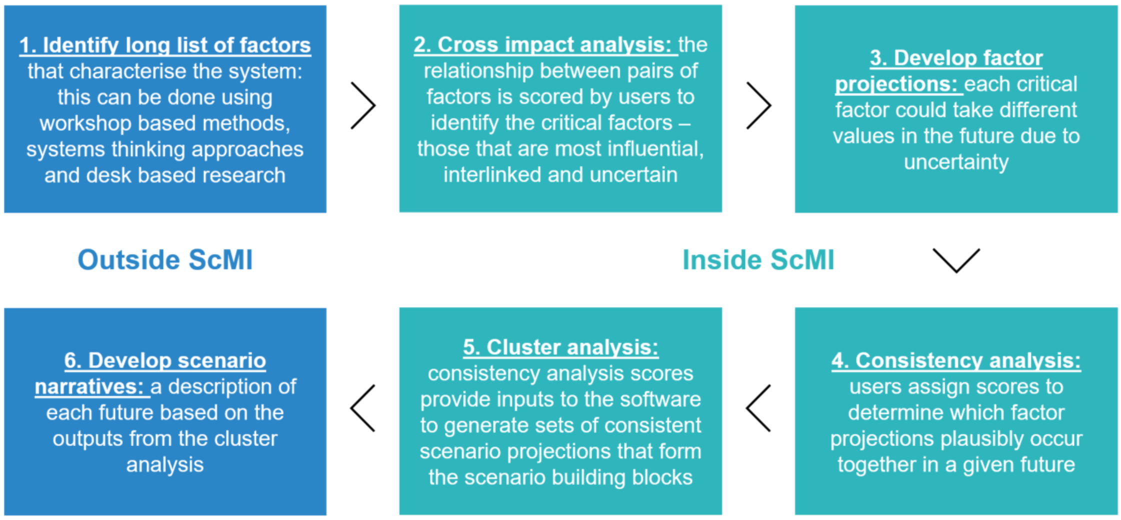
Scenarios are not forecasts. They do not propose a most likely future based on knowledge of current trends but are designed to be representative of a wide spectrum of possible future states. It is important that scenarios should be plausible – in other words that the combination of factors and the future values of the factors (projections) that characterise a scenario could reasonably occur together. Hence plausible implies that scenarios are not only possible but also internally consistent, i.e. that the scenario makes sense overall. Plausibility says nothing about the probability of the future state. However, scenarios are useful, firstly, for understanding that the future may evolve in different ways and the implications of this for policy objectives, and secondly, for testing the robustness of policy actions across different plausible futures.

A.2 Implementing the structured scenario approach

In this study, a structured-scenario development methodology was used. A key feature of this approach was that the scenarios were developed based on a multi-factor, multi-sector, interrelated system and did not rely on one or two main drivers (such as only growth and climate change). The scenario components therefore provided an internally consistent, and, in that sense, plausible picture of what may happen in the water system of interest and more broadly. It was particularly suited to complex systems of factors, given the future variations in these factors are uncertain. Simpler approaches could be used such as 2x2 scenarios, which consider a future based on two basic influence factors, e.g., GDP and climate change impacts, to yield four scenarios. However, the 2x2 matrices often can't consider the impact of key influences.

The Mott MacDonald FUTURES[11] approach was delivered using Scenario Manager software developed by ScMI[12], and was implemented in six steps as shown in Figure A.1.

Figure A.1: Generic steps in the scenario development



A.2.1 Steps in the scenario development

A.2.1.1 Step 1: Identification of a long list of factors

A long list of factors was identified that might impact the objectives of integrated water management in London boroughs. These were identified in an internal workshop using outputs from the systems mapping and expert judgement. Factors are items of uncertainty that may influence desired outcomes for people and the environment. The factors are listed in Table A.1.

Table A.1: Factor long list

Key Areas	Factor Number	Factor
Demographic	1	Total population (upstream and main catchment)
	2	Opportunity areas

[11] FUTURES: vision-led planning for an uncertain world - Mott MacDonald

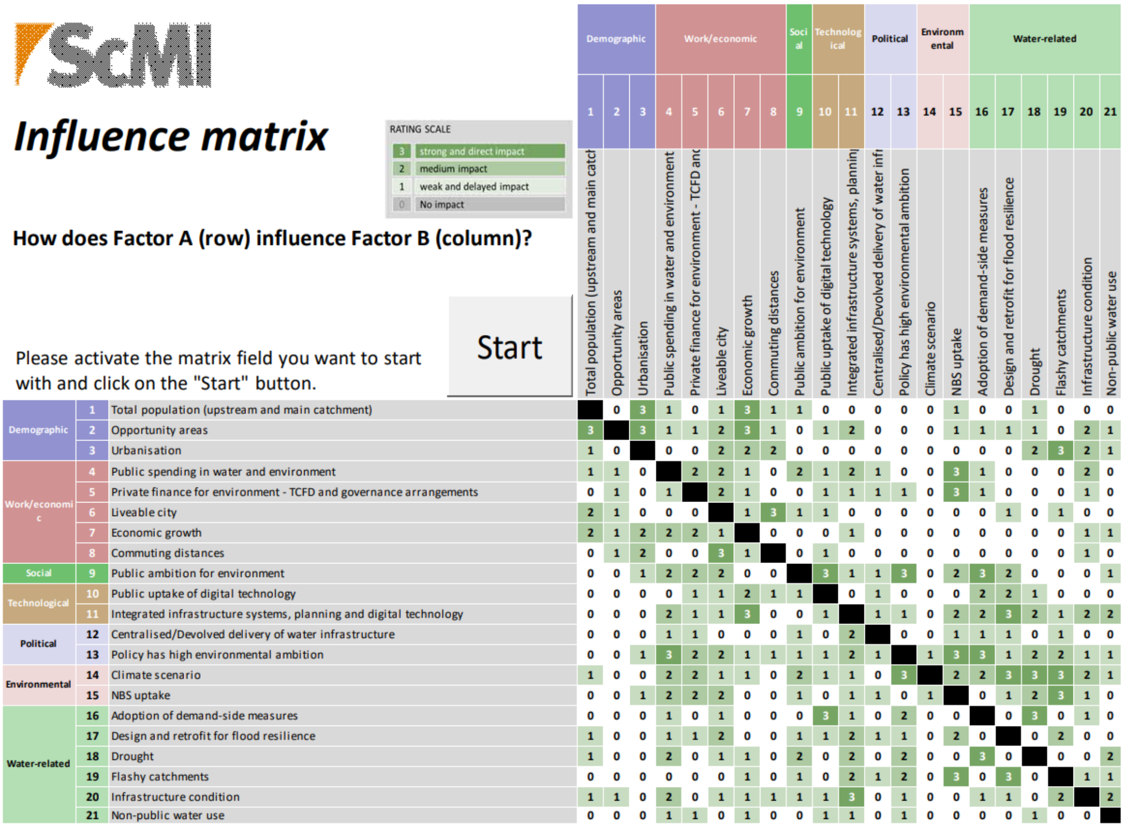
[12] https://www.scmi.de/en/software/scenario-manager%E2%84%A2

Key Areas	Factor Number	Factor
	3	Urbanisation
Work/economic	4	Public spending in water and environment
	5	Private finance for environment - TCFD and governance arrangements
	6	Liveable city
	7	Economic growth
	8	Commuting distances
Social	9	Public ambition for environment
Technological	10	Public uptake of digital technology
	11	Integrated infrastructure systems, planning and digital technology
Political	12	Centralised/Devolved delivery of water infrastructure
	13	Policy has high environmental ambition
Environmental	14	Climate scenario
	15	Nature Based Solution (NBS) uptake
Water-related	16	Adoption of demand-side measures
	17	Design and retrofit for flood resilience
	18	Drought
	19	Flashy catchments
	20	Infrastructure condition
	21	Non-public water use

A.2.1.2 Step 2: Cross-impact analysis

Critical factors were derived from the factor longlist, using cross-impact analysis in which the influence of each factor on all other factors was scored. This process identified those factors that have the most influence on other factors in the system (called “active” factors), and those that are most influenced by other factors (called “passive” factors).

Figure A.2: SIWMS influence matrix



ScMI

Influence matrix

RATING SCALE
3 strong and direct impact
2 medium impact
1 weak and delayed impact
0 No impact

How does Factor A (row) influence Factor B (column)?

Please activate the matrix field you want to start with and click on the "Start" button.

Start

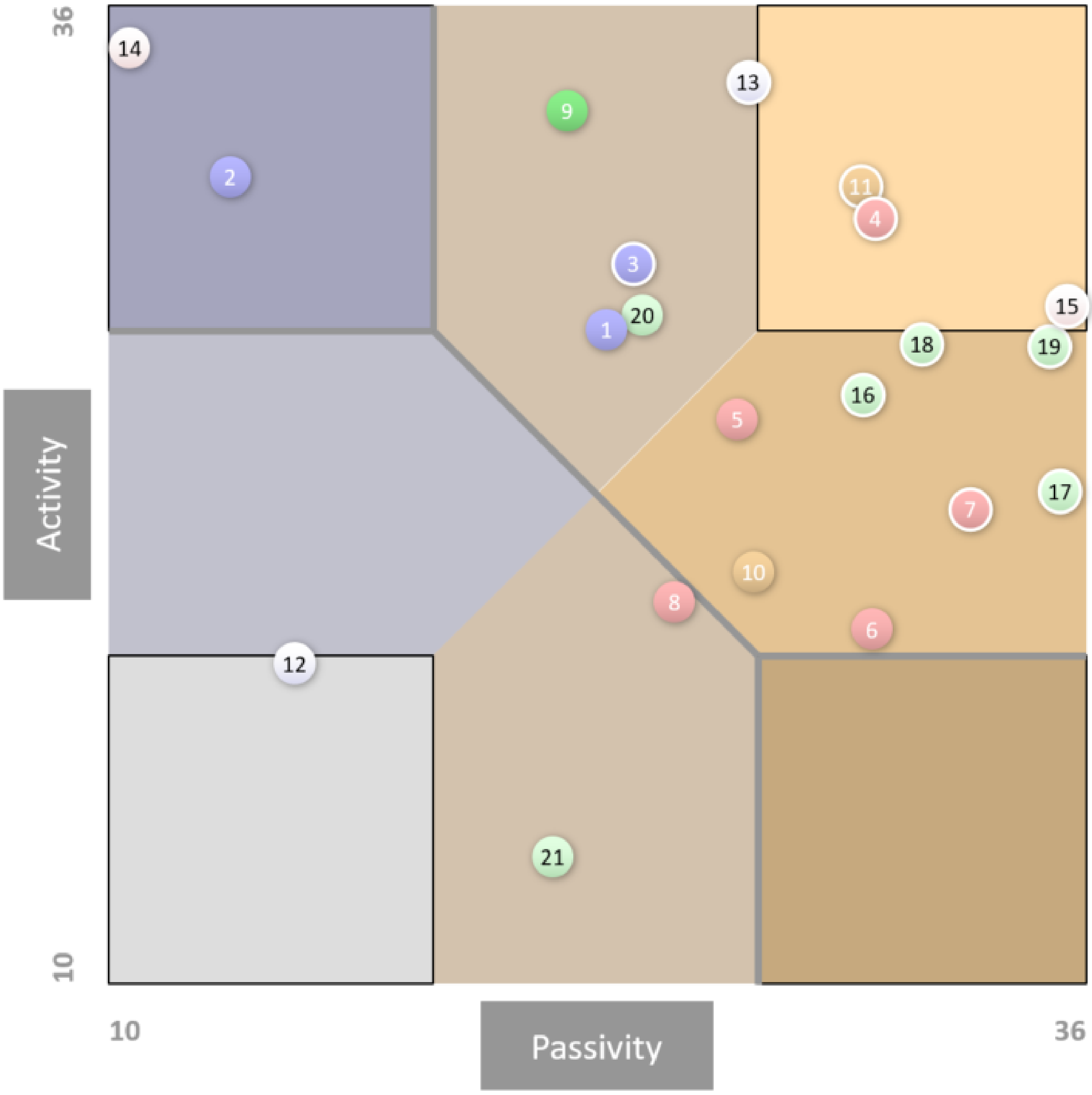
			1 Total population (upstream and main catch	2 Opportunity areas	3 Urbanisation	4 Public spending in water and environment	5 Private finance for environment - TCFD and	6 Liveable city	7 Economic growth	8 Commuting distances	9 Public ambition for environment	10 Public uptake of digital technology	11 Integrated infrastructure systems, plannin	12 Centralised/Devolved delivery of water infr	13 Policy has high environmental ambition	14 Climate scenario	15 NBS uptake	16 Adoption of demand-side measures	17 Design and retrofit for flood resilience	18 Drought	19 Flashy catchments	20 Infrastructure condition	21 Non-public water use
Demographic	1	Total population (upstream and main catchment)		0	3	1	0	1	3	1	1	0	0	0	0	0	1	0	0	1	0	0	0
	2	Opportunity areas	3		3	1	1	2	3	1	0	1	2	0	0	0	1	1	1	1	0	2	1
	3	Urbanisation	1	0		0	0	2	2	2	0	0	0	0	0	0	0	0	0	2	3	2	1
Work/economic	4	Public spending in water and environment	1	1	0		2	2	1	0	2	1	2	1	0	0	3	1	0	0	0	2	0
	5	Private finance for environment - TCFD and governance arrangements	0	1	0	1		2	1	0	0	1	1	1	1	0	3	1	0	0	0	1	0
	6	Liveable city	2	1	0	0	0		1	3	1	1	0	0	0	0	0	0	1	0	1	0	0
	7	Economic growth	2	1	2	2	2	1		0	0	0	1	0	0	0	0	0	0	0	0	1	1
	8	Commuting distances	0	1	2	0	0	3	1		0	1	0	0	0	0	0	0	0	0	0	1	0
Social	9	Public ambition for environment	0	0	1	2	2	2	0	0		3	1	1	3	0	2	3	2	0	0	0	1
Technological	10	Public uptake of digital technology	0	0	0	0	1	1	2	1	1		0	1	0	0	0	2	2	1	0	0	0
	11	Integrated infrastructure systems, planning and digital technology	0	0	0	2	1	1	3	0	0	1		1	1	0	2	2	3	2	1	2	2
Political	12	Centralised/Devolved delivery of water infrastructure	0	0	0	1	1	0	0	0	1	0	2		0	0	1	1	1	0	1	0	0
	13	Policy has high environmental ambition	0	0	1	3	2	2	1	1	1	1	2	1		1	3	3	1	2	2	1	1
Environmental	14	Climate scenario	1	0	0	2	2	1	1	0	2	1	1	0	3		2	2	3	3	3	2	1
	15	NBS uptake	0	0	1	2	2	2	0	0	1	0	1	1	0	1		0	1	2	3	1	0
Water-related	16	Adoption of demand-side measures	0	0	0	1	0	1	0	0	0	3	1	0	2	0	0		0	3	0	1	0
	17	Design and retrofit for flood resilience	1	0	0	1	1	2	0	0	1	1	2	1	1	0	2	0		0	2	0	0
	18	Drought	1	0	0	2	0	1	1	0	2	0	2	0	2	0	0	3	0		0	0	2
	19	Flashy catchments	0	0	0	0	0	0	1	0	1	0	2	1	2	0	3	0	3	0		1	1
	20	Infrastructure condition	1	1	0	2	0	1	1	1	1	1	3	0	1	0	0	1	1	0	2		2
	21	Non-public water use	0	0	0	1	1	0	1	0	0	1	1	0	1	0	0	0	0	1	0	0	

Column groups: Demographic (1–3), Work/economic (4–8), Social (9), Technological (10–11), Political (12–13), Environmental (14–15), Water-related (16–21).

Source: ScMI

The cross-impact analysis was undertaken in an influence matrix seen in Figure A.2, and the results presented on an activity/passivity plot.

Figure A.3: SIWMS absolute activity/passivity plot



Source: ScMI

16 factors were selected for development of projections and scenarios from the activity/passivity plot. Five of the original factors were rejected as they had minimal impact on the other factors considered, resulting in a low activity score.

Table A.2: Factors selected for projection and scenario development

Primary Impact Area	Factors
Demographic	Opportunity areas
	Urbanisation - city
	Urbanisation- rural
Work/economic	Private spending

Primary Impact Area	Factors
	Public spending
	Liveable city
	Economic growth
Social	Public ambition for environment - urban
	Public ambition for environment - rural
Technological	Integrated infrastructure systems, planning and digital technology
Political	Policy has high environmental ambition
Environmental	Climate scenario
	NBS uptake
Water-related	Level of demand for water
	Design and retrofit for flood resilience
	Abstraction regime

A.2.1.3 Step 3: Develop future projections

Using the 16 factors, the scenarios comprise a combination of different projections for each factor, e.g. “high” or “low”. The future projections for the factors reflect the uncertainty in their future direction of travel and are intended to represent divergent outcomes. Between two and three projections were developed for each factor drawing on the expertise of the project team. The factor projections are qualitative but are appropriate to the future year for which the scenarios are developed.

An example is the future projections for adaptation.

- High future projection consists of:
  - High engagement levels in public ambition for the environment
  - Well integrated infrastructure systems, planning and digital technology
  - High NBS uptake
  - Policy ambition to enhance green space and water usage
  - High uptake of design and retrofit of flood resilience measures
- Low future projection consists of:
  - Low engagement levels in public ambition for the environment
  - Poorly integrated approach to infrastructure management
  - Low NBS uptake
  - Policy ambition does not focus on environmental enhancement

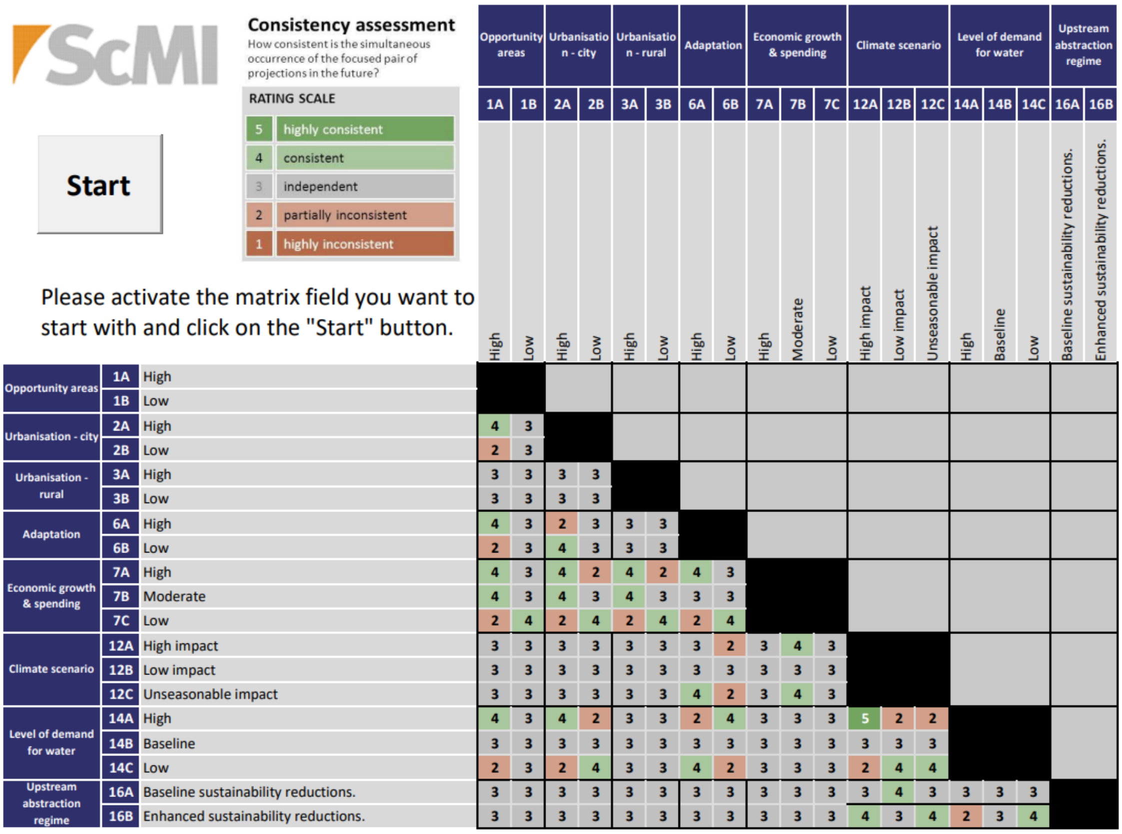
– Low uptake of design and retrofit of flood resilience measures

A.2.1.4 Step 4: Consistency analysis

The 16 critical factors were further amalgamated and constrained into a set of eight factors without loss of information through the consistency analysis, where the projection consistency of two or three factors was very similar. The final eight factors are described in section A.2.2.

To ensure the consistency of factor projections in the scenarios, each combination of plausible factor projections was scored from 1 to 5 (where 1 indicated that co-occurrence is highly inconsistent and 5 that it is highly consistent). This information formed the basis for identifying consistent clusters of factor projections, which became the building blocks for the future scenarios. The consistency analysis shown in Figure A.4 was based on expert judgement and was undertaken by the study team.

Figure A.4: SIWMS consistency analysis



			1A	1B	2A	2B	3A	3B	6A	6B	7A	7B	7C	12A	12B	12C	14A	14B	14C	16A	16B
			Opportunity areas		Urbanisation - city		Urbanisation - rural		Adaptation		Economic growth & spending			Climate scenario			Level of demand for water			Upstream abstraction regime	
			High	Low	High	Low	High	Low	High	Low	High	Moderate	Low	High impact	Low impact	Unseasonable impact	High	Baseline	Low	Baseline sustainability reductions.	Enhanced sustainability reductions.
Opportunity areas	1A	High																			
	1B	Low																			
Urbanisation - city	2A	High	4	3																	
	2B	Low	2	3																	
Urbanisation - rural	3A	High	3	3	3	3															
	3B	Low	3	3	3	3															
Adaptation	6A	High	4	3	2	3	3	3													
	6B	Low	2	3	4	3	3	3													
Economic growth & spending	7A	High	4	3	4	2	4	2	4	3											
	7B	Moderate	4	3	4	3	4	3	3	3											
	7C	Low	2	4	2	4	2	4	2	4											
Climate scenario	12A	High impact	3	3	3	3	3	3	3	2	3	4	3								
	12B	Low impact	3	3	3	3	3	3	3	3	3	3	3								
	12C	Unseasonable impact	3	3	3	3	3	3	4	2	3	4	3								
Level of demand for water	14A	High	4	3	4	2	3	3	2	4	3	3	3	5	2	2					
	14B	Baseline	3	3	3	3	3	3	3	3	3	3	3	3	3	3					
	14C	Low	2	3	2	4	3	3	4	2	3	3	3	2	4	4					
Upstream abstraction regime	16A	Baseline sustainability reductions.	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3		
	16B	Enhanced sustainability reductions.	3	3	3	3	3	3	3	3	3	3	3	4	3	4	2	3	4		

Source: ScMI

A.2.1.5 Step 5: Cluster analysis

Cluster analysis was performed on the consistency analysis scores within the ScMI software to generate a set of scenarios, each of which is characterised by a set of factor projections. The analysis identified a set of seven scenarios. The seven scenarios were discussed with a focus group who were part of the wider steering group, from which a list of five scenarios was identified for development into full narratives. The reduction from seven to five was so that the final number was manageable, and a clear distinct narrative could be given for each scenario. The reduction was achieved by amalgamating scenarios which were similar.

A.2.1.6 Step 6: Scenario narratives

An important part of the scenario process is to build a narrative around the projections for each scenario. The narrative is told from the perspective of the future, building on the factor projections and, in a sense, bringing them to life to provide a description of the water system situated in the context of broader societal developments. Where necessary, the narrative provides an indicative pathway as to how the 2035 future has been reached and is designed to provide sufficient information for policy testing without being prescriptive.

The narratives are described in section A.3.1.

A.2.2 Factors included in the scenario development

The list of factors used for the scenarios in this study was:

- Opportunity areas
- Urbanisation - City
- Urbanisation - Rural
- Adaptation
- Abstraction regime changes
- Level of demand for water
- Economic growth and spending
- Climate change

The effects of economic growth and spending were not quantified to include in the modelling as their effects were captured within the projections for other factors.

A.2.2.1 Opportunity areas

The lower Lea catchment contains several opportunity areas (OAs) which have been identified for urban development, with target projections for housing and job growth set within these areas. The opportunity areas within the catchment are:

- Royal Docks and Beckton Riverside (emerging OA, outside of the modelled boundary and covered by the local IWMS)

- Isle of Dogs and South Poplar (outside of the modelled boundary and covered by the local IWMS)
- City Fringe/Tech City
- Olympic Legacy
- Lea Valley

For each scenario, a percentage of the projected OA growth has been modelled depending on the expected levels of urban growth of the scenario. The percentages used are stated in Table A.5. For the purpose of this study as there was only one emerging OA in the study, all were considered with the same percentage of the projected growth.

A.2.2.2 Urbanisation – city

The level of urban growth within the lower Lea catchment, and the consequent increase in building areas, has been considered, based on Office for National Statistics (ONS) and Greater London Authority (GLA) growth figures for the catchment. The assumptions used for each scenario are detailed in Table A.5.

A.2.2.3 Urbanisation – rural

Similarly to the lower Lea catchment, the ONS growth projections for the upper Lea catchment have been used to estimate the increase in runoff area for the modelling of each scenario, detailed in Table A.5.

A.2.2.4 Adaptation

The level of land use change for the purpose of SuDS and nature-based solutions, environmental improvements and STW changes in response to the WINEP programme have been considered for each of the future scenarios developed. To represent this in the modelling of scenarios, a percentage reduction in impermeable area has been assumed depending on the priority paced on environmental factors within each scenario.

A.2.2.5 Abstraction regime changes

The Environment Agency (EA) has set aspirations for chalk stream restoration in the River Lea that are considered to be enhanced sustainability reductions, which are to be achieved through licence changes that reduces the amount of abstraction permitted from the chalk streams. In scenarios which place high importance on the environment, the modelling approach used assumed that enhanced sustainability reductions are implemented, and the restoration aspirations are met. Lesser reductions are applied for scenarios of less ambition based on medium and low projections. Thames Water provided values for low, medium and high ambition as specified in Table A.3.

Table A.3: Thames Water abstraction licence reductions for upstream abstraction regime projections

	Abstraction Licence Ml/d			
Thames Water - Licence Group	**Low Ambition**	**Medium Ambition**	**High Ambition**	**Comment**
River Lea, Enfield Group	550.5	200	78.6	NB medium ambition would also require a HOF of 50 Ml/d
Northern New River Wells	100.5	80.65	58.7	N.A.
New Gauge	101.9	40	0	N.A.

Source: Thames Water

There is an 82% reduction in abstractions under the ‘severe’ scenario and a 57% reduction in the ‘moderate’ scenario.

A.2.2.6 Level of demand for water

Within each future scenario, measures will be implemented to reduce the per capita consumption (PCC) of water. Scenarios in which PCC is expected to decrease significantly have been modelled as 90l/h/d aligning with the targets set out in most local flood risk management plans (LFRMPs), while moderate decreases have been modelled as 105l/h/d which is the target set out by Thames Water. Scenarios which were expected to maintain the current PCC or increase it have been modelled the same as the baseline.

A.2.2.7 Economic growth

Economic growth is represented by the opportunity areas and urbanisation factors, so therefore was not quantified for modelling as its own factor.

A.2.2.8 Climate change

Six different future climates were tested, with three being based on a ‘best case’ climate projection and three based on a ‘worst case’ climate projection to test how much variation is shown between climates for each scenario. The climate projections are based on Representative Concentration Pathway (RCP) trajectories of greenhouse gases being applied to a historic climate period from 2000-2020. The best case projections are based on the RCP 2.6 pathway, while the worst case projections are based on the RCP 8.5 pathway. The 6 climates used are defined in Table A.4.

Table A.4: Description of climate scenarios

Name	Description
RCP 2.6	'Best case' climate, 50th percentile precipitation
RCP 2.6 DS	'Best case' climate, 25th percentile precipitation (Dryer summers, wetter winters)
RCP 2.6 WS	'Best case' climate, 75th percentile unseasonable precipitation (Wetter summers, dryer winters)
RCP 8.5	'Worst case' climate, 50th percentile precipitation
RCP 8.5 DS	'Worst case' climate, 25th percentile precipitation (Dryer summers, wetter winters)
RCP 8.5 WS	'Worst case' climate, 75th percentile unseasonable precipitation (Wetter summers, dryer winters)

Further details on the climate scenarios used are include within appendix D.

A.3 Outputs of scenario approach

From the scenario approach, 5 possible future scenarios were developed, and proposed modelling approaches were recommended for each factor considered in each scenario.

A.3.1 Scenario narrative

A.3.1.1 Country Life

In this scenario, people have decided they want to live in the countryside rather than the city. Therefore, rural urbanisation has increased, while city growth in the lower river Lea catchment has not increased as projected. Opportunity areas have only achieved 50% of their potential and water demand in the subregion drops. As people are living in the countryside, they place more importance on the environment and this results in a large number of adaptations such as nature-based solutions, and pressure to restore chalk streams in the upper Lea. As economic growth has been moderate, they have the money to spend on these environmental enhancements.

A.3.1.2 Unrealised Urbanisation

In the Unrealised Urbanisation scenario, economic growth has been low. Opportunity Areas have been implemented from a policy perspective, but the intended impact has not been realised. They have seen low growth and success, as people couldn't afford to move to the city. Attempts at building infrastructure to allow for growth have taken place, leading to increased urbanisation, which is not being utilised to its full extent. There is no spending on environmental adaptations, such as nature-based solutions, as finances have been required elsewhere on social benefits. There are baseline sustainability reductions with regards to upstream abstraction regime alterations and the demand for water remains the same as the baseline.

A.3.1.3 City Living

In the City Living scenario people choose to live as close to the centre of London as they can afford, and therefore opportunity areas are very successful. There's high urbanisation within the London boroughs as well as increased urbanisation in the commuter belt. Impacts to the environment in central London, caused by increased population, result in some focus on environmental protection which is supported by a moderate economic growth.

A.3.1.4 Prosperous Growth

The leading factor in Prosperous Growth is that there has been high economic growth and therefore spending. Opportunity areas are successful, there's high urbanisation in the city and rurally, and this spending also benefits the environment. Increased environmental protection measures are implemented such as nature-based solutions, flood resilience and digital technology, resulting in the need for water being low per capita. It's important to understand that the difference in this scenario is that the culture towards the environment has not changed as a whole, it's simply that prosperity encourages funding of the measures that environmental protectors deem necessary.

A.3.1.5 Environmental Priority

The Environmental Priority scenario is the opposite to that of Prosperous Growth. The culture towards the environment has high ambition for the environment. Enhanced adaptations and enhanced sustainability reductions for upstream abstractions are undertaken. Digital technology and environmental groups become more popular through education, and the level of demand for water is low per capita because of this. The change in culture is supported by moderate economic growth, which supports the opportunity areas which are successfully increasing urbanisation in the city.

A.3.2 Proposed approach for scenarios developed

Using the scenario narratives developed, the proposed modelling approach for each scenario regarding the factors discussed in section A.2.2 were determined. The approaches are presented in Table A.5.

The 6 climate variations discussed in section A.2.2.8, were applied to each of the scenarios

Table A.5: Scenarios and modelling approaches

		Country Life		Unrealised Urbanisation		City Living		Prosperous Growth		Environmental Priority		Basis for modelling assumptions
Factors	**Factor Description**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	
Opportunity areas	Growth focussed in opportunity areas impacting housing and jobs	Medium	Assumed 50% of projected growth in confirmed OAs only	Low	Assumed 30% of projected growth in confirmed OAs only	High	Assumed 100% of projected growth in confirmed OAs	High	Assumed 100% of projected growth in confirmed OAs	High	Assumed 100% of projected growth in confirmed OAs	Opportunity areas to be added as additional population. OAs may not achieve full ambition but for high growth, 100% is assumed. Confirmed OAs have secured policy ambition; whereas emerging are still under review. Key driver here is growth, but minor benefits of technology enhancement (no modelling impact), improved infrastructure. Aim is to act as a hub for growth.
Urbanisation - city	Increased building leading to increased runoff in the lower catchment of the River Lea	Low	Assume ONS growth figures; assume no creep	Medium	Assume GLA housing-led growth figures (past delivery)[13]; assume creep at 4m2 per house per year; 2% increase for commercial and flats.	High	Assume GLA housing led growth figures (housing targets)[13]; assume creep at 4m2 per house per year; 2% increase for commercial and flats.	High	Assume GLA housing led growth figures (housing targets)[13]; assume creep at 4m2 per house per year; 2% increase for commercial and flats.	High	Assume GLA housing led growth figures (housing targets)[13]; assume creep at 4m2 per house per year; 2% increase for commercial and flats.	Urbanisation-city includes growth outside of opportunity areas (e.g. shortfall between opportunity areas, GLA growth projections and/or ONS growth projections); also includes development of infrastructure/paved areas, so creep included (4m2 per house, 2% increase for commercial) based on TW standards. Difference between population projections to be defined. ONS data provided at LSOA level

[13] Population and household projections – London Datastore

		Country Life		Unrealised Urbanisation		City Living		Prosperous Growth		Environmental Priority		Basis for modelling assumptions
Factors	**Factor Description**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	
Urbanisation - rural	Increased building leading to increased runoff in the upper catchment of the River Lea	High	Assume ONS Alternative internal migration projections (Table 23), assume creep increase runoff by 4m2 per property per year; increase in no. of properties and therefore impermeable area based on 80% housing projections, assume average 100m2	Very Low	Assume ONS 'Low international' migration projections (Table 22); assume no creep; increase in no. of properties and therefore impermeable area based on 50% housing projections, assume average 100m2	Medium	Assume ONS 'High international' migration projections (Table 21); assume creep increase runoff by 4m2 per property per year; increase in no. of properties and therefore impermeable area based on 80% housing projections, assume average 100m2	Very High	Assume ONS '10yr migration variant' projections (Table 217032020155604); assume creep increase runoff by 4m2 per property per year; increase in no. of properties and therefore impermeable area based on 100% housing projections, assume average 100m2	Low	Assume ONS Table 2 projections; increase in no. of properties and therefore impermeable area based on 60% housing projections, assume average 100m2	Urbanisation-rural includes growth outside of study area (e.g. upper Lea catchment); also includes development of infrastructure/paved areas, so creep included (4m2 per house, 2% increase for commercial) based on TW standards. ONS data used to assess no. of properties. Average house area of 100m2 to be used. Further refinement/sensitivity may be required
Adaptation	Related Environmental cultural adaptions or similar. it includes: Public ambition for environment - urban Public	High uptake	Assume reduction in impermeable area of 20%; all upper Lea WINEP[14] Schemes realised.	Low uptake	Assume reduction in impermeable area of 1% only	Medium uptake	*Assume reduction in impermeable area of 1%; assume reduction of spills in upper Lea at East Hyde, Rye Meads, Harpenden only (network*	High uptake	Assume reduction in impermeable area of 20%; all upper Lea WINEP[14] Schemes realised	High uptake	Assume reduction in impermeable area of 20%; all upper Lea WINEP[14] Schemes realised	Ambition for adaptation is split into 3 key categories: - Implementation of Suds/NBS - Implementation of Wastewater Improvements - Implementation of environmental improvements For SuDS/NBS - low

[14] WINEP changes to sewage treatment plants were from the initial position for WINEP at the time of the study. These are known to have been developed since.

		Country Life		**Unrealised Urbanisation**		**City Living**		**Prosperous Growth**		**Environmental Priority**		**Basis for modelling assumptions**
Factors	**Factor Description**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	
	ambition for environment - rural Policy has high environmental ambition Integrated infrastructure systems, planning and digital technology NBS uptake Flood Resilience						*enhancement/ SW management only)*					uptake is based on all new developments implementing suds to have net impact of reverting to greenfield runoff rates, high uptake is an assumption of 20% impermeable area is retrofitted. For Wastewater Improvements - low uptake is no improvements (i.e. just keep the lights on and bare minimum compliance), medium uptake is low capital interventions such as SuDS and network enhancements (i.e. outputs from STWs do not significantly change); high uptake is improvements to STW compliance, along with network enhancements and SuDS. Uptake is partially linked with public perception of the environment and water companies' impact on it. WINEP Schemes provided from national programme - mostly monitoring, so impact will be negligible.

		Country Life		Unrealised Urbanisation		City Living		Prosperous Growth		Environmental Priority		Basis for modelling assumptions
Factors	**Factor Description**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	**Factor Variable**	**Proposed Modelling Approach**	
Abstraction regime changes		High Ambition	82% reduction: abstraction licence of 78.6Ml/d in Lea, 58.7Ml/d in Northern Wells, 0 in New Gauge	Low Ambition	*0% reduction: abstraction licence of 550.5Ml/d in Lea, 100.5Ml/d in Northern Wells, 101.9 in New Gauge*	Medium Ambition	*57% reduction: abstraction licence of 200Ml/d in Lea, 80.65Ml/d in Northern Wells, 40 in New Gauge*	Medium Ambition	*57% reduction:, abstraction licence of 200Ml/d in Lea, 80.65Ml/d in Northern Wells, 40 in New Gauge*	High Ambition	82% reduction:, abstraction licence of 78.6Ml/d in Lea, 58.7Ml/d in Northern Wells, 0 in New Gauge	We want to understand here the impact of chalk streams and other reductions in water abstractions on the lower Lea catchment. Fully realised versus partially realised. Estimated 20-30% for partially realised ambition.
Level of demand for water	Water demand	Low Water Use	Assume PCC drops to 90l/h/d for new properties, reduces by 15l/h/d in existing population*	Current Water Use	*Assume PCC remains as current**	High Water Use	Assume PCC remains as current, or increases further (up to 160l/h/d)	Reduced Water Use[15]	*Assume PCC drops to 105l/h/d**	Reduced Water Use	*Assume PCC drops to 105l/h/d*	Policy ambition for each borough is to reduce per-capita consumption; low consumption rate of 90l/h/d is present in most local plans; with 105l/h/d in TW and remaining local plans; high demand is to remain as currently modelled
Economic growth & spending		Medium	No modelling impact	Low	No modelling impact	High	No modelling impact	Very High	No modelling impact	Medium	No modelling impact	Not modelled, represented and realised to scenario though growth/adaptation etc.

[15] In line with Government set national target for water consumption.

A.4 Conclusions

To demonstrate potential future pathways, and enable adaptive plans to be developed, the FUTURES method was used.

Using the FUTURES method, 21 different variables were assessed to identify different future scenarios for the River Lea catchment. The number of variables was reduced to 16 using cross-impact analysis. The variables were further reduced to eight influencing factors through consistency analysis, which resulted in eliminating variables that were closely aligned and did not have an independent influence. From the 8 influencing factors, 5 plausible future scenarios 5 scenarios were derived:

- Country Life
- Unrealised Urbanisation
- City Living
- Prosperous Growth
- Environmental Priority

The narratives were well received by the steering group and they were able to understand naming convention which summarised a large number of factors and inputs into the modelling. The study team found the approach was labour intensive but has the benefit of a comprehensive and auditable rationale for the scenarios used in the planning process.

This project has been run as a pilot for a Subregional Integrated Water Management Strategy. Overall, we would recommend that a participatory scenario development exercise would be merited as an exercise for London to inform numerous planning processes – energy, water, data, transport etc. Thereby the investment in time and money would be made worthwhile by the wider benefits derived from the work.

The steering group preferred using multiple factors, when compared to a simple 2x2 matrix, for scenarios. Although, they suggested it would have been useful to see the disaggregated impacts of the individual factors modelled. This would have shown the impact each factor contributed to the overall scenario results.

B. Option identification and analysis

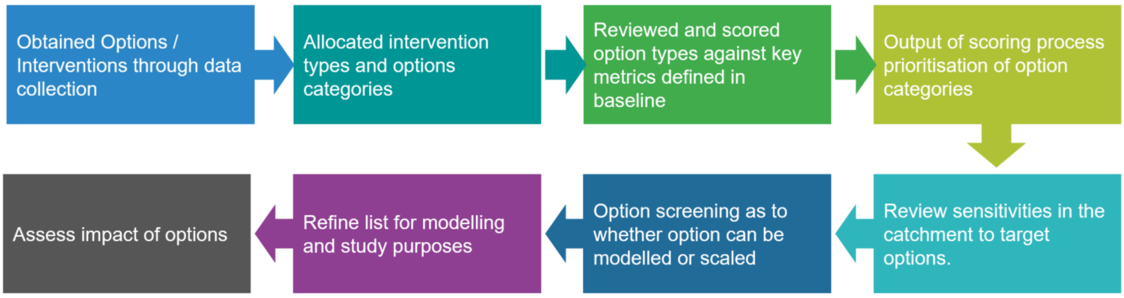
Project:	East London Subregional Integrated Water Management Strategy		
Our reference:	100108845 | 4.1 | B	**Date:**	06/04/2023
Updated by:	RLS	**Checked by:**	KM
Approved by:	LB		

B.1 Introduction

To demonstrate the potential impacts that existing planning options could have on the catchment's water system, options have been obtained from existing planning documents which affect the lower Lea catchment. The options were then scored against a series of criteria to determine their overall impact. A selection of these options was chosen to model based on the scale and size of their impact and the potential to quantify the options for modelling purposes. The selected options were modelled with two of the potential future scenarios which were developed for the catchment which were 'City living' and 'Country life', which are detailed in Appendix A Scenario Approach. The options modelled within the baseline and both scenarios were compared to see how the impacts would differ under the various circumstances and the overall benefits they would provide.

The option identification process is summarised in Figure B.5.

Figure B.5: Option Identification Process



B.2 Option Categories and Intervention Types

B.2.1 Data sources and categorisation

Options impacting the river Lea were taken from the Thames Water DWMP (Beckton and Deephams catchments) and WRMP, the EA RBMP and FRMP, TE2100 Plan, WINEP, Isle of Dogs and South Poplar IWMS and the LFRMSs of City of London, Enfield, Hackney, Haringey, Newham, Tower Hamlets, and Waltham Forest. We collated options in a spreadsheet and scored based on their impacts across metrics defined in the systems mapping. As there were consistencies between the LFRMSs of each borough, the plan options from all of these were grouped together under 'LFRMS' within the scoring spreadsheet. The compilation of LFRMS options aided the screening process and was also suitable for the scale of the SIWMS. The scale was appropriate as options adopted in one local plan can reasonably be applied in the rest of the boroughs, meaning they can be merged and considered at catchment level.

The options which were obtained from the planning documents were grouped within the categories shown in Table B.6 according to what they aimed to address. The options in each category were also grouped into intervention types based on the method of achieving the planned aim. Table B.7 shows which intervention types were included in each category. Grouping the options into categories and intervention types helped to compare multiple options from different planning sources that aim to address similar issues.

Table B.6: Option Categories

Category	Description
Awareness and Education	Increasing society's understanding of the water system and improving their contribution to it. Building networks and linking with partners to unlock potential.
Blue-Green Infrastructure	Natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem service
Digital	Using data for planning and investment decision.
Existing Assets	Maintaining and fully utilising existing infrastructure and systems i.e. existing flood defences.
Hard Engineering	Building artificial structures to control natural processes.
River Health	River restoration and managing modifications to watercourses.
Water Efficiency	Promoting sustainable use of water.
Water Resources	Ensuring a secure and resilient water supply from natural sources of water.

Table B.7: Intervention Types

Intervention Type	Option Category
Adoption of demand side measures	• Digital • Water Efficiency
Communication	• Awareness and Education • Hard Engineering • Water Efficiency
Flood Defences	• Hard Engineering
Flood Forecasting and Modelling	• Awareness and Education • Digital
Flood Response	• Awareness and Education
Maintenance	• Awareness and Education • Blue Green Infrastructure • Existing Assets
Natural Capital Enhancement	• Blue Green Infrastructure
Network Capacity	• Hard Engineering • Water Resources
Partnership	• Awareness and Education • Hard Engineering
Property Resilience	• Awareness and Education • Blue Green Infrastructure • Hard Engineering
River Restoration	• Blue Green Infrastructure • River Health
Standards, policy and compliance	• Awareness and Education • Blue Green Infrastructure • Existing Assets • River Health
SuDS	• Blue Green Infrastructure • Hard Engineering
Upstream sustainability reductions	• Water Resources
Wastewater Treatment Capacity	• Hard Engineering
Water Quality Improvements	• Blue Green Infrastructure • Hard Engineering
Water Resource Enhancements	• Water Efficiency • Water Resources

Once the options were scored, we could then prioritise option intervention types and categories based on those which had the most impact.

B.3 Scoring Metrics and Option Screening

B.3.1 Scoring criteria and metrics

To determine which options would provide the most benefit to the sub region, each option was scored against the set of criteria in Table B.8 based on the key metrics obtained from the systems mapping carried out during the baseline assessment of the sub-region:

Table B.8: Option scoring criteria and metrics

Criteria	Metrics
Flood protection	Properties at risk of flooding (includes sub metrics for wastewater, surface water and fluvial flooding)
Flood placemaking	Q5 QMED flow R-B index
Water quality	Water Framework Directive (WFD) status
High flow water quality	99 percentile BOD Phosphate and ammonia concentrations
Environmental flow	Q95 flow deficit
Water resources	Dry year supply demand balance benefit (Ml/d)
Morphology	Water Framework Directive (WFD) status
Invasive non-native species (INNS)	INNS WFD pressure status
Carbon sequestration	Tonnes carbon equivalent
Embodied carbon	Tonnes carbon equivalent (embodied)
Operational carbon	Tonnes carbon equivalent (operational)
Biodiversity	Biodiversity net gain
Soil health	Soil health and erosion risks metrics
Mental health	Weighted score based on increased access to green/blue space for recreation
Physical health	Weighted score based on increased access to green/blue space for recreation
Urban heat	Weighted score based on increased access to green/blue space for recreation
Air quality	Weighted score based on increased access to green/blue space for recreation

Criteria	Metrics
Social connectivity and networks	Local connectivity impacts and stakeholder networks

B.3.2 Scoring mechanism

The options were scored on a scale of 3 to -2 for each criterion to evaluate the specific benefits of them all as well as their overall impact based on the sum of scores. The scale is as follows:

- 3 = Very Positive Impact/ Main purpose
- 2 = Positive Impact
- 1 = Slightly Positive Impact
- 0 = No impact
- -1 = Slightly Negative impact on criteria/metric
- -2 = Negative impact on the criteria/metric

When scoring the options, the scale of the impact within the sub region was considered. Options which had very positive impacts on a criterion but only did so at a small/local scale were given a score of 2, while options with similar benefits on a larger scale would receive a 3.

Once the options were scored, the scores of each option were squared and summed together, then were ranked in order of the square root of these sums. The reason for ranking the options this way was so that options with highly impacted metrics, both positive and negative, were given greater weighting in the ranking process so that the options were ranked according to impact, rather than benefits. In addition to assessing the root of the sum of squared scores, the number of non-zero scores for each option was determined to see which options were more widely impactful. The options collated included duplications between different plans which had similar objectives and measures. The duplicated options were all considered in the scoring process; however, it was not factored into the weight of the scoring how common the option type was.
Option Screening

The options extracted were screened for inclusion in the study based on their potential to be modelled or whether they act as a wider enabler for other options. The scoring results were also used to determine whether the options were impactful enough to potentially make a significant difference within the model. The basis for including options was:

- The option targets were quantifiable for inclusion within the model.
- The option was appropriate for the scale of the subregion.
- The option was highly impactful across several scoring metrics.

- The scenario model results provided evidence of which option types would have the largest impact on the subregion. These results were also taken into consideration in the option screening.

The reasons for excluding options were:

- The option was addressed in scenarios that are modelled.
- The option was outside of the subregion.
- The option affected single or few multi-criteria or is low scoring.
- The impacts of the option was likely to be localised and therefore not visible at the subregional scale.
- The option was not relevant to the sub region.
- The option was a duplication of another option that had already been chosen for inclusion.

The options included for modelling all fell within the option categories shown in Table B.9. The general reasoning for other option types not being included for modelling is as follows:

- Awareness and education options are beneficial in enabling other options and bringing positive behavioural change, but the impacts are difficult to quantify for modelling purposes.
- River health and restoration options from the planning documents either had low impact or were not detailed sufficiently to agree parameters for modelling.
- Existing asset options primarily involved maintenance work on existing structures to maintain its current condition and performance, without providing significant improvements above the baseline and therefore would not demonstrate real change to the metrics.

Table B.9: Option categories of modelled options

Option	Option Category
Natural Capital	Blue Green Infrastructure
Deephams reuse	Water Resources
London WRZ	Water Resources
Metering	Digital
Leakage reduction	Water Efficiency
Reducing misconnections	Blue Green Infrastructure
SuDS	Blue Green Infrastructure

B.4 Options Modelled

A shortlist of options to be included from the screening process. Some of the included options sourced from multiple plans involved varying methods which contributed to similar outcomes. The options which contributed to the same objectives were merged into a single modelling option. An example of the merged modelling options is the SuDS option developed, which comprises of option elements from the Thames Water DWMP and the LFRMS' of the local boroughs within the study area.

The final options included for modelling were:

- Natural capital
- Deephams reuse
- London WRZ
- Metering
- Leakage reduction
- Reducing misconnections
- SuDS

The modelled results all received maximum scores in the criteria that they primarily targeted as seen in Table B.10, also providing benefits to a wider range of criteria as a result. The implementation of these options will also have negative impacts on some criteria, primarily increasing embodied and operational carbon.

Table B.10: Modelled option scoring results

	Scoring Criteria																		
Option	**Properties at risk from flooding**	**Flood placemaking**	**Q5 QMED flow and R-B Index**	**Water quality (WFD)**	**High flow water quality (BOD, P, NH3)**	**Environmental flow (WFD)**	**Water resources (SDB)**	**River Morphology**	**Invasive Non-Native Species (INNS)**	**Carbon sequestration**	**Embodied carbon**	**Operational carbon**	**Biodiversity**	**Soil health**	**Mental health**	**Physical health**	**Urban heat**	**Air quality**	**Social connectivity and networks**
Natural Capital	0	0	1	2	2	2	0	3	3	0	0	0	3	1	1	0	1	0	2
Deephams reuse	0	0	1	1	1	1	3	0	0	0	-1	-1	0	0	0	0	0	0	0
London WRZ	0	0	1	0	0	0	3	0	0	0	-2	-1	0	0	0	0	0	0	0
Metering	0	0	0	1	1	1	3	0	0	0	0	3	0	0	1	0	0	0	1

	Scoring Criteria																		
Leakage reduction	0	-1	0	1	1	1	3	0	0	0	0	2	0	0	0	0	0	0	0
Reducing misconnections	2	0	1	2	2	2	0	1	1	0	-1	1	1	1	1	0	0	0	1
SuDS	3	2	2	1	1	0	0	0	0	0	-1	2	1	1	1	0	1	1	1

Certain options were discounted from modelling as the study is focused on demonstrating potential impacts at a subregional scale. Many of these option types focused on very localised risks which would not be impactful at the subregional scale. While some of the benefits of the excluded options may not have had much impact at the sub-regional scale, they still have potential to provide local benefits when implemented and are therefore worth pursuing.

B.4.1 Natural Capital Option

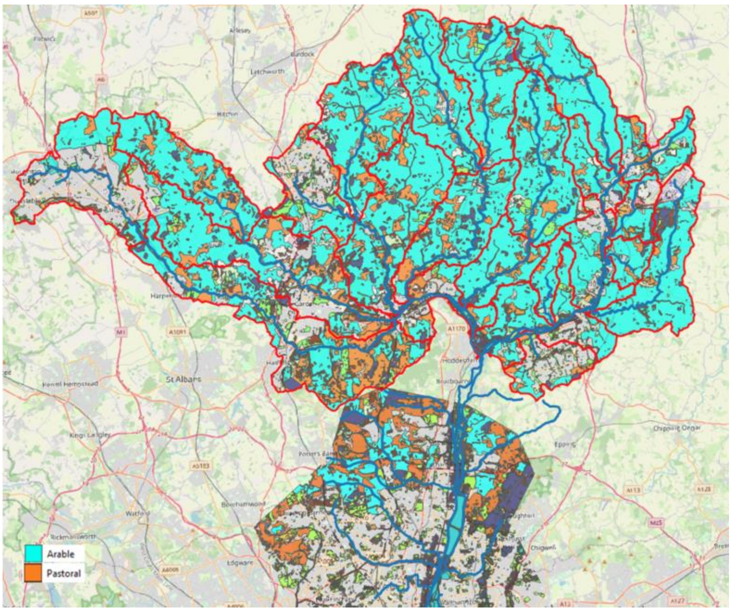
The natural capital option that was developed is derived from options in the EA Thames RBMP, WINEP and the TE2100 plan which aim to protect and improve natural capital sites. The options involved river and lake restoration, diffusing pollution, management of freshwater invasive species, habitat restoration on wetland sites and other measures to achieve protection and restoration.

The plans were not detailed in their approach to implement the options in terms of areas or quantifiable changes. For modelling purposes, the approach taken was to modify runoff rates and percolation to represent the changes natural capital could introduce. The modelling approach for the natural capital option was to convert exiting natural capital stocks which had minimal impact or were negative to the water environment into stocks which were more beneficial.

The northern reaches of the Lower Lea catchment and the Upper Lea catchment shown in Figure B.6 both contain large areas of arable and pastoral land, which are often detrimental to the water environment. Due to the large areas of agricultural land in these regions, 50% of agricultural land was converted for regenerative farming, such as cover cropping which benefits soil quality, organic matter and water retention[16], within the model to investigate the benefits this could provide. Further details of the modelled options are discussed in Appendix D SIWMS: Demonstration modelling using Water Systems Integration (WSIMOD) framework.

[16] https://media.ahdb.org.uk/media/Default/Imported%20Publication%20Docs/IS41%20Opportunities%20for%20cover%20crops%20in%20conventional%20arable-rotations%20(2018).pdf

Figure B.6: Existing Natural Capital



Another method for developing the modelled natural capital option was considered. The alternative was to implement natural capital modifications along the river corridors of the region, resulting in the conversion of 10-20% of the existing agricultural land which is largely in the Upper Lea Catchment. Targeting the river corridors would have been to maximise the positive impacts seen in the river waterbodies, particularly related to water quality and flood risk. However, this method was not incorporated in the final modelled option. The enhanced river corridors may have secondary benefits towards mental health and social connectivity, as an increase in accessible green spaces can support wellbeing in the community.

B.4.2 Deephams Reuse Option

The 'Deephams reuse' option, which is derived from the Thames WRMP, implements a wastewater reuse scheme at the Deephams sewage treatment works, with a target of 46 Ml/d of water being recycled by 2061. We are aware that this volume was taken from WRMP19 and subsequent WRMP revisions may differ. The recycling scheme would reduce the volume of water discharged at Deephams STW by the target volume and discharge flows either, into the King George V reservoir into the river upstream of the reservoir intake.

The operation of the reuse scheme would have some negative impacts, as it will cause an increase in embodied carbon through being constructed as well as operational carbon once the scheme is launched.

B.4.3 London WRZ Options

The Thames WRMP details plans to improve water resources in the London Water Resource Zone (WRZ) by supplementing water in the London WRZ from other WRZs including:

- SESRO 150Mm^3 scheme
- Oxford canal raw water transfer
- Reduced abstraction at Farmoor reservoir
- Groundwater schemes
- Release of network constraints

All of the options will contribute to providing an additional 175 Ml/d to the London WRZ. For modelling purposes, an assumption that 20% of the additional water will be used within the Lower Lea catchment based on the proportionality of the study area to the wider London WRZ area. The assumption was also made that all the additional water will be discharged at Deephams STW. The assumptions made result in an additional 45 Ml/d being available to the catchment area and subsequently being discharged from Deephams STW into the river Lea and Beckton STW (unmodelled) discharging to the river Thames.

The development of these schemes will involve embodied and operational carbon.

B.4.4 Metering Option

The Thames Water WRMP includes a progressive metering plan (PMP) which aims to install smart meter technology in 73% of homes within the London WRZ by 2030. The target of the WRMP is to reduce personal consumption from 142 l/p/d to 124 l/p/d by 2045, which does not meet the government set national target of 110 l/p/d by 2050. Each of the local planning authorities within the study area have also stated a common water consumption target of 105 l/p/d or less for new developments. The targets set by the different authorities are not aligned, however the local planning policies will achieve the government set target. While Thames Water have been conservative in their targets as they are currently unsure the government target is achievable, there are plans to investigate methods of further reducing PCC in the future to achieve this. The reduction in personal consumption will consequently reduce the demand and therefore the water requiring treatment at Coppermills for distribution, as well as the volume of water discharged at Deephams STW which will impact the river Lea.

Both the PMP and consumption targets for new developments will also result in a reduction in operational carbon for water treatment due to the reduced volume of water needed in supply, and also wastewater treatment. Meter installation will result in customers spending less on water, which could also mental health benefits by decreasing financial stress and potentially improve cooperation with the water provider due to the positive impact the metering has on the customers.

B.4.5 Leakage Reduction Option

In the Thames Water WRMP, there are targets set to reduce leakage by 122.4 Ml/d during 2020-2024 as well as deliver a further 76 Ml/d leakage reduction in London across AMP8 and AMP9. Reductions will be achieved through a combination of demand-side measures and mains rehabilitation. The option will increase water availability within the London WRZ. For modelling purposes, the additional water availability provided by this option has been scaled down proportionally to the sub region providing 40 Ml/d.

Leakage reduction would consequently improve environmental flows and water quality as there will be reduced abstraction needs. The reduction in abstraction requirements would also reduce the operational carbon.

B.4.6 Reducing Misconnections Option

The Local Flood Risk Management Strategies (LFRMS) of the Boroughs within the subregional strategy area, the EA Thames RBMP and Thames Water DWMP contain measures to identify and disconnect surface water sewers from existing combined sewer networks to improve water quality and separate flows from sewer systems.

For modelling purposes, an assumed number of misconnections and contribution along Pymmes Brook were proposed to model as a test case to see how it would benefit water quality.

The implementation of disconnection measure will require embodied carbon; however, the disconnections will reduce the volume of water processed through sewage treatment works which would reduce the operational carbon requirements at the treatment works.

B.4.7 SuDS Option

The Thames Water DWMP for London and the LFRMS' of the Boroughs within the subregion contain plans to reduce flood risk by implementing SuDS and disconnecting surface water from combined sewer networks. Disconnection and attenuation measures are considered, such as permeable paving, swales, rain gardens etc. These measures allow groundwater infiltration which prevents surface water entering combined sewers, or holds back the flow so that it discharges at a much slower rate reducing flood risk from sewers and surface water.

While the development of SuDS will require embodied carbon, the reduction in operational carbon of sewage treatment caused by less surface water entering combined sewer systems will outweigh the embodied carbon involved in their implementation.

B.5 Options viewed as enablers

B.5.1 Benefits of enablers

Along with the metrics included for modelling, several options were included as wider enablers. The enabling options primarily aim to improve awareness and communication between communities, planning authorities and infrastructure providers and reinforcing collaboration.

Increasing awareness amongst the public will improve their understanding of the water environment and the water systems in place which will encourage positive behavioural change, such as reduced water consumption, volunteering to restore and enhance habitats, improved flood protection due to engagement with alert services and preparation to minimise risk along with other benefits.

Greater communication channels between parties will also improve landowners and developers' understanding of their responsibilities. Guidance for riparian owners and private owners of flood defences can be developed, while planning policies and requirements can ensure that developments incorporate SuDS and regulate land use. Opportunities to incorporate enhancements to the water environment can also be identified through improved communication with developers.

B.5.2 Options included as enablers

The options which were included as enablers can be seen in Table B.11. The enabling options were derived from the awareness and education category.

Table B.11: Option Categories of options included as enablers

Option	Awareness and Education
Skills through training	✓
Engaging communities	✓
Community partnership officer	✓
Lea catchment website	✓
Coordination of development	✓

Sustainable policy	✓
Establish and maintain partnerships	✓
Communicate with at risk communities	✓
Supporting privately owned water assets	✓
Partnership approach to flood risk management	✓
Promote flood resistance and resilience measures	✓
Information sharing	✓

B.5.2.1 Skills through training

The aim of this option for the EA Thames RBMP is to develop and provide a ‘skills through training’ programme as part of Thames21’s existing accredited training programme[17]. The programme’s purpose would be to empower members of the community to effectively engage and raise issues with statutory bodies.

B.5.2.2 Engaging communities

The EA Thames RBMP option and other options mentioned in the LFRMS’ would engage people and communities by improving their knowledge and understanding of the catchment, and of the impact of their behaviour on the water environment. This will result in greater public engagement and participation in improving the catchment’s ecology.

B.5.2.3 Community partnership officer

The EA state in the Thames RBMP a proposed plan to employ a full-time independent community Partnership Officer to further engage communities, provide volunteering opportunities, coordinate ‘friends of’ groups and river champions across the catchment in a community focused, ‘grassroots’ partnership.

B.5.2.4 Lea catchment website

The EA plan to use the London Lea catchment website for collating information on projects, news and events across the catchment and publicising them.

[17] Leading Action for Healthy Rivers: Thames21's flagship training course - Thames21

B.5.2.5 Coordination of development

The Isle of Dogs and South Poplar IWMP and the LFRMS' suggest opportunities should be sought to coordinate with work underway to improve planting, drainage, and water quality in this zone. Plans for road resurfacing should include SuDS and maximise opportunities for roadside landscaping and improvements to the public realm. There is potential for delivery of upgrades to energy infrastructure which could be coordinated with installation of new surface water sewers.

B.5.2.6 Sustainable policy

The LFRMS' state plans to ensure local planning policy sets out minimum requirements for flood mitigation measures. It intends to deliver a strategy for implementing a statutory consultee role regarding management of surface water on planning applications. Boroughs would proactively enforce SuDS use through planning requirements and develop and implement a planning process for identifying and designating significant structures or features with significant influence on flood risk.

B.5.2.7 Establish and maintain partnerships

The LFRMS' aim to clarify roles/responsibilities of all risk management authorities and key stakeholders. They also plan to identify and monitor funding sources, while reviewing resources available within the council for flood risk management. The boroughs will maintain positive relations and explore partnership working opportunities with residents, businesses, and RMAs. The EA RBMP also states the roles and responsibilities of the various regulators, operators, influencers and project undertakers so that all involved understand how they should contribute to achieving the targets set. The Thames Water DWMP has set out stakeholder engagement aims to encourage collaborative working and identify co-funding opportunities.

B.5.2.8 Communicate with at-risk communities

The LFRMS' plan to develop effective methods for communicating and sharing flood risk information with at risk communities. They will also work with at-risk businesses and community groups to develop risk management and continuity plans that enhance natural environment and are proportional to local risk. Workshops will be delivered across multiple partners, including EA, emergency responders and relevant charities. All information on flood risk will be published and refreshed along with how residents/businesses can minimise their risk, and what to do in the event of a flood, on the Councils website. A register of flood risk assets will be created and maintained. Residents and businesses will be alerted and advised when flood alerts and flood warnings are received from the

Environment Agency and take appropriate action in accordance with the Multi Agency Flood Plan (MAFP).

B.5.2.9 Supporting privately owned water assets

The LFRMS' contain plans to establish consenting procedures to control building of structures that may affect water flow and advertise consenting procedures across London Boroughs. Guidance for riparian owners in their responsibilities will be developed, while private owners of flood defences will be supported. All appropriate structures/assets on watercourses will be recorded so that ownership and responsibilities are identified.

B.5.2.10 Partnership approach to flood risk management

The Boroughs within the catchment plan to continue actively engaging in the LoDEG & Drain London Forum to contribute to a coordinated London-wide approach to flood risk management. Regular flood group meetings will be held and there are plans for neighbouring boroughs to coordinate a London wide holistic approach to FRM. There will be collaboration with the EA to improve flood risk understanding, implement local flood alleviation schemes and bid for funding. Engagement with partners will aid in sharing information on local flood risk and discussing collaborative methods of reducing likelihood.

The newly formed Strategic Surface Water Governance Group will also support collaborative approaches between the GLA, Thames Water, TFL, London Councils and the Environment Agency and political representatives from London Boroughs who are all involved.

B.5.2.11 Promote flood resistance and resilience measures

Local Boroughs will identify properties where an acceptable standard of protection cannot be achieved. They will also promote community flood plans and business continuity plans where significant residual flood risk remains. Individual property protection measures will be promoted including flood resistance and resilience measures where significant residual flood risk remains.

B.5.2.12 Information sharing

Information sharing mechanisms investigated and created by the boroughs in the study area. Best practise examples will also be collected for sharing purposes.

B.6 Conclusions

The combination of planning documents used to compile the existing options in the study area showed varying approaches taken between water sub systems and at differing scales. Comparing the existing options showed instances where the vision and plans of different authorities aligned, particularly between the local boroughs involved. The existing options were also considered based on the different scales over which they aim to target a problem. Some localised options were scaled up, whereas some options, particularly related to water resources had to be scaled down, to cover the subregional area.

The scoring criteria and mechanisms used were a clear way of determining the impacts each planning option had along assessed against the key metrics. We were then able to rank our options based on which had most effect on improving water quality, water resources, flood risk and river health.

Individual options which are implemented alone are shown to be unsuccessful in achieving significant change for the water environment. It is important that organisations continue to collaborate and develop their options in combination for meaningful change to occur. To create the necessary cultural shift amongst these organisations and the communities, the enabling options compiled should be implemented so that options such as the ones modelled can be implemented effectively.

C. Adaptive planning review

Project:	East London Subregional Integrated Water Management Strategy		
Our reference:	100108845 | 5.2 | A	**Date:**	03/03/2023
Prepared by:	KM	**Checked by:**	LB
Approved by:	RLS		

C.1 Background

East London is earmarked for significant growth in future. To meet growing demand, we need to understand how the current infrastructure will perform in various future scenarios so that we can plan upgrades in service ability. However, those future scenarios come with uncertainty which will need to be managed to allow for targeted investment to meet emerging needs.

This technical note explores the current best practice and guidance around adaptive planning, approaches to managing uncertainty and recommends a preferred approach for the Subregional Integrated Water Management Strategy (SIWMS). Seven key tasks were required to deliver the SIWMS:

1. Baseline of current subregional situation
2. Set collective ambition
3. Scenario analysis
4. Option identification and analysis
5. Planning, timing and sequencing
6. Delivery strategy
7. Data viewing platform

Whilst the principles of adaptive planning align predominately with Task 5, they also inform the other six tasks.

C.1.1 What is adaptive planning?

Adaptive planning is a technique that enables organisations to make decisions under uncertainty. Strategies and projects can be implemented in the short-term, whilst having a monitoring framework in place to review and adapt decisions depending on future scenarios. This enables flexibility and avoids ‘lock-in’ or maladaptation. Connecting short-term decision-making with longer-term planning helps build resilience into risk management. Organisations can remain agile to uncertainties and external stressors including climate change, population growth, increased urbanisation and policy changes and re-evaluate options as required. A glossary of key terms used in adaptive planning literature is provided in Table C.12.

Table C.12: Glossary of key terms used in adaptive planning

Term	Definition	Source
Action point	What action will be taken when the **threshold** is reached	Ofwat (Option 4)
Adaptive Pathway	Sequences of potential actions that are intended to anticipate and respond to evolving threats, risks and opportunities across multiple future scenarios. These actions are linked to specific thresholds where a change in circumstances is reached and further adaptive action may be required	Environment Agency (Option 3)
Decision point	Triggered when conditions change or are likely to change as they approach a **threshold**	Environment Agency (Option 3)
Driver of change	Source or driver of uncertainty	Environment Agency (Option 3), Ofwat (Option 4), WRSE (Option 5)
Threshold	Point beyond which a system is deemed to be no longer effective	BSI (Option 2)
Trigger point	Monitored indicator that shows conditions are approaching a **threshold**.	BSI (Option 2)
Uncertainty	The state, even partial, of deficiency of information related to, understanding or	BSI (Option 2)

Term	Definition	Source
	knowledge of, an event, its consequence or likelihood.	

C.1.2 Why is adaptive planning required for this project?

Adaptive planning will help to co-ordinate and integrate planning across different organisations to deliver flood management, wastewater systems and sustainable water resources to enable growth. The pace and timing of action required to support sustainability can be used to create a cohesive water management strategy, to bring important efficiencies and synergies to the overall planning. The range of potential future scenarios identified in Task 3 will inform the adaptive plan in Task 5, which relates to planning, timing and sequencing of measures to be incorporated into the SIWMS.

A review of adaptive planning approaches applied in different contexts was performed to inform the methodology for the adaptive plan. It included five options across climate change, wastewater management, flood and coastal risk management, and water resource management.

C.2 Summary of different methods

A summary of each of the five options reviewed is provided. When comparing the different approaches, the review focused on methods which were most explicit about setting thresholds, trigger points and a monitoring framework to align with Task 5.

C.2.1 Option 1: Adaptive Pathway Planning, Thames Water and Atkins[18]

This document is a technical appendix for Adaptive Pathway Planning for Thames Water and Atkins Drainage and Wastewater Management Plan (DWMP). A summary of the approach includes:

- Adaptive pathway planning (scenario planning)
- Modelling different futures and their impacts
- Understanding trigger points
- Having solutions that can be adapted to accommodate future uncertainties
- Having a monitoring programme in place

[18] Thames Water and Atkins, 2022. Our draft Drainage and Wastewater Management Plan, 2025-2050. Appendix G – Adaptive Pathway Planning.

- Adaptive pathway planning in catchment in London (strategy, options, metric, monitoring activity)
- Adaptive pathway planning in catchment outside London (strategy, options, metric, monitoring activity)

The plan tested for different future pathways for some of their complex systems which includes technological innovation scenarios, delivery of SuDS programme, and a range of spills scenarios in response to policy change. Key uncertainties identified included climate change, population growth, resilience to flooding, storm overflow spills policy, and innovation and technology. Trigger points included strategic decisions, demand changes and technological advances. The core pathway identified was based on technology options in assessing future demand on their most complex sewage treatment works. The monitoring programme included how trigger points related to the reduction of system capacity relative to the performance objective target. When the peak water levels exceed a risk-based threshold then an investment decision will be required. Treatment works are monitored for compliance metrics.

C.2.2 Option 2: Adaptation to climate change – Using adaptation pathways for decision making- Guide by BSI Standards Publications[19]

This document provides a guide for identifying adaptation pathways for responding to climate change and its associated uncertainties. It outlines the following nine-step approach:

1. Planning – involves setting the context, scope and intended outcomes of the adaptive pathways process.
2. Understand the risks and opportunities from current climate – involves a baseline assessment
3. Understand the risks and opportunities from a range of future climate change scenarios, including highest climate scenarios – involves identifying sources of uncertainty and implications on results and what conditions would indicate thresholds are being approached.
4. Consider adaptation options for different levels of risks and opportunities, and their thresholds
5. Identify and evaluate the implications of interdependencies with other drivers
6. Assemble a route map of adaptation pathways – includes first draw a decision tree in which each action is a branch and where each implementation point is a node that indicates a threshold is being approaches and that an adaptation decision needs to be taken.

[19] BSI Standards Publication, 2021. Adaptation to climate change – Using adaptation pathways for decision-making – Guide.

7. Evaluate and choose adaptation pathways – includes decision-making approaches such as cost-benefit analysis, multi-criteria analysis and/or robust decision-making.
8. Report preferred adaptation pathways
9. Set out implementation, monitoring and evaluation plans

C.2.3 Option 3: Literature review on an adaptive approach to flood and coastal risk management, by the Environment Agency[20]

This document provides a rapid evidence assessment of developing and applying adaptive pathways. It provides recommendations for applying best practice to adaptation pathways to inform evidence-based decision making. A summary of adaptive planning methods include:

1. Framing of the problem, objective setting and scenario analysis
2. Option appraisal, pathway development and identification of triggers
3. Select preferred pathway and implementation
4. Monitoring, evaluation and learning phase

Key enablers for effective adaptive planning include:

- Identifying and quantifying uncertainty robustly
- Appropriate governance arrangements for adaptive planning approaches
- Stakeholder engagement

Barriers for effective adaptive planning include:

- Managing uncertainty
- Navigating complexity
- Overcoming a traditional short-term focus around decision-making
- Securing wider institutional commitment and support

It outlines the following recommendations:

- Multiple future scenarios should be considered within the plan development. High-end scenarios are recommended to ensure resilience and increase trust from stakeholders.
- Clear baseline conditions should be established from the outset, against which future trends and trigger points can be compared. This is imperative for supporting future decision points when comparing monitoring indicators against baseline conditions.

[20] Allison, R., Hassnoot, M, Reeder, T. and Green, M., 2021. Literature review on adaptive approach to flood and coastal risk management. Environment Agency.

- Workshop sessions for stakeholders which consider multiple futures to facilitate discussion and co-create options.
- Detailed plans should be developed that include clear definition of roles and responsibilities, funding arrangements, a monitoring framework, definition of tipping points, records of decisions made and justifications, and an engagement plan for the duration of the project.
- The monitoring/evaluation framework must address the following questions:
  - What will be measured and how to analyse derived signals?
  - Are these indicators directly measuring the hazard or providing proxies for changes in the hazard? How does this impact the decision-making process?
  - What is the periodicity of monitoring (continuous or periodic reviews)?
  - What is the periodicity of review cycles where the plan would be updated (as needed or regularly)? At what point would the passing of a threshold or trigger point lead to a full review of the plan?
- A relatively short review cycle of approximately 5 years or less is recommended to allow for updates to the monitoring and implementation plan, including ensuring that the adaptation pathway is still correct.

C.2.4 Option 4: Guidance on long-term delivery strategies at PR24, by Ofwat[21]

This document provides guidance on the requirements for long-term delivery strategies. It outlines the following guidance for scenario testing:

- Adaptive pathways contain decision points where pathways deviate from each other as different sets of options are chosen informed by pre-defined trigger points. These set out the conditions that would cause one pathway to be adopted over another, using clear and observable metrics supported by a monitoring plan.
- The strategy should present a core and alternative pathways.
- Core pathway is consistent with best practice adaptation techniques and should include all activities that need to be undertaken to be ready for all plausible future scenarios.
- Scenario analysis for drivers of uncertainty (climate change, technology, demand and abstraction reductions) with two parameters (benign and adverse)

[21] Ofwat, 2022. PR24 and beyond: Final guidance on long-term delivery strategies.

- Each alternative pathway should consider: 1) the point in time at which the alternative pathway deviates from the core or another alternative pathway; 2) when the decision point is needed 3) the trigger point which indicates the circumstances under which the alternative pathway would need to be followed 4) how these circumstances will be assessed and monitored.
- It is essential that all scenarios used to test the long-term delivery strategy are plausible, with an estimated impact of each reference scenario
- Strategies should be subjected to wider scenario testing
- Monitor and evaluate the implementation of the pathways – monitoring plan should identify the metrics to be monitored, how these will be calculated and the source of the data; the frequency of monitoring; the threshold the metrics will be monitored against and what action will be taken when the threshold is reached; how the monitoring of the metrics will be reported.
- Best value options should consider environmental and social impacts over a suitable timeframe.

C.2.5 Option 5: Best value planning, by WRSE[22]

This document provides a method statement on WRSE approach to best value planning and the decision support tools they have used to develop a best value, adaptive regional plan to secure water supplies for the South East until 2075. The adaptive regional plan has seven key stages:

1. Problem characterisation to identify the technical approach. This identifies the data required.
2. Define decision-making criteria framework, set objectives and identify the criteria to define best value.
3. Define problems to be solved exploring uncertainties and risk. Then, identify the range of alternative futures (situation tree) and which pathway will be used for reporting purposes. Then use real and adaptive planning methods to identify a range of investment programmes that resolve the integrated risk problems to 2075. Solutions can be described using a number of criteria including cost, resilience, environmental and customer preference best value plan metrics.
4. Visualisation tool to illustrate and understand complexity. Identify least cost plan and select a short-list of reasonable alternative programmes through the incorporation of best value planning metrics.
5. Further assessment and stress-testing of shortlist programmes

[22] Water Resources South East, 2022. Method Statement: Best Value Planning.

6. Draft best value regional plan
7. Consult on draft best value regional plan

Stage 3 focuses on adaptive planning, which has the following key steps:

a. Defining futures – identify key uncertainties (growth, climate change and environmental ambition), the core baseline position, alternative baseline situations
b. Generating futures
c. Choosing single situations
d. Choosing branched pathways – ‘situation trees’ can use probabilities or deterministic approaches to define the situation trees and branching points
e. Investment modelling

C.2.6 Comparison of options for implementation

The outputs of the review of the five different options are summarised in Table C.13. Figure C.7 provides a summary overview of key themes in the adaptive planning literature. During the review it became evident that the BSI nine-step approach had transparent guidance for adaptive planning implementation. An additional column was subsequently added to the table to inform whether any of the options could support a particular stage in the BSI 9 step approach.

Figure C.7: Summary of common themes across adaptive planning literature

Source: Wood et al. 2020 cited in Allison, R., Hassnoot, M, Reeder, T. and Green, M., 2021. Literature review on adaptive approach to flood and coastal risk management. Environment Agency.

Table C.13: Comparison of adaptive planning approaches, including benefits and barriers to implementation

Option	Context	Adaptive plan approach	Benefits of approach	Barrier to implementation	How does it differ across work streams?	Does it feed into 9 step approach?
Option 1: Thames Water	Drainage Wastewater Management Plan (DWMP).	Scenario planning, understanding trigger points, solutions for future uncertainties and monitoring framework.	Flexible, applicable to different scales, align alternative pathways through subsequent cycles of DWMP, increases transparency, supports engagement.	Provides a detailed overview of their approach, but tangible information about how to implement the method is limited. Scenario planning considers how different drivers interact but is not explicit about how this has been done.	Uses core and alternative pathways (based on new technology)	Step 3 and 4
Option 2: BSI	Climate change	9 step iterative framework – includes guidance and	Clear strategy to follow for implementation. Outlines approach for	Boundaries of the system – ensure adaptive activities to no cause conflicts	It focuses on climate change, but guidance is clear to interpret	Clear strategy to follow for implementation

Option	Context	Adaptive plan approach	Benefits of approach	Barrier to implementation	How does it differ across work streams?	Does it feed into 9 step approach?
		decision-making within each step.	system interdependencies. Provides case study examples and additional guidance documents.	with neighbouring local governments and communities	for other contexts.	
Option 3: Environment Agency	Flood and coastal risk management	Review of methods and provides overview of BSI 9 step approach	Discusses identifying and quantifying uncertainty, co-benefits, governance, stakeholder engagement and timely detection for thresholds. Provides case study examples with key lessons learned. Monitoring of metrics for	Discusses difficulties in quantifying the value of co-benefits, managing uncertainty, navigating complexity in designing adaptation pathways, overcoming a traditional short-term focus	Provides an overview of a range of methods and case study applications (e.g. real options analysis vs adaptation pathways).	Step 3, 4, 6, 7 and 9.

Option	Context	Adaptive plan approach	Benefits of approach	Barrier to implementation	How does it differ across work streams?	Does it feed into 9 step approach?
			drivers of change	around decision-making, securing wider institutional support		
Option 4: Ofwat	Water and wastewater, consumer, economic.	Adaptation strategy should have a core pathway (with set criteria to meet) and then set out an alternative pathway (depending on certain circumstances).	Provides clear definitions and outlines methodology for scenario planning with key criteria to be met.	Focus of methodology is on scenario planning. There is less tangible information or examples on how to create visualisation tools for mapping, determine thresholds and trigger points, or implement the monitoring framework. Scale of application - sub-	Core vs alternative pathways Discusses guidance for interdependencies between scenario planning	Step 3 & potentially Step 5

Option	Context	Adaptive plan approach	Benefits of approach	Barrier to implementation	How does it differ across work streams?	Does it feed into 9 step approach?
				regional application might be too complex.		
Option 5: WRSE	Multi-sector, regional resilience plan to secure water supplies	Seven key stages for best value regional plan.	Method to measure metrics which provide additional value Scale of application (complex)	Complex methodology: implementation information on trigger points, thresholds, APs and monitoring framework not as transparent.	Core baseline assessment and alternative future scenarios. Focus is on investment modelling and value criteria. Covers both adaptive planning process and real option analysis	Step 6 and 7

C.3 Justification for chosen approach

Informed by the review, we selected the BSI 2021 nine-step approach to adaptive planning to apply to the SIWMS project, with informed analysis from the EA review (Option 3) to incorporate key lessons learned from the literature (Section C.2.3). The strengths for applying this approach include its interdisciplinary context (climate change) meaning it can be translated for integrated water management, its explicit guidance on systems analysis and interdependencies between drivers, comprehensive overview of each stage and case studies to provide real-word examples following each of the nine steps. Table C.14 outlines the nine steps mapped against each SIWMS project stage.

Table C.14: Detailed description of the 9 step AP process against the SIWMS Project progress. Note that the term ‘organization’ refers to the SIWMS Project Team for this context.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
1. Planning	The organisation should identify the context, scope and intended outcomes of the Adaptation Pathways (AP) process including a) the extent of the APs to be developed, b) the objectives that the APs seek to deliver, including timeframe and c) the limitations of its AP activity Current and future risk and opportunity should be identified with the input of interested parties and informed by analysis or additional expert input. The organisation should document the results of this assessment as part of the AP plan with measurable outputs as well as a description of any constraints.	Task 2 and 3 Baseline and Strategy Reports	The SIWMS ambition is for the plan to align with the principles of adaptive planning, building in the ability to change and evolve as future scenarios materialise. Task 2 in SIWMS involved engagement with the steering group to set collective ambition for the sub-region. Task 3 identified future risk and opportunities to create future scenarios. Results from the planning stage were documented in the SIWMS baseline report.
2. Understand the risks and opportunities from current climate	The organisation should carry out a baseline assessment of current levels of risk and opportunity to the organisation associated with current conditions. This baseline assessment should include the current levels of risk and opportunities to the organisation-relevant systems. The organisation should identify opportunities arising from current impacts, including those as a result of taking action. Any trade-offs with other sustainability priorities should be evaluated and recorded.	Task 1 and Task 3	Documented in the SIWMS baseline report. Risks from the different future projections on metric thresholds have been explained in Appendix D.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
	Risks and opportunities from the current climate should be documented, along with data used and assumptions made. The level of risk identified should be reviewed against the organisation's tolerable risk.		
3. Understand the risks and opportunities from a range of future climate change scenarios, including highest climate scenarios	The organisation should identify and prioritise risks and opportunities associated with a range of different projections of future scenarios and their uncertainties. The organisation should identify sources of uncertainty and understand how these uncertainties propagate through the forms of analysis undertaken and their implications for the results. Assessment of impacts from scenarios should consider all impacts that might occur in the relevant planning period. Thresholds for each impact should be identified beyond which the relevant systems might fail to achieve their objective if no adaptations are made. The organisation should consider a) what degree of future changes might cause thresholds to be crossed; b) what conditions (trigger points) would indicate that thresholds are being approached; and c) the consequences that could arise if thresholds are crossed, drawing particular attention to consequences that cannot be reversed. The organisation should document findings from this stage.	Task 3	Developed in the scenario analysis Modelling limitations and implications are discussed in Appendix D. Scenario analysis has identified five plausible future scenarios. Threshold bands have been identified and are discussed in the Strategy report and Appendix D. The findings are documented in Section 3 of the report, with more detail in Appendix D.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
4. Consider adaptation options for different levels of risks and opportunities, and their thresholds	Considering the outputs from steps 2 and 3, the organisation should identify potential adaptation options.	Task 4	Options have been modelled against different scenarios to identify 'least regret' options for the adaptive plan.
	Following the implementation of adaptation options, new thresholds should be created and assessed. When these new thresholds are reached, additional adaptation options might be required.	Task 6	This is part of the monitoring and evaluation of the SIWMS, and highlighted in the delivery strategy (Section 6)
	The organisation should consider the lead-in time of each adaptation option and whether adaptation action could foreclose other potentially useful actions (lock-in)	N.A.	Lead-in times are not analysed within the pilot SIWMS.
	The adaptation option selected for each scenario should be documented. Engagement and consultation should be undertaken with those impacted by and with an influence over each adaptation option (feasibility, scale of impact and understanding).	Task 4	Task 4 discusses what the future could look like and compares the impact each option has under different future scenarios. This was also discussed with the Steering Group.
	Evaluation should be undertaken to prioritise and possibly exclude some of the identified adaptation options.	Task 5	Least regret analysis has been performed to identify the portfolio of options with maximum benefits and no trade-offs under future scenarios.
	Where opportunities for action have been identified, the organisation should document any trade-offs with other sustainability priorities.	Task 4 and Task 5	Trade-offs have been identified in Task 4, Task 5 and Appendix B.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
5. Identify and evaluate the implications of interdependencies with other drivers	The organisation should identify the influence of other forms of change (drivers) on thresholds and on selecting and implementing adaptation options. The practicality of the adaption options identified should be assessed against other drivers of change. In planning adaptation actions, the organisation should consider interdependencies with other drivers of change (e.g. socio-economic, environment, political, technological). Adaptation identified should be updated and take account of interdependencies with other drivers and re-evaluated if necessary. This should be documented.	Task 3 & Task 4	Task 3 identified other drivers of change (e.g. abstraction license, future levels of adaptation) as part of the scenario development. Task 4 assessed the options against these future scenarios. Task 4 also links option performance to drivers of change in the future scenarios.
6. Assemble a route map of adaptation pathways	Using information from steps 4 and 5, the organisation should assemble sequences of adaptation actions in the form of a route map of potential APs that address different risk and opportunities associated with the scenarios over the planning horizon. These should take account of possible constraints and requirements for transformative adaptation.	Task 5	A route map has been identified based on least regret analysis of options.
	APs can be created by first drawing a decision tree in which action is a branch and where each implementation point is a node that indicates a threshold is being approached and that an adaptation decision needs to be taken. The decision tree can be drawn using two axes where one axis indicates changing conditions and the other shows the adaptation actions that can be considered at each implementation point.	Task 5	A route map has been identified in Figure 5.1 to highlight key decision points that align with water and urban planning cycles.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
	The organisation should identify what actions are feasible and desirable at each decision-making point.	N.A.	This is out with the scope of the pilot SIWMS. Each organisation will need to drive this forward.
	Nodes can be used to indicate the limit to each action's effectiveness.	N.A.	This is out with the scope of the pilot SIWMS. Each organisation will need to drive this forward.
	The route map should indicate where it is advised to review the choice of AP option. This needs to be built into the monitoring framework developed in step 9.	Task 5	Decision points have been established based on the timelines of plans which are likely to influence future scenarios.
	Adaptation measures should be implemented in advance of the anticipated timing of impact.	Task 5	The proposed adaptive plan set out in Task 5 would enable this.
	Once the route map has been developed, it can be useful to review the scenarios being considered and identify when the different thresholds for starting or stopping action are likely to occur under the different scenarios being considered.	Task 5	All modelled options have been assessed under future scenarios for 2050. It is out with scope of the pilot project to analyse the detailed timeline of future scenarios and options.
	This step should be documented.	Task 5	Documented in Section 5 of the SIWMS report.
7. Evaluate and choose adaptation pathways	The organisation should assess the economic, social, environmental, political and other relevant costs, benefits and attributes of each adaptation pathway developed.	Task 4 & Task 5	Task 4 identified wider benefits of each option as part of the screening method. A cost-benefit analysis of

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
	The evaluation can apply one or more decision-making approaches such as cost-benefit analysis multi-criteria analysis or robust decision making. Analysis should be carried out against individual scenarios. APs should 1) incorporate the greatest degree of flexibility and adaptive capacity, 2) be based on trigger points and thresholds that can be effectively monitored, 3) incorporated adaptation measured that can be implemented in good time across a range of scenarios, 4) be implemented within the expected growth in adaptive capacity of the organisation		the proposed options has not been included in the pilot project. Least regret options proposed in Task 5 enable the greatest degree of flexibility under future scenarios identified from the threshold classifications.
8. Report preferred adaptation pathways	The organisation should record outputs from previous steps in a report following the guidance outlined in the step.	Tasks 1-6	This has been done in the Strategy report.
9. Set out implementation, monitoring and evaluation plans	The organisation should create an adaptation plan based on the outputs of the adaptation pathways report. The organisation should create an implementation, monitoring and evaluation plan. Identify regular review periods of this plan. Where possible, the plan should be integrated into current organisational monitoring and reporting activities. A schedule of activities to take the approved adaptation plan and APs forward should be identified and implemented. The organisation should have mechanisms to monitor the implementation of the APs plan based on decisions. Plans should be made to monitor actual or predicted changes in key parameters, so	Task 5, Task 6 and Task 7	Task 5 outlines key decision points. The SIWMS has developed a delivery strategy to ensure the adaptive plan is implemented on the ground. The proposed Data Viewing Platform would also enable future changes to technology and the strategy as it evolves beyond the scope of the SIWMS project.

BSI adaptive planning guidance		SIWMs Project interpretation	
Step	**Description**	**Task**	**Summary**
	that changes can be implemented with sufficient lead time to review the plan. The organisation should consider changes in technologies or processes to respond to impacts. An effective monitoring process should be created that has identified regular and consistent actions. It should include a feedback framework for learning and development within the plan. The plan should be documented and shared.		

D. Imperial College London: Demonstration modelling using Water Systems Integration (WSIMOD) framework

D.1 Executive summary

This report focusses on the application of integrated modelling to a case study of the River Lea catchment. The work was commissioned by the Mott MacDonald consultancy under the Subregional Integrated Water Management Strategy (SIWMS) project, led by the Greater London Authority (GLA). The work was focussed on the application of integrated modelling software WSIMOD, developed at the Imperial College London (ICL), to evaluate how the tool could be used to assess the impacts of development scenarios and interventions. The WSIMOD model developed for the selected case study integrates 35 sub-catchments in the region, 39 wastewater treatment plants, and extensive water supply infrastructure. Simulations cover scenarios that capture:

- Population projections (various ONS scenarios and GLA projections) and associated urban creep
- Future climates (RCP 2.6, RCP 8.5, and RCP 2.6 with unseasonable changes)
- Sustainability reductions to the water supply abstractions
- Household water efficiency improvements (in the Upper Lea)
- Adaptation measures including water treatment improvements, reductions in impervious areas, alleviation of combined sewer overflows.

We also implement a variety of interventions to capture their integrated impacts:

- Deephams wastewater effluent reuse scheme
- SuDS in London catchments (two varieties: disconnecting impervious areas from the sewer network and reducing surface runoff for pervious areas)
- Natural capital in the Upper Lea (implemented as a regenerative farming strategy)
- Household water efficiency improvements (in London)
- New water resources and leakage reductions

For all simulations we investigate changes to:

- Water resources
- Low flows (drought resilience)
- High flows (fluvial flood risk)
- Water quality (ammonia, phosphate and nitrate), presented in the format of Water Framework Directive (WFD) classifications

For a highlight of key findings, we point readers to the Summary section. We also provide an ancillary Pymmes Brook misconnection data analysis, which was made possible by the insights gained from integrated modelling but was conducted using observational data due to its sensitivity and the uncertainty in underlying processes.

D.2 Introduction

This document is a draft of the simulation work carried out as part of the Subregional Integrated Water Management Strategy (SIWMS) project.

The focus of this report was to model a region included both upstream rural catchments and a substantial area within the Greater London Authority (GLA) region with an integrated modelling approach. The modelling was undertaken in partnership with The Centre for Systems Engineering and Innovation[23] (CSEI) at Imperial College London. The modelling aims to showcase how intervention scenarios and options can produce multiple impacts in areas across the four core systems of interest: water resources, wastewater, water quality/environment and flooding.

D.3 Context

- What is Water Systems Integration Modelling Framework?

The Water Systems Integration Modelling Framework (WSIMOD) is an open-source software package developed by Imperial College London, funded by CAMELLIA, a NERC research programme[24]. It includes models of all key elements of the water cycle in both urban and rural environments, with each modelled element referred to as a component. The components are designed to interact with each other, allowing for a flexible representation of the water cycle to accommodate different built and natural infrastructure configurations. The WSIMOD software is publicly available[25] under a permissive free software license (BSD-3 clause) and has been featured in several peer-reviewed articles

[23] The Centre for Systems Engineering and Innovation
[24] https://www.camelliawater.org
[25] https://barneydobson.github.io/wsi/

(see examples below), with the core model code undergoing peer review for the Journal of Open Source Software[26].

- How can it add value to integrated regional water management planning?

The primary aim of utilizing WSIMOD is to identify potential impacts, either positive or negative, that may arise from the interactions between various components of the water cycle (as outlined in Table D.15). The development of WSIMOD is aimed at enabling the assessment of the integrated impacts of planning, development, and intervention scenarios on various environmental indicators such as water quantity, quality, and resources.

Table D.15: The summary of integrated modelling added value to address challenges of fragmented water planning

Integrated modelling using WSIMOD	Added value
We can simulate both water flow and quality at a range of scales (water body to regional)	We can compare development scenarios and management options across a range of indicators and scales relevant for multiple plans and organisations
We can simulate both urban and rural systems, natural processes, and blue, green, and grey infrastructure	We can account for urban-rural interactions (link between abstractions, discharges, and pollution) and compare Blue Green (urban and/or rural) and Grey (infrastructure) options to analyse trade-offs and co-benefits arising from their implementation
We can simulate urban planning (housing development and water demand), infrastructure operation (abstractions, discharges, fertiliser use) and policy (abstraction licences) decisions	We can explicitly link urban planning with water management decisions and include behavioural, operational or policy options in the portfolio of interventions for future planning, which enables analysis of the value of interventions for multiple stakeholders (LPAs, water companies, Environment Agency, Natural England....)

[26] https://joss.theoj.org/papers/9df09dbd84388e336f911bb1d55c7a87

- Current examples of the work – short description of published case studies

We have demonstrated the WSIMOD methodology in a variety of case studies which highlight the added value of an integrated systems view:

- A comprehensive assessment of London's urban water cycle with WSIMOD has shown that reducing water abstractions on days when combined sewer overflows (CSOs) are likely can help dilute the spills and enhance water quality, thereby avoiding the need for over £200 million worth of infrastructure to mitigate the problem[27].This approach, if implemented strategically on days when reservoir levels are high, has negligible impacts on the reliability of water resources.
- By analyzing commuter traffic patterns, we were able to predict how the COVID-19 lockdown impacted the generation of wastewater, and consequently, the amount of wastewater influent that reached wastewater treatment works (WWTWs) and resulted in increased pollution concentrations in inner London tributaries such as the River Wandle and Lea[28]. Our study revealed a significant decrease of around 25% in the influent at Beckton WWTW, and although timely data from Thames Water was not available, they have confirmed our findings anecdotally and suggested that our approach is the only way to disentangle hydrological and climatic variability from the changes seen at WWTWs.
- A simulation of the integrated urban-rural water cycle in Cherwell Catchment revealed that rural water has a greater impact on river flows during wet periods, whereas urban water dominates during dry periods[29]. This finding led to the development of an integrated water quality management strategy that reduces fertilizer application during wet periods and enhances wastewater treatment during dry periods. Our simulations demonstrate that this strategy is more effective in improving river water quality than an uncoordinated approach.
- Optimising the placement and sizing of nature based solutions in the Wensum and Yar catchments[30], incorporating three rural and two urban NBS interventions at different implementation scales. This study

[27] B. Dobson, A. Mijic, Protecting rivers by integrating supply-wastewater infrastructure planning and coordinating operational decisions. Environ. Res. Lett., 0–31 (2020).

[28] B. Dobson, T. Jovanovic, Y. Chen, et al., Integrated modelling to support analysis of COVID-19 impacts on London’s water system and in-river water quality. Front. Water. 3, 26 (2021).

[29] L. Liu, B. Dobson, A. Mijic, Hierarchical systems integration for coordinated urban-rural water quality management at a catchment scale. Sci. Total Environ. 806, 150642 (2022).

[30] L. Liu, B. Dobson, A. Mijic, Optimisation of urban-rural nature-based solutions for integrated catchment water management. J. Environ. Manage. 329, 117045 (2023).

developed an integrated urban-rural nature-based solution (NBS) planning framework to maximise co-benefits for water availability, water quality, and flood management at a catchment scale. Results showed that rural NBS have a greater impact on improving water availability, and regenerative farming is most effective for water quality and flood management, while expanding urban green space can reduce phosphorus levels but trades off against water availability, flood, nitrogen, and suspended solids.

In addition, it has been applied in a non-research context for the Oxford-Cambridge development arc, where it was used to test a variety of water infrastructure, and their integrated system impacts, in the Cam river catchment[31].

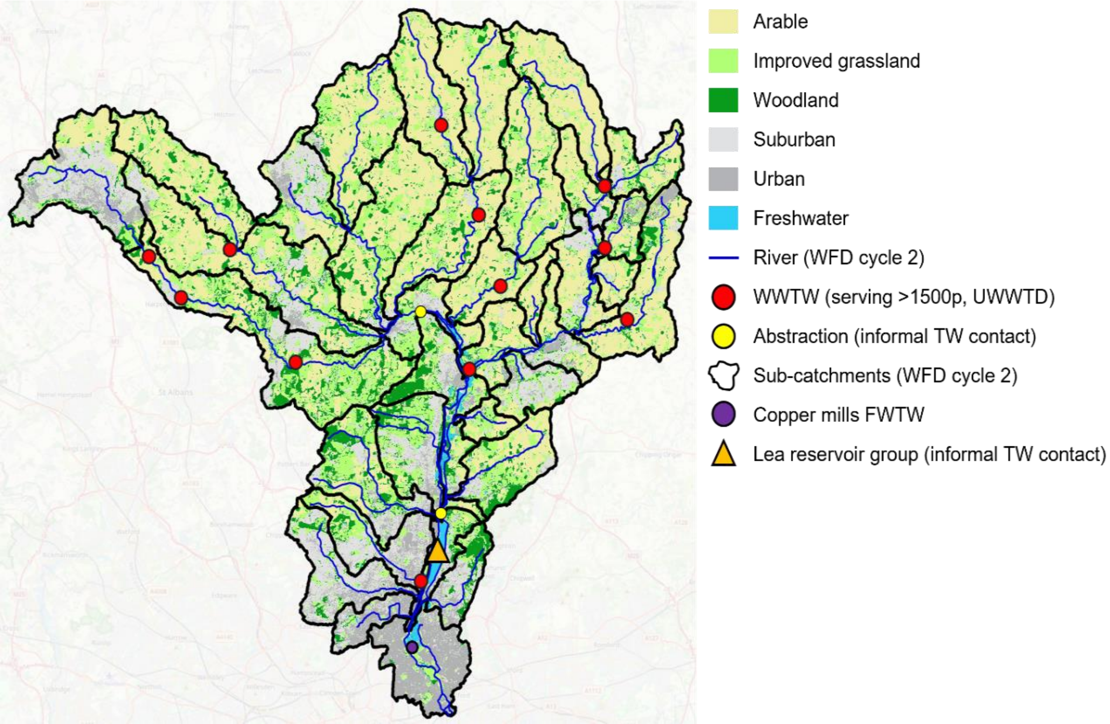
D.4 Methods

Sub-catchments

We have selected the entire River Lea as the study region for SIWMS. The River Lea is an interesting catchment that extends into Bedfordshire and Hertfordshire in its upper reaches, before flowing into London and ultimately the tidal River Thames. It has a variety of different land covers throughout including dense urban areas (e.g., London, Luton, 25% of land cover), extensive agriculture (50,000ha in total, 40% of land cover, half of which is wheat farming), and some highly forested regions (15,000ha in total, 12% of land cover). It has a mix of distinct hydro-geologies with the Chalk aquifer covering most Northern catchments and London Clay in the Southern catchments. A series of canals and diversions for water supply and flood control further complicate the progress of the Lea as it approaches the Thames. The variety and complexity of factors in the Lea's water cycle make it an ideal modelling case for the highly flexible integrated water system modelling software, WSIMOD. It is a catchment with a highly integrated water cycle, containing significant wastewater treatment plants and large abstractions that supply up to around a quarter of London's total water demand. See depicted in Figure D.8.

[31] https://static1.squarespace.com/static/5e85a98d5277001874963880/t/62ea52115e5a9c535902898d/1659523647859/OxCam+IWMF+Phase+1+Report+inc+ICL+annex.pdf

Figure D.8: Map of the Lea sub-catchments used in this study and key data involved in model creation and parameterisation. FWTW/WWTW stands for fresh/wastewater treatment works, WFD stands for Water Framework Directory, UWWTD stands for Urban Wastewater Treatment



A key modelling choice in selection of the model sub-catchments were to represent all catchments at Water Framework Directive (WFD) water body scale[32], thus enabling alignment with WFD water quality classifications and giving access to the ICL team's streamlined model pre-processing to provide an easy model setup. The ability to use finer resolution sub-catchments is within the capabilities of WSIMOD, however, would require significantly more resources in model setup and iteration in selection of sub-catchments, thus we opted to use the default model resolution (WFD boundaries).

A further modelling choice was to include the entire Upper Lea, despite the study region being focussed on the downstream catchments. In part this was essential to properly capture the New River abstraction location, and in part because any model setup that deviates from the ICL's default setup would require additional resources. Thus, we considered the additional computational speed that would have been gained not to be worthwhile.

[32] https://www.data.gov.uk/dataset/298258ee-c4a0-4505-a3b5-0e6585ecfdb2/wfd-river-waterbody-catchments-cycle-2

The implementation of flow direction through the complicated river and canal networks in the Lower Lea are based on the WFD river network[33], and have been visually sense-checked.

Model structure and assumptions

Below we provide a high-level description of the assumptions used in this application of WSIMOD, however a complete set of assumptions are available as part of the documentation[34].

Model assumptions – wastewater and hydrology

Because the wastewater and hydrological representations used by WSIMOD have been described and peer reviewed elsewhere[35][36], we provide only a short overview of the specific assumptions made in this study.

WSIMOD provides pre-built conceptualisations of all parts of the water cycle (each subsystem is referred to as a component) that can be easily parameterised with publicly available data. The arrangement of these components is selected by a model user however we show a generic catchment in Figure D.9, which shows a catchment that has a wastewater treatment works (WWTW) with a foul catchment aligned with the hydrological catchment boundaries. All arcs depicted simulate both the flow and water quality between the different components. We highlight the arcs for infiltration and misconnection since these are both below-surface processes that are poorly understood and minimally supported by open or Thames Water data. We currently calibrate these parameters for study catchments but highlight that the processes are represented with a high degree of uncertainty that could be reduced with further data. Surface hydrology processes are implemented using the lumped IHACRES model[37], agricultural processes and nitrogen/phosphorus cycling are based on HYPE[38], while the groundwater tank aligns with each surface catchment above and follows a residence time formulation as in CatchWat[39]. Non-aligned boundaries, e.g., of the borough of Enfield, the Deephams WWTW catchment and the Pymmes/Salmon/Turkey rivers, are

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[33] https://www.data.gov.uk/dataset/c5a3e877-12c3-4e81-8603-d2d205d52d7a/wfd-river-canal-and-surface-water-transfer-waterbodies-cycle-2

[34] https://barneydobson.github.io/wsi/component-library/

[35] B. Dobson, T. Jovanovic, Y. Chen, et al., Integrated modelling to support analysis of COVID-19 impacts on London's water system and in-river water quality. Front. Water. 3, 26 (2021).

[36] L. Liu, B. Dobson, A. Mijic, Hierarchical systems integration for coordinated urban-rural water quality management at a catchment scale. Sci. Total Environ. 806, 150642 (2022).

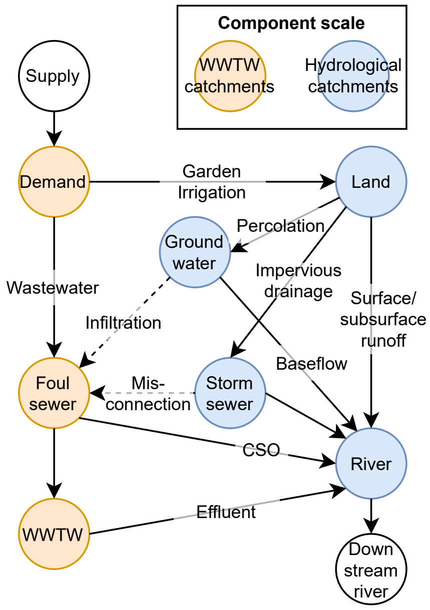
[37] B. CROKE, A. JAKEMAN, A catchment moisture deficit module for the IHACRES rainfall-runoff model. Environ. Model. Softw. 19, 1–5 (2004).

[38] G. Lindström, C. Pers, J. Rosberg, et al., Development and testing of the HYPE (Hydrological Predictions for the Environment) water quality model for different spatial scales. Hydrol. Res. 41, 295–319 (2010).

[39] L. Liu, B. Dobson, A. Mijic, Hierarchical systems integration for coordinated urban-rural water quality management at a catchment scale. Sci. Total Environ. 806, 150642 (2022).

captured in a physically consistent way by intersecting foul and surface water catchments and creating individual model nodes for each.

Figure D.9: Schematic depicting the flows between different modelled sub-systems within a 'typical' catchment (that contains a WWTW).

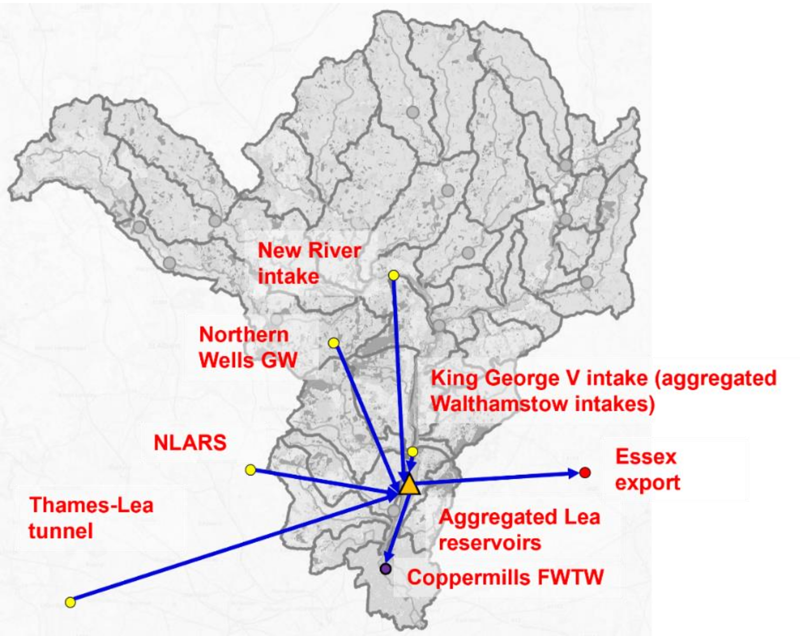


Model assumptions – water resources

Water supply systems are highly case specific and so generic descriptions would not be useful. Thus, below we provide a detailed description of the formulation used in this study.

The collection of reservoirs and associated infrastructure in Walthamstow along the River Lea form an essential part of London's water supply system, Figure D.10, on average providing around 25% of London's total supply. It is critical to note that this infrastructure is operated conjunctively with the reservoirs on the River Thames and other parts of the water supply systems (e.g., South London boreholes). Thus, in this study where only the Lea is modelled, there will be an unavoidable limit on water resources simulation accuracy that could only be fully captured if all of London and the River Thames were modelled, which was considered not possible with the current resources for this work. Although the Lea supply system is more complicated than is presented in Figure D.10 given the above limitations, we considered it sensible to simplify the system for more manageable simulations that are easier to calibrate.

Figure D.10: Map depicting the simplified water resources system that is simulated. Yellow nodes indicate supply sources. NLARS stands for North London Artificial Recharge Scheme and GW stands for groundwater.



Our formulation of the water supply system has been created based on informal contacts and meetings with Thames Water. The two key in-river abstractions are a diversion at the New Gauge (New River intake) and the King George V (KGV) pumping station. In our simulation model, the New River Intake can draw down the river to a minimum flow of 60 megalitres/day (Ml/d), which is an operational preference for Thames Water. Meanwhile, the Lea is diverted into the Lea Navigation and a flood relief channel from which the KGV abstractions are made. The Lea Navigation must have a minimum of 25Ml/d diverted, and all remaining water is abstractable from the flood relief channel (up to a maximum of 2,600Ml/d with an average annual licence of 550Ml/d).

Two key groundwater sources are modelled, the North London Artificial Recharge Scheme (NLARS) and the Northern Wells boreholes. The Northern Wells can provide up to 100Ml/d, which is their licence. NLARS can provide up to 220Ml/d, although only when the simulated reservoirs drop below the Lower Thames Operating Agreement (LTOA) control curve, in addition, for each consecutive month that they are used, the available abstraction is reduced. For both groundwater sources, the model will deprioritise their use in comparison to surface water sources.

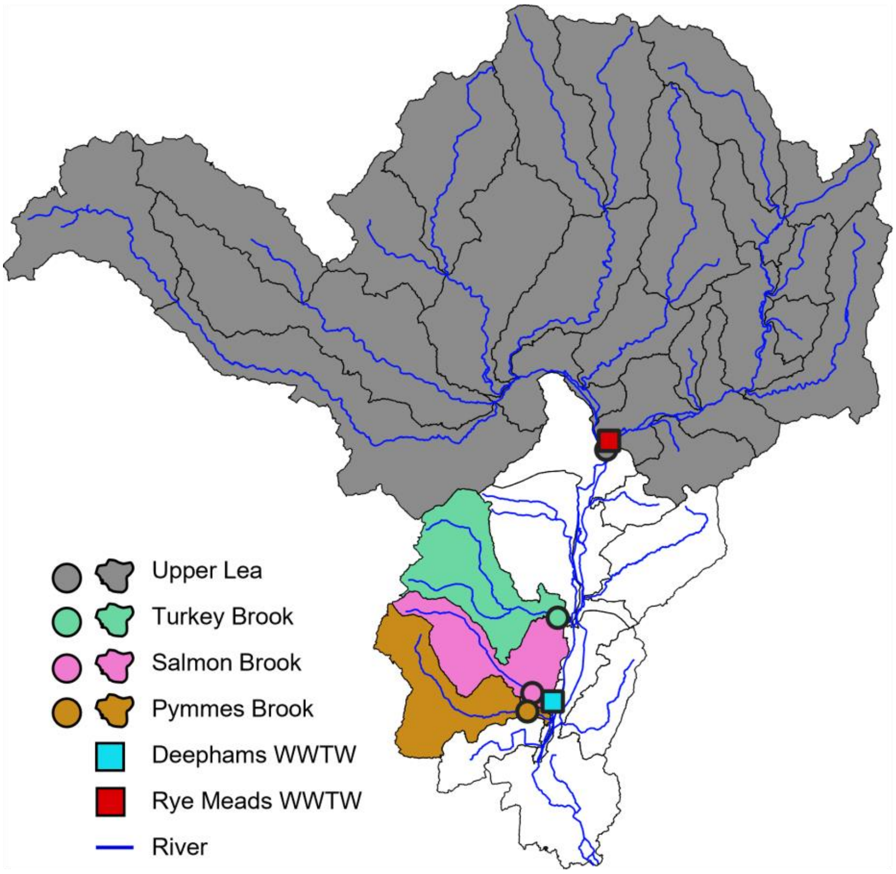
The final key source of water for the Walthamstow reservoirs is via the Thames-Lea tunnel, which enables transfer of water from the Thames portion of the system. Particularly for this water supply, but which is true for all of the above supplies, the operation depends on the behaviour of London's wider supply situation. Following our modelling boundary limitations, we opted to simply limit this supply to 215Ml/d, based on historic data for this infrastructure.

For our model, we aggregated the Walthamstow reservoirs into a single conceptual reservoir that represents their entire storage, with a total capacity of 37,738Ml. Abstractions from this reservoir were made primarily to Coppermills freshwater treatment works (FWTW), to Essex and Suffolk water (ESW), and back into the NLARS scheme. Each of these reservoir water uses varies significantly in time, based on the wider London supply situation and on the situation in the ESW supply region. As previous, we instead fix these at their historic average values: 480Ml/d to Coppermills, 90Ml/d to ESW and 10Ml/d to NLARS.

Baseline

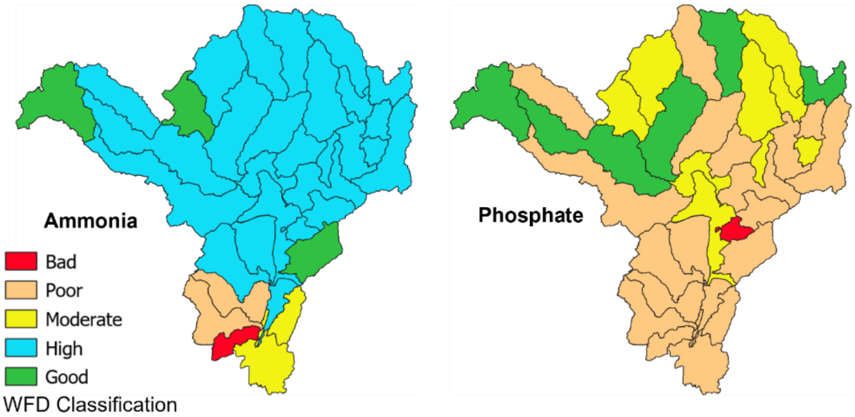
35 sub-catchments are modelled in this study, however, because the focus of this study is primarily on the Lower Lea, we target our model calibration and evaluation to four key catchment locations, depicted in Figure D.11. In London, we select three catchments: Turkey Brook, Salmon Brook and Pymmes Brook. These catchments were selected because they cover the borough of Enfield and they are well monitored, both in terms of flows and water quality, thus providing a sensible validation point. The Feildes Weir that captures both the Upper Lea and the River Stort was selected as the other in-river evaluation location because it controls the amount of water available for abstractions at KGV (see Figure D.10) and it determines the pollution and dilution that the Lower Lea catchments discharge into. In addition, behaviour at the two largest WWTWs (Deephams and Rye Meads) is also evaluated since these are key sources of in-river pollution and may be of interest in terms of options later in the project.

Figure D.11: Map highlighting the study focus locations where observational data is compared.



WSIMOD can simulate a wide variety of pollutants or chemical water quality indicators. However, again in the interest of providing a more focussed and digestible report, we primarily examine pollutants that are proven to be of concern in the Lower Lea. As shown in Figure D.12, both ammonia and phosphate levels are chemical pollutants contributing to the low WFD classifications found in the focus catchments. Thus, our simulations will focus results on these pollutants, and pollutants that chemically interact with them (nitrate and nitrite).

Figure D.12: Map showing the WFD classifications for different catchments for both ammonia and phosphate.



Scenarios

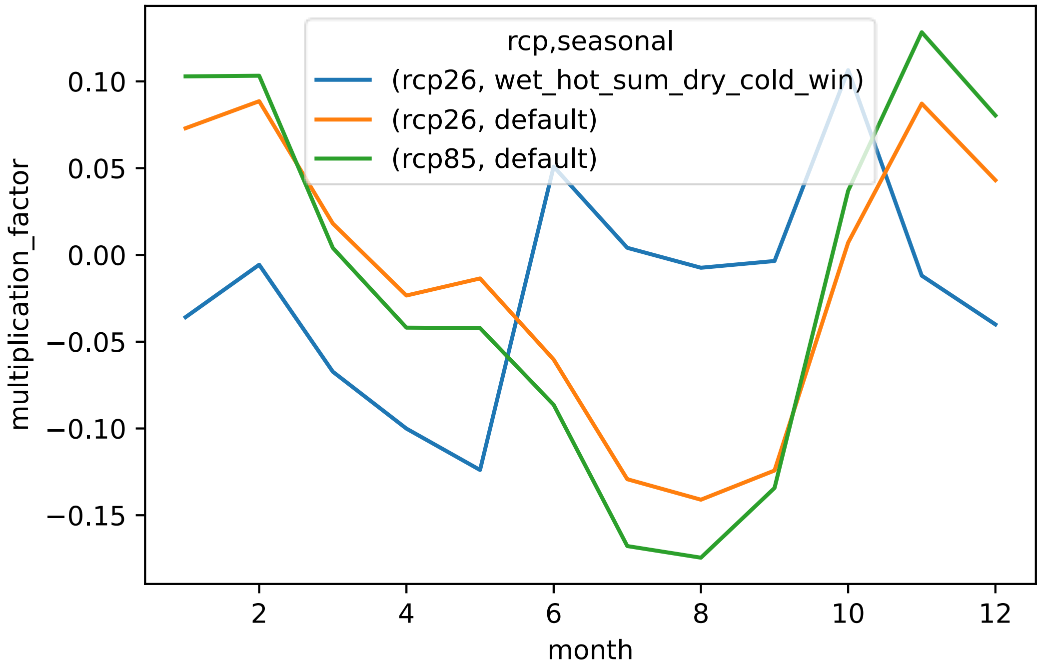
We describe how the scenarios have been implemented in WSIMOD.

Climate

The study tested three non-historic climate scenarios. These scenarios were based on UKCP18 probabilistic projections[40], which provide monthly multiplication factors for changes in precipitation, temperature, and potential evapotranspiration up to 2090. The data has a resolution of 25 km2 and a representative grid point was selected for the study. The simulations applied the monthly multiplication factors to the historic period of 2000-2020 to simulate future climate conditions for the years 2030-2050. The "default" simulations used the 50th percentile projections as instructed by OFWAT, but the study also tested unseasonable projections that result in wetter and hotter summers. The study considered two representative concentration pathways (RCP2.6 and RCP8.5) as the "best case" and "worst case" climate scenarios, respectively, by varying radiative forcing at 2.6 W/m^2 and 8.5 W/m^2. How likely either of these scenarios are a controversial topic outside scope of this report, although we can say with some confidence that the true future is likely to lie somewhere between them. A sample of the multiplication factors for the year 2050 are presented in Figure D.13

[40] https://catalogue.ceda.ac.uk/uuid/9f8dfaf790644dbcb2c3f69f409a70d6

Figure D.13: Multiplication factors for changes under UKCP18 probabilistic projections, sample taken for precipitation changes in 2050. 0 indicates no change from the historic period. 0.1, for example, indicates a 10% increase in precipitation for all daily precipitation.



Population growth and urban creep

Population growth has been implemented in WSIMOD using a variety of data sources: ONS principal growth projections, ONS alternative internal migration, ONS low international migration, ONS high international migration, ONS 10-year migration variant, GLA housing led growth (target), GLA housing led growth (past delivery). The specific projection is dependent on the scenario (see Table D.16). GLA growth data are provided at MSOA scale, while ONS at LAD scale. For modelling, both are transformed to population node scale (the intersection between foul catchments and hydrological sub-catchments). Both datasets provide data at an annual scale, but we interpolate between years to create daily data. Thus, each population node ultimately has a daily timeseries to specify population, which, via per capita water use, is reflected in changing water use and wastewater generation.

The changing population associated with the different projections also impacts urban creep. Urban creep occurs in WSIMOD in two ways:

- New households require 100m^2 per house.

- Urban areas in the Upper Lea may also experience gradual creep, which we assume to occur at a rate of $4m^2$ per house per year.

As with population data, this is converted into a daily timestep, with the two forms of creep amalgamated to provide daily total impervious area per population node. Since not all the projections specify occupancy, we have assumed an average of 2.5 persons/household (e.g., 1000 new people requires 400 new houses). Due to the complexity of development planning, we have simply assumed that this additional impervious area comes from the ‘Grassland’ surface category of a land node. This category can broadly be thought of as analogous to the CEH’s ‘Improved Grassland’ land cover type (Rowland 2017)[41], although with a specific provision that farmland is unaffected.

Per capita use

Per capita water use is directly a parameter of WSIMOD population nodes, and so is reasonably straightforward to change. In all population nodes, these changes will propagate to wastewater generation, although we assume that changes in per capita water use will not change total mass of household pollution generated (e.g., if a person’s per capita water use changes from 160l/d to 140l/d, the amount of phosphate that they generate remains constant at 0.001kg/d) on the basis that per capita reductions are primarily achieved by increased water efficiency. For the scenarios, per capita changes are only implemented in the Upper Lea because per capita changes within London are considered as an option.

WINEP

WINEP changes come in two key forms, the first is increasing the wastewater infrastructure such that spills do not occur in the following STWs: East Hyde, Rye Meads, Harpenden. The second is a variety of changes to the treatment efficacy in many STWs. Each pollutant has a treatment efficiency parameter in the wastewater treatment module in WSIMOD, which is improved to reflect these changes. They are summarised in Table D.16.

Table D.16: Summary of the WINEP changes to treatment plants.

Sewage treatment works (STW)	Ammonia (Upper Tier 95%ile) mg/l	BOD (Upper Tier 95%ile) mg/l	Phosphorus (as mean mg/l)
Barkway STW	N.A.	N.A.	3.5
Bishops Stortford STW	N.A.	N.A.	0.25

[41] Land Cover Map 2017 - EIDC (ceh.ac.uk)

Braughing STW	N.A.	N.A.	0.4
Buntingford STW	N.A.	N.A.	0.25
Clavering STW	N.A.	N.A.	0.3
Harpenden STW	N.A.	N.A.	0.3
Hatfield (Mill Green) STW	N.A.	N.A.	1
Hatfield Heath STW	N.A.	N.A.	0.9
Kimpton STW	12	50	5.5
Little Hallingbury STW	N.A.	N.A.	0.25
Luton (East Hyde) STW	N.A.	N.A.	0.25
Manuden STW	N.A.	N.A.	0.3
Standon STW	N.A.	N.A.	0.4
Stansted Mountfitchett STW	N.A.	N.A.	0.25
Takeley STW	20	50	0.9
Therfield STW	N.A.	N.A.	0.4
Weston (Herts) STW	N.A.	N.A.	0.4

Abstraction licence changes

To understand how proposed changes to the large Thames Water abstractions in the River Lea (New River, Northern Wells and Lea at Walthamstow), we have tested two variations on the licences. These licences are parameters in the model and so changing them is straightforward. They are summarised in Table D.17.

Table D.17: Summary of the existing and proposed licence changes modelled. Licences are shown as average annualised daily abstraction.

Location	Existing Licence	Medium reduction	Severe reduction
New River	100Ml/d	40Ml/d	0Ml/d
Northern Wells	100Ml/d	80.6Ml/d	60Ml/d

Lea at Walthamstow	550Ml/d	200Ml/d	78.6Ml/d

Because these changes so dramatically change the picture of water resources, flooding and pollution, we run all simulations both with and without these changes in place.

Options

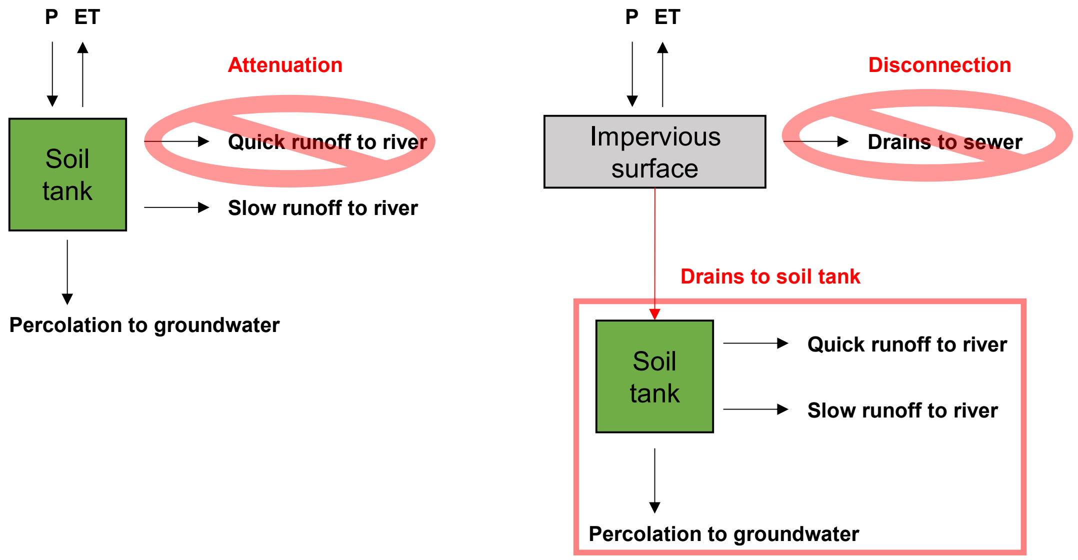
Deephams reuse

Deephams wastewater reuse has been conceptualised as a direct arc between the Deephams STW and the aggregated Lea reservoir node. When the option is in place, the capacity is set to 46Ml/d and is prioritised over all other water resources. Due to lack of data, we assume that no additional treatment processes take place for this water.

SuDS

Implementation of SuDS comes in two forms: disconnection and attenuation. Disconnection redirects the drainage of an impervious area from storm sewers to rivers. Attenuation eliminates the quick runoff from non-impervious areas, thus increasing percolation and slow runoff. The two processes are visualised in Figure D.14.

Figure D.14: Illustration of attenuation (left) and disconnection (right). Changes due to options highlighted in red.



The specific changes to catchments are summarised in Table D.18.

Table D.18: Summary of changes to London catchments when the SuDS option is in place.

Sub-catchment	Area for attenuation (ha)	Area for disconnection (ha)	Total Catchment Area (ha)
Ching Brook	100	100	2200
Lea navigation Enfield Locks to Tottenham locks	100	100	1600
Lea Tottenham Locks to Bow Locks/Three Mills Locks	200	100	4600
Moselle Brook	100	100	1700
Pymmes Brook upstream Salmon Brook confluence	100	100	4100
Salmon Brook upstream Deephams STW	100	100	3700
Turkey Brook and Cuffley Brook	100	100	4900

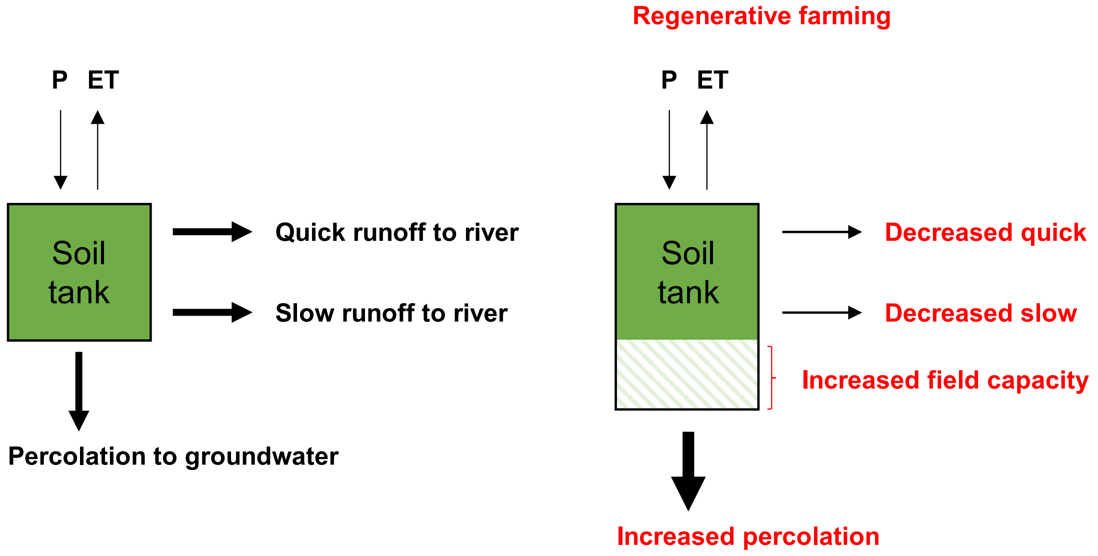
Natural Capital

Natural capital option implements regenerative farming techniques in all Upper Lea catchments. Regenerative farming techniques have been reported to help loosen the structure of the compacted soil. It can increase the ability for soil to hold more water than before, which is conceptualised by increasing the field capacity. It is also reported to increase the infiltration and groundwater recharge generated by around 50%[42].Thus, when regenerative farming is implemented

[42] Basche AD, DeLonge MS (2019) Comparing infiltration rates in soils managed with conventional and alternative farming methods: A meta-analysis. PLoS ONE 14(9): e0215702. https://doi.org/10.1371/journal.pone.0215702

on a crop, the runoff is slowed, groundwater recharge increased, and soil field capacity increased, illustrated in Figure D.15.

Figure D.15: Illustration of converting a standard crop soil tank (left) to one with regenerative farming implemented.



Following these literature recommendations, when a natural capital option is selected, we implement regenerative farming to 50% of agricultural land area in the Upper Lea, which increases percolation by 50% (decreasing quick and slow runoff accordingly) and the soil field capacity by 10%.

New water resources/Leakage reductions

New water resources and leakage reductions are both conceptualised as a ‘water resources only’ option since they will mainly take place outside of the modelled boundaries. Thus, they are modelled as a flat increase in water supply availability for the Walthamstow supply system. The new water resources provide 45Ml/d while the leakage reductions 40Ml/d.

Per capita reductions

See per capita use for description of implementing per capita changes in WSIMOD. When the per capita reductions option is in place, London population nodes have their per capita water use reduced to 105l/d. Besides decreasing the wastewater generated (described above), these changes have a knock-on impact to water supply, thus reducing the amount of water needing to be drawn from water resources equivalently.

Explanation of metrics

We broadly group the results into three categories: water quality, water resources, and flows.

Water quality: WFD classification

To characterise water quality and changes to it, we categorised simulated pollutant levels using the thresholds used in the WFD. We provide the thresholds implemented below,

Table D.19: Thresholds used to classify river water quality (all units in mg/l).

Pollutant	High	Good	Moderate	Poor	Fail
Ammonia	<0.3	<0.6	<1.1	<2.5	>2.5
Phosphate	<0.05	<0.12	<0.25	<1	>1
Nitrate	<5	<8	<10	<40	>40

These values are based off a WFD report[43], however we note they may not perfectly match in-river thresholds used on the ground since local conditions can change these values somewhat. We use thresholds rather than absolute values because, based on stakeholder feedback, they provide results that are easier to understand, and focus the attention on larger impacts.

Flows: low and high flows

Low flows and high flows cannot easily be characterised in the same way that (e.g.,) water quality can (i.e., via pollutant concentration). This is because whether they are causing negative impacts is highly dependent on the local conditions (e.g., a flow of 2m3/s may be problematic in some rivers but not others). We considered a localised high and low flow assessment outside the scope of this work, and instead quantify impacts in relative terms to the baseline conditions. As with the pollutants, this is done using thresholds:

Table D.20: Thresholds used to classify low flows (all units in % change relative to baseline, where no change would be 0%).

Flow	High	Good	Moderate	Poor	Fail
Low (Q95)	>50	>10	>-10	>-50	<-50
High (Q5)	<-20	<-5	<5	<20	>20

We note that the bands used for low flows are wider than the bands used for high flows because low flows are significantly easier to influence than high flows.

Water resources metrics: days of water stress

To characterise stress on the water supply system we use the metric ‘days of water stress’, which is the number of days that the reservoir is not in Band 1 of

[43] https://www.daera-ni.gov.uk/sites/default/files/publications/doe/UKTAG-environmental-standards-and-conditions-phase-1.PDF

the Lower Thames Control Diagram. It is important to note that this will not directly imply a water supply disruption (e.g., a hosepipe ban), although the more days of water stress the more likely water supply disruption would be. We have selected this metric rather than a more severe measure of water stress (e.g., a hosepipe ban) for a variety of reasons:

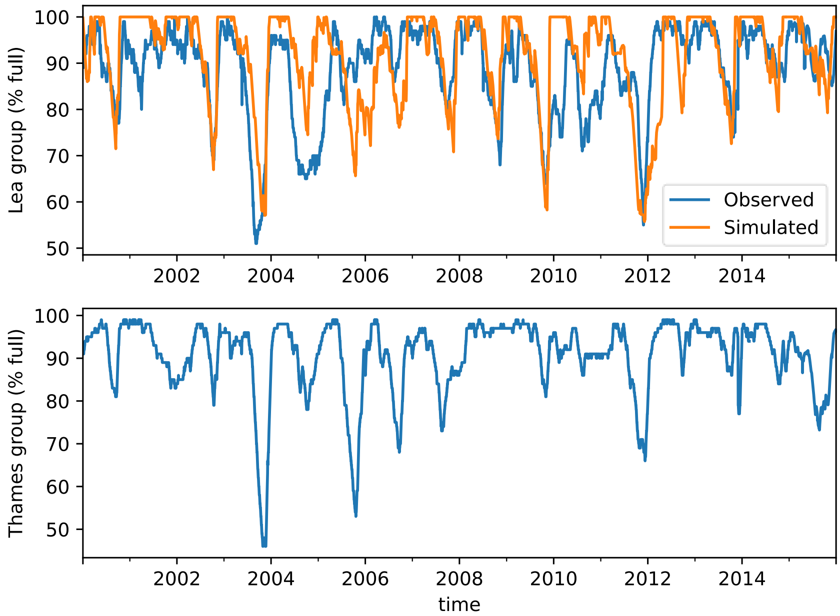
1. Our model is better at predicting this number against historic data, compared to the more severe bands. That is primarily because,
2. London's water supply exists as part of an extensive supply network, which (see Model assumptions – water resources) we considered outside the scope of modelling and,
3. During drought events (when water disruption occurs), Thames Water have available to them a wide range of emergency measures which we would have had to model to capture the occurrence of water disruption, also considered outside scope (except for those mentioned in Model assumptions – water resources).
4. If we had measured water resources in terms of water disruption, this would still not have directly aligned with the key numbers that Thames Water uses in their WRMP, because our model is simulating over a long historic timeseries, rather than under the strategic events for which deployable output is calculated.

Model evaluation

Model evaluation – water resources

In Figure D.16 we show the simulated reservoir level in the aggregated Lea reservoirs in comparison to both observed historic levels (blue) in the Lea (upper panel) and Thames reservoir group (lower panel).

Figure D.16: Time series depicting observed reservoir levels in both the Thames and Lea reservoir groups (blue) and the simulated Lea reservoir levels (orange).

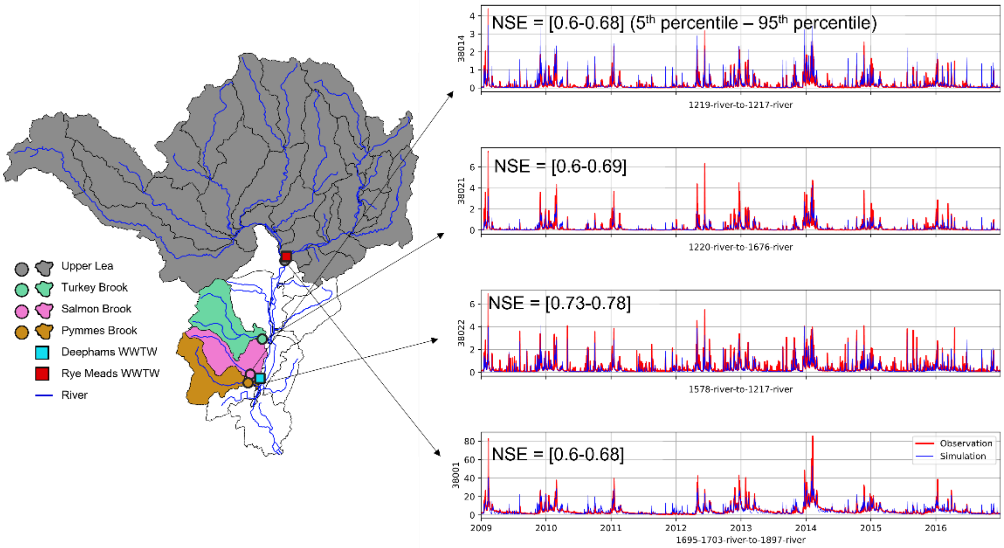


Our model currently does not include the complicated operational decision-making that is involved in transferring water along the Thames-Lea-Tunnel and in balancing the two reservoir groups (Thames and Lea) via the distribution network. The impacts of this assumption are most apparent when the observed Thames group reservoir levels are most out-of-sync with the Lea group (2005-6, 2010-11), and operational constraints or decision-maker preferences (i.e., not captured in our simulations) are causing the two groups to be imbalanced. Thus, these discrepancies would require a River Thames model to be run in conjunction with the Lea model in this study to be resolved. Although this reduces our ability to match historical data, the physically based reasoning behind discrepancies provides confidence that the Lea model can still provide a meaningful assessment of the water resources situation and how it will react to future developments/climates, even if it could not be used operationally.

Model evaluation – rivers

We show evaluation of simulated flows in comparison to gauged flows at the four in-river study locations. We perform bootstrapping to build confidence intervals on our performance metrics. We were heartened to find that even the 5th lowest percentile of the Nash-Sutcliffe performance metric (NSE) was consistently above 0.6, which can be considered a good minimum threshold for meaningful simulations. We note that a limited multi-objective calibration (2000 iterations) has been performed, however the metrics shown are the validation rather than calibration metrics. The calibration period was 2000-08 and the key parameters selected during this process were the field capacity, wilting point, percolation coefficient, surface coefficient, misconnection rate and groundwater residence time for the four study locations, 24 parameters in total. We also note that further information from Thames Water has led us to change some details around the model formulation, however the simulations are still being calibrated for these new changes, which are expected to improve the model performance.

Figure D.17: Timeseries simulations and observations of in-river flow at the four study focus locations (Salmon Brook top, Turkey Brook middle top, Salmon Brook middle bottom, Feildes Weir bottom).



Performance metrics on validation period (calibration performance is about 0.1 higher on average)

We also compare simulation results against in-river water quality observations. We highlight that, while the flow gauges measure flow averaged over a daily period, water quality observations are the lab-analysed chemical concentration of a pollutant from a spot sample. In this sense, the spot samples (which provide a single snapshot of water quality) should be taken with high uncertainty in comparison to our simulations (which provide a daily value). To reduce the observation uncertainty, we align water quality samples with flow gauges to convert their value from concentration (mg/l) to a mass total (kg/d). We also stress that, for these reasons, we have not calibrated our model to water quality indicators. Instead, we propose making manual adjustments based on the results discussed below.

Figure D.18 shows our water quality simulations in comparison to samples for a range of pollutants. We focus attention on this catchment because the density of water quality sampling is far greater than the other catchments, thus it highlights the wide variability present in water quality samples and is why we opt to show water quality validation primarily in terms of time series plots. Despite the high sample uncertainty, we find our simulations providing reasonable results for a range of water quality indicators, and in particular phosphate and ammonia, which are the two indicators of concern in this study.

Figure D.18: Timeseries simulations and observations of in-river flow and water quality indicators at Salmon Brook.

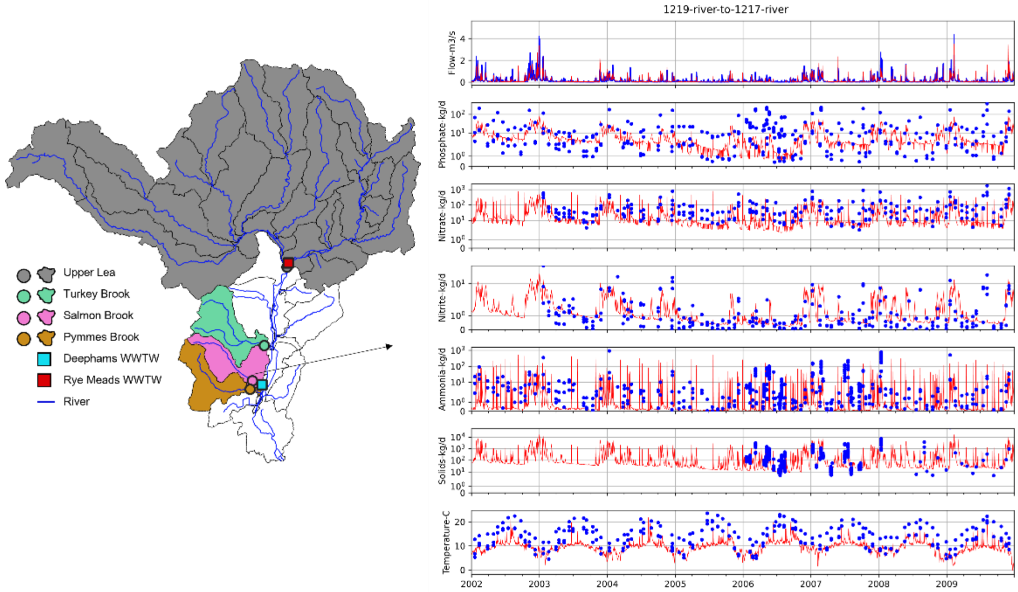


Figure D.19 shows our simulation results in the Pymmes Brook catchment. In general, our simulations under-estimate ammonia and phosphate amounts. We expect that the key driver behind this is a mis-connected sewer network, which an existing study suggests is highly prevalent in the Pymmes Brook catchment[44]. These two chemicals are highly present in sewage, and so misconnection would increase their amounts beyond what would be typical. In addition, while not visible in the flow plots, our simulations consistently under-estimate low flows in this catchment – despite that the catchment has little to no groundwater, it has a very strong baseflow, which could be explained by misconnection.

[44] G. Bussi, P. G. Whitehead, R. Nelson, et al., Green infrastructure and climate change impacts on the flows and water quality of urban catchments: Salmons Brook and Pymmes Brook in north-east London. Hydrol. Res. 53, 638–656 (2022).

Figure D.19: Timeseries simulations and observations of in-river flow and water quality indicators at Pymmes Brook.

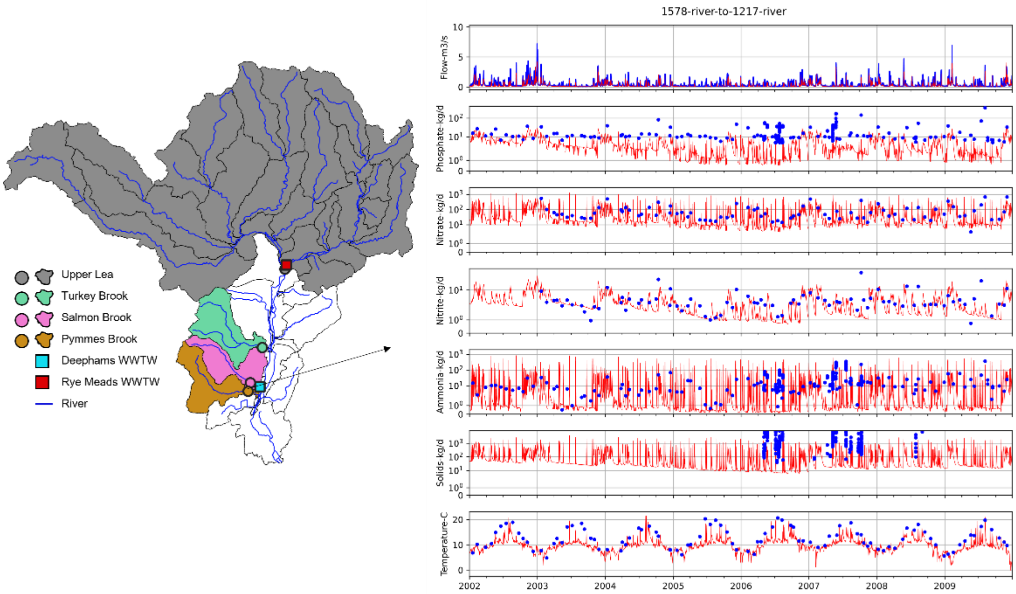


Figure D.20 shows flow and chemical levels in Turkey Brook, we see accurate ammonia simulations, although we find that phosphate levels are overestimated. Because these overpredictions are not present for ammonia and phosphate simulations are generally acceptable in other catchments, we expect that phosphorus-based fertiliser use in Turkey Brook is inconsistent with the behaviour that would be typical for the crop types in the catchment. We also see poor nitrite simulations, however, we suggest that this is not a concern, since nitrite is simulated primarily because it is the intermediary state between ammonia and nitrate (as part of the nitrification process). Nitrite is highly reactive and so simulating it precisely is difficult, but the good ammonia and nitrate simulations suggest that broadly our capturing of the nitrogen cycle is sufficient.

Figure D.20: Timeseries simulations and observations of in-river flow and water quality indicators at Turkey Brook.

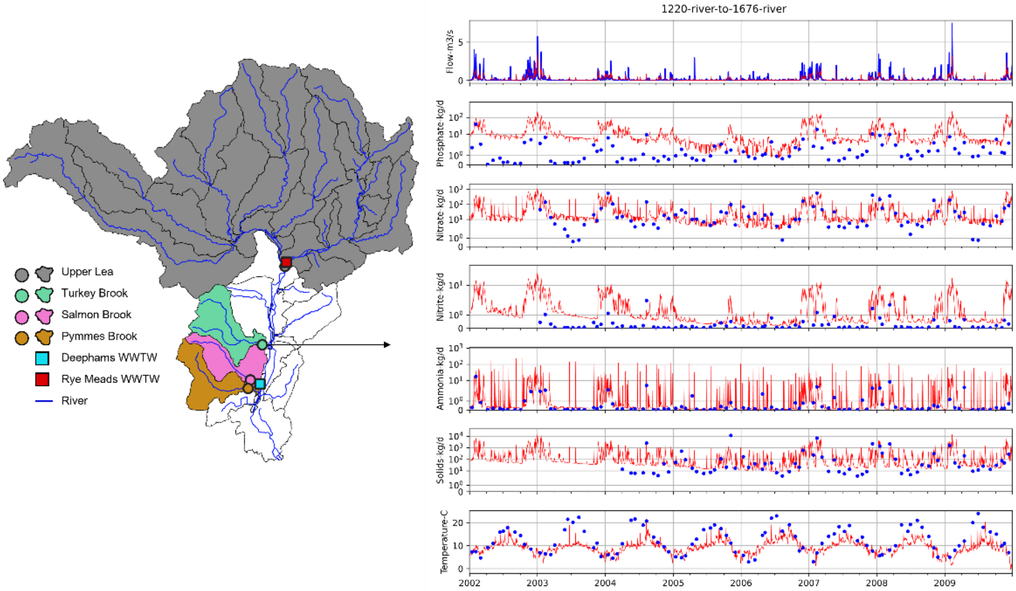
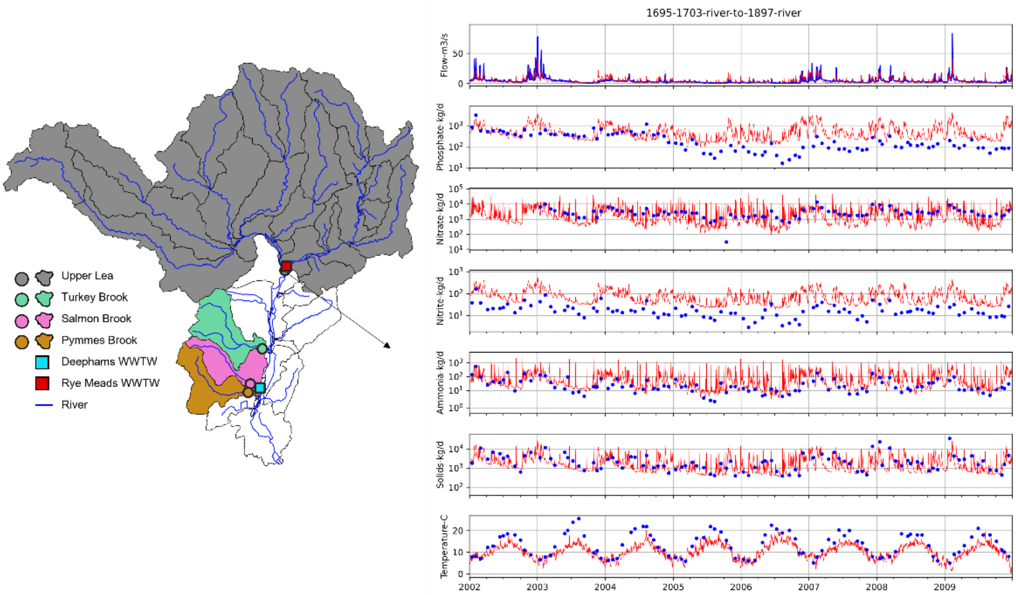


Figure D.21 shows simulation results for the Upper Lea at Feildes weir (flow) and further downstream for water quality. We see reasonable ammonia simulations and good phosphate simulations at the start of the timeseries but worsening throughout. We expect that the observed drop in phosphate amount that is not reflected in our simulations is due to the changing behaviour at Rye Meads WWTW (see following section).

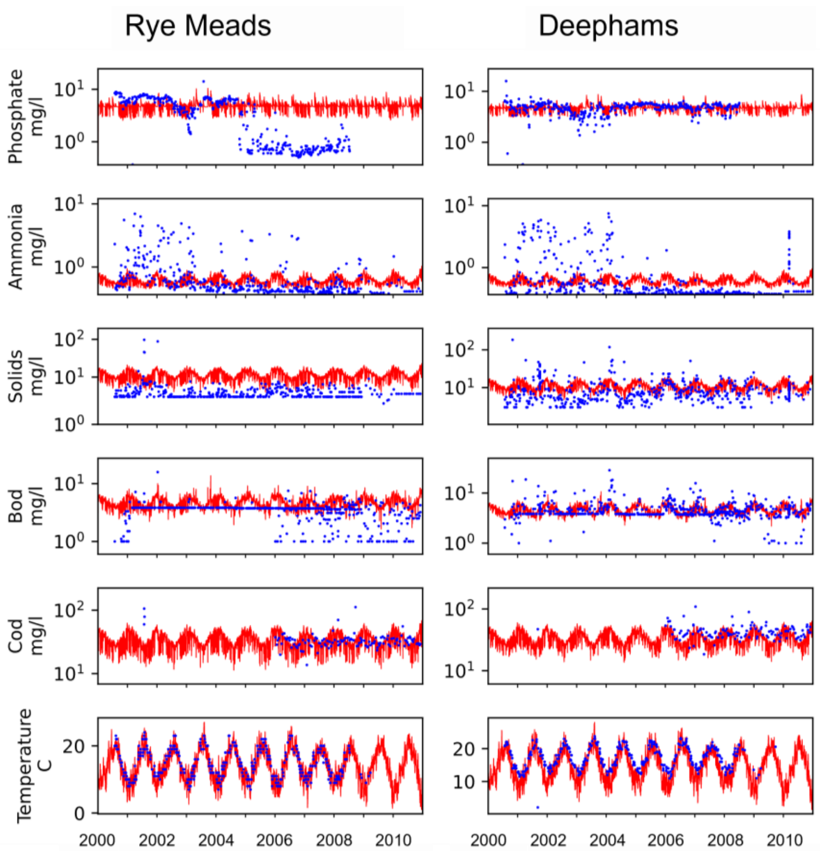
Figure D.21: Timeseries simulations and observations of in-river flow and water quality indicators at Feildes Weir.



Model evaluation – wastewater treatment

We also simulate the behaviour at all WWTWs that discharge into the Lea or any of its tributaries. We depict Rye Meads and Deephams in Figure D.22 because these are by far the two largest plants. Our simulation of WWTW behaviour is based on a simplistic transform in influent concentrations and does not capture the behaviour of individual processes within the plant. Thus, we see reasonable predictions in the average, but shortcomings in capturing some of the dynamical variability that results from changing operational conditions. The two key examples of this are in ammonia concentrations (both plants) and phosphate concentration (Rye Meads), in which we see dramatic changes in the observed concentrations and their variability over time. Following communication with Thames Water, we can confirm that these changes in observed behaviour are primarily due to changes in permitted effluent concentrations, which is currently not captured by the model.

Figure D.22: Timeseries simulations and observations of effluent water quality at Rye Meads and Deephams WWTWs.



D.5 Results

Summary

All options have been simulated in combination with all scenarios under all climates, both with the licence reforms in place and without (for a total of almost 1,000 simulations). Considering that there are 11 sub-catchments of interest (those downstream of Feildes Weir), we have been highly selective about how to present results, aiming to focus on the most significant changes. Below we highlight some of the key findings but reiterate that these are subject to the model assumptions and thresholds selected described above.

- Our baseline assessment against observational data highlights that the approach is suitable for investigating the aggregated water quality and flow measures described in Explanation of metrics. Although we note how Figure D.18 highlights the incredible variability in water quality data, and thus recommend that more detailed modelling would be needed for design studies.
- Two variations on proposed abstraction licence changes (moderate reductions and severe reductions) have far-reaching impacts, providing some water quality improvements in the Lower Lea compared to the baseline but also worsening flood risk. Additionally, both variations have significant impacts on the water resources situation. Severe abstraction licence changes essentially remove the usefulness of the Lea water supply infrastructure, placing the area in a presumed irrecoverable water resources position. Moderate licence changes also cause significant impacts, although these impacts can be limited by the water resources options, and likely alleviated by a suite of multiple water resources options (although combinations of options were not tested).
- Phosphate classifications are incredibly difficult to improve, even scenarios containing the extensive WINEP treatment plant alterations are insufficient to achieve more than a single WFD phosphate classification improvement without also reducing non-point pollution sources in the Upper Lea. Our data analysis of misconnections in the Pymmes Brook shows similar results.
- Climate change scenarios present considerable flood risk impacts driven by worsening winter storms. In some cases, these impacts can be mitigated by SuDS.
- Conversely, an unseasonable climate scenario (wetter summers) may present future opportunities from a low flow and water resources perspective, where additional rainfall can (under some conditions) support supplies.

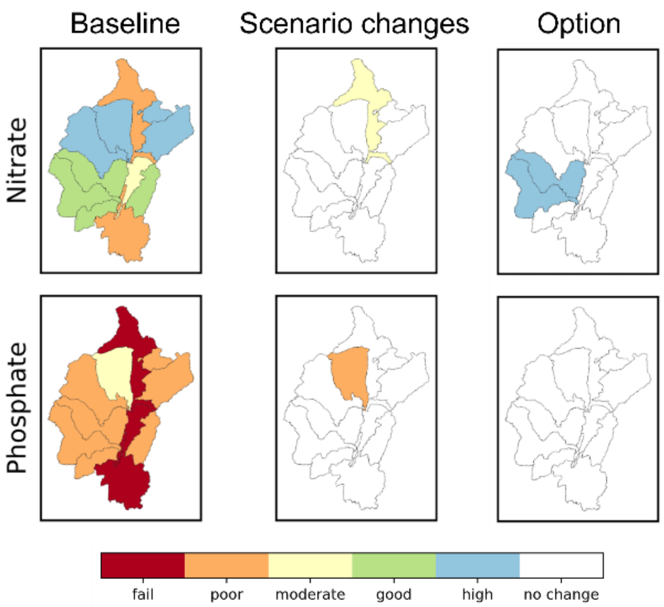
- Per capita reductions achieved by improved water efficiency, while a beneficial water resources option, come with a water quality price of reducing the dilution of household waste.
- SuDS in London catchments (see Table D.18, total of 1500ha) can improve flood risk and low flow classifications by diverting more water to the soil tank and groundwater, ultimately reducing peaks, and providing more baseflow during low flows.
- Natural capital (regenerative farming techniques applied to half of arable farm area in the Upper Lea) is found to be a complement to, but not a substitute for, the conventional water resources options, however, their water quality improvements tend to be localised.
- Low flows in the Lower Lea are significantly supported by Deephams effluent, thus a reuse option can worsen low flows (despite its efficacy as a water resources option).

Understanding results figures

Water Quality Results

We present baseline results (Figure D.23, left column) in a similar format to the WFD classification mapping, using the thresholds presented in Table D.19.

Figure D.23: Demonstration of results mapping (water quality).



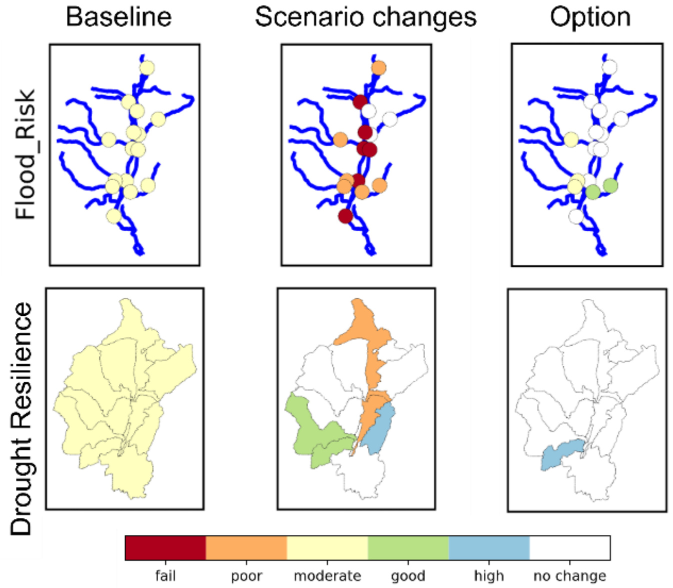
To present the impact of scenarios (Figure D.23, middle column), we show the water quality threshold in catchments only where there is a change from the baseline. We highlight the size of the thresholds in Table D.19, for example, to improve a phosphate classification in a catchment one would have to more than half the amount of in-river phosphate or double the river's flow without changing phosphate input. Thus, readers should bear in mind that ‘no change’ does not mean ‘no impact’, but more accurately, no change that crosses a threshold. Although this provides less granularity in results, our iterations with stakeholders confirmed that it was worthwhile to create results that were easier to read.

To present the impact of options (Figure D.23, right column), we show the water quality threshold in catchments only where there is a change from the scenario. We highlight changes from the scenario rather than the baseline to avoid duplication from the middle column and to show changes that are solely attributable to the option, rather than both the option and scenario.

Flow results

The same logic is applied to low and high flows (Figure D.24) as is water quality (Figure D.23). However, there are a few noteworthy changes.

Figure D.24: Demonstration of results mapping (low and high flows)

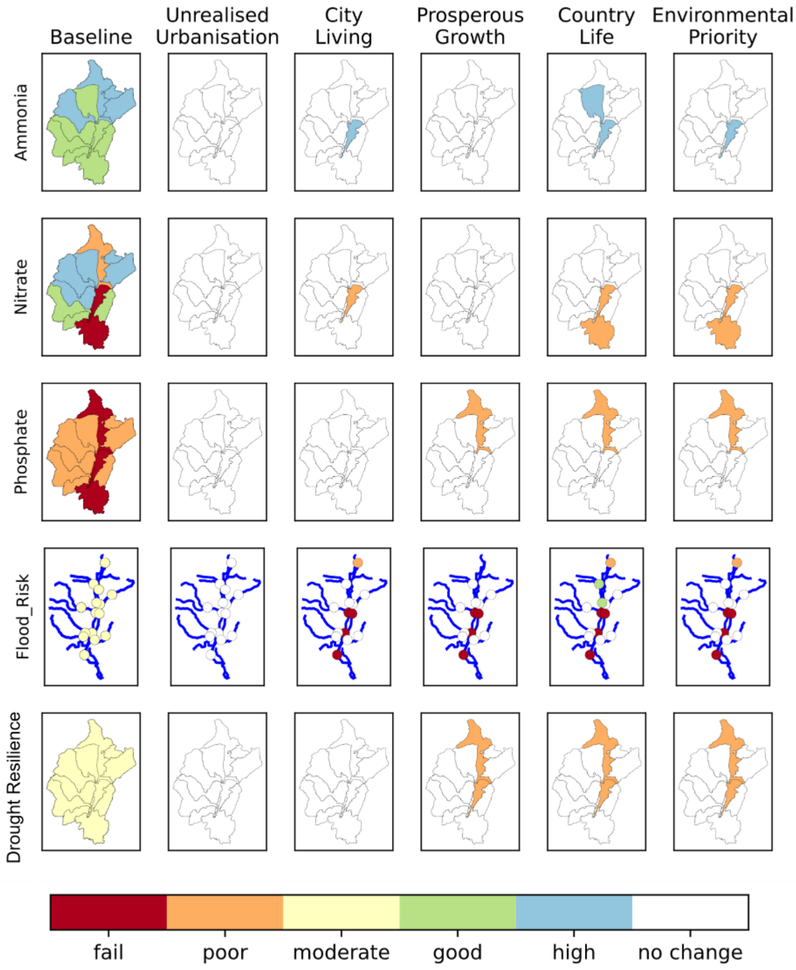


First, as discussed in Flows: low and high flows, no baseline assessment of low or high flows was performed due to the importance of local conditions. Thus, in all catchments/locations the baseline assessment is simply given as ‘moderate’ (cream coloured) and scenario changes are highlighted only when the differences from the baseline are greater than the ‘moderate’ bands shown in Table D.20. As with water quality, Option changes are relative to the scenario, for example, the cream points in the Western catchments in the top right panel of Figure D.24 indicate that the flood risk, which was worsened to ‘poor’ under the scenario, has returned back to the ‘moderate’ classification when the option is in place.

Baseline and scenario impacts

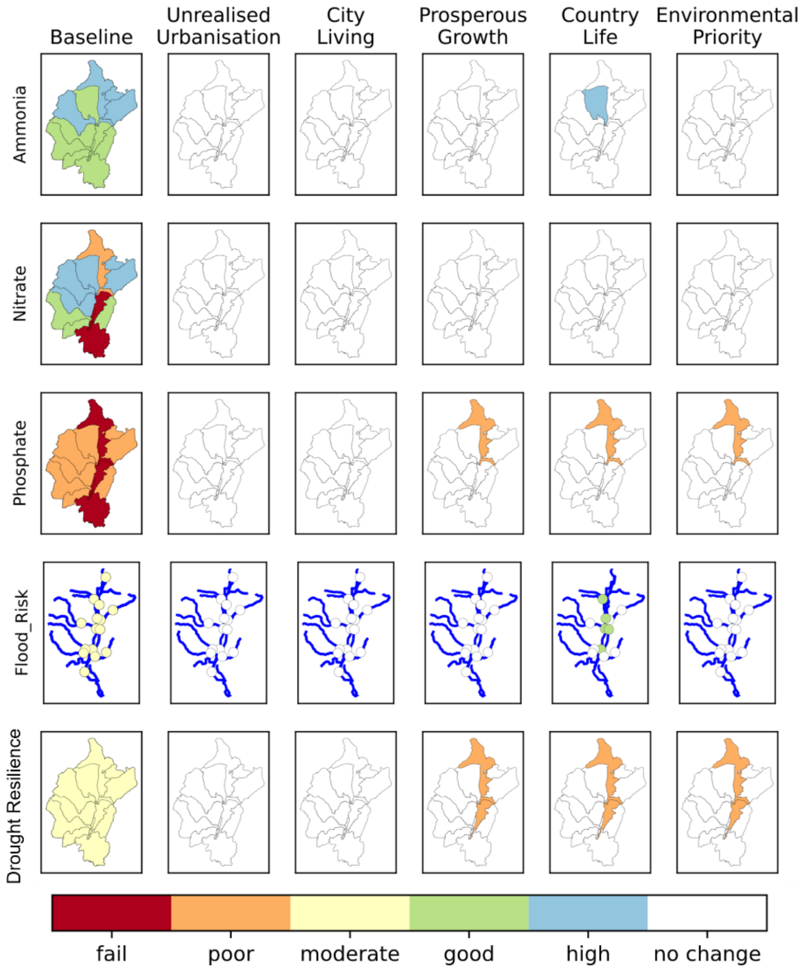
In Figure D.25 we show the impact of the five different scenarios in terms of their changes to the baseline classifications, discussed below.

Figure D.25: Summary of scenario impacts with abstraction licence changes in place and no climate change



The most significant changes that we see are the abstraction licence impacts on flood risk, under either moderate or severe licence changes we see failing flood classification in the main River Lea. The increased flows that result from the licence changes are sufficient to improve the water quality classifications in the main Lea. However, the specifics differ between scenarios. We can isolate the impact of abstraction licences by viewing the scenarios without licence changes, see Figure D.26. Where we can verify that both the flood risk worsening and nitrate/ammonia improvements in the main River Lea are attributable to the licence changes. We can also see that the high urban population growth due to city living and prosperous growth outweighs most benefits attributable to the licence changes (minimal nitrate/ammonia improvement in the Lower Lea in Figure D.25).

Figure D.26: Summary of scenario impacts with no abstraction licence changes and no climate change



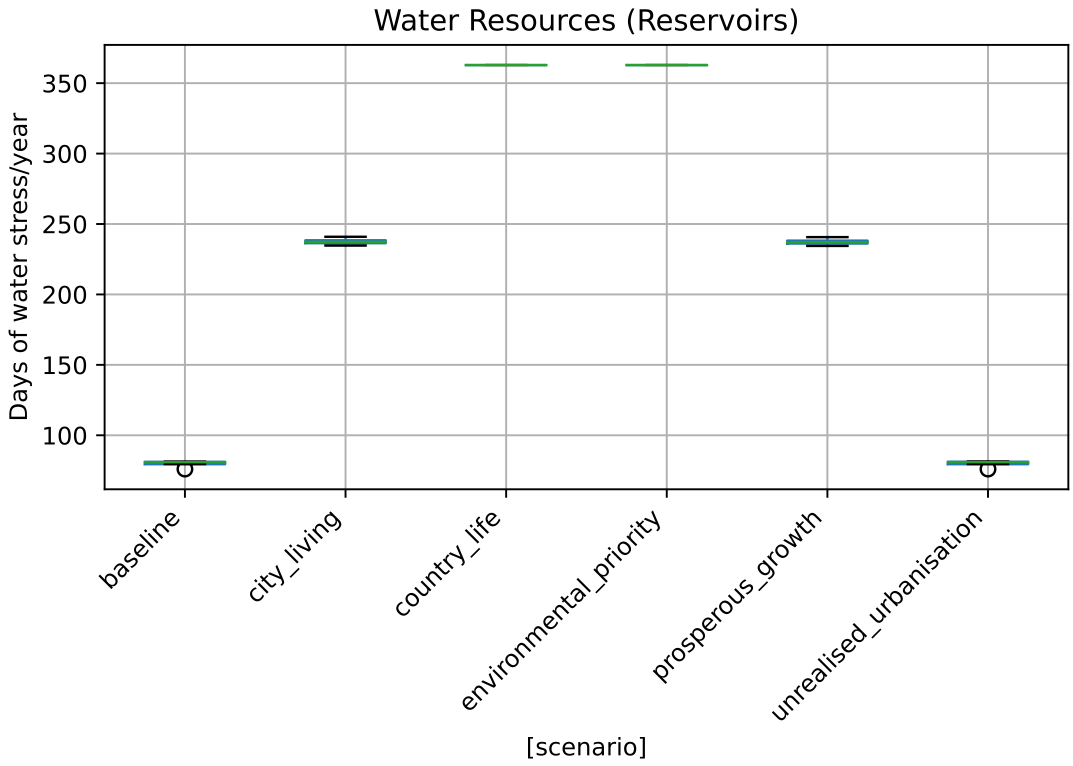
Because of the importance of effluent in supporting low flows, the Upper Lea per capita reductions (in the prosperous growth, country life, and environmental priorities scenarios) worsen drought risk.

We have observed some positive effects of the WINEP treatment plant improvements in reducing the amount of phosphate in the River Lea, specifically in the prosperous growth, country life, and environmental priorities scenarios. However, we must point out that, despite the significant expenses of these improvements and significant associated phosphate reductions, only one WFD classification threshold was gained. Moreover, these phosphate reductions become less noticeable as the Lea river flows downstream, primarily because the Deephams effluent also flows into it. Based on the available data, our best interpretation is that treated effluent and non-point sources of pollution, mainly fertilizers, contribute about equally to the phosphate load in the Lea. Thus, we can conclude that even with the significant investment made by WINEP in improving wastewater infrastructure, there is a limit to the amount of phosphate reduction that can be achieved without also addressing non-wastewater pollution sources.

In most cases, the adaptation reductions in impervious area are counterbalanced by urban creep, however the country life scenario, which has no urban creep at all enables these reductions to make their full impact, evidenced by the reduced flood risk in many urban catchments and the main Lea.

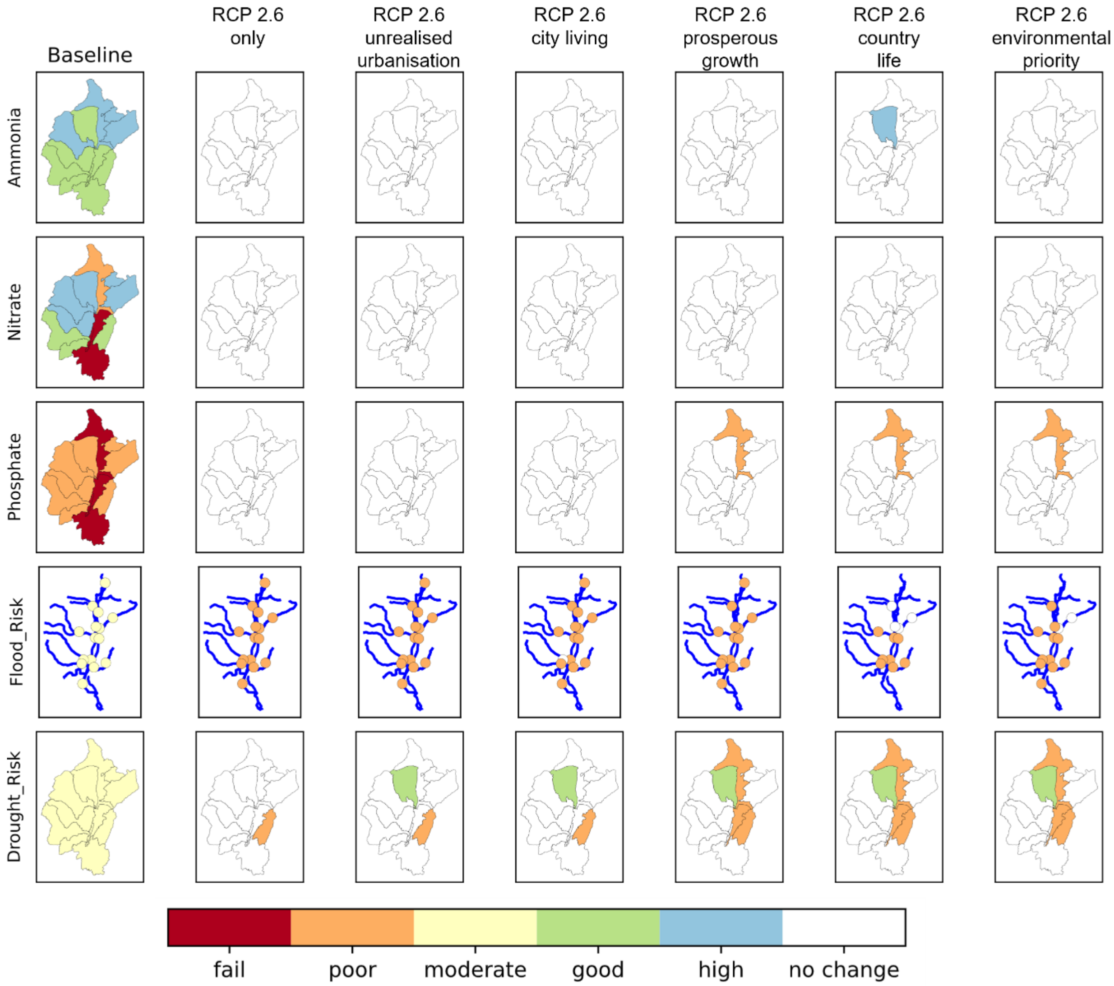
In Figure D.27 we show the water resources metric for the different scenarios. Results are starkly grouped based on their licence changes, with negligible differences otherwise. No licence changes (unrealised urbanisation) producing results that are similar to the baseline. Moderate licence changes (city living and prosperous growth) present a significantly deteriorated water resources picture, while severe licence changes (country life and environmental priority) render the Lea water infrastructure essentially redundant.

Figure D.27: Water resources metric under scenarios that include licence changes



In Figure D.28 we demonstrate that the primary impacts of climate change are in flood risk, with nearly every point worsening under the RCP 2.6 scenario. The only mitigation than can improve this in the scenarios is the country life reduced urban creep. Although not shown, we note that SuDS is sufficient to mitigate these climate impacts in catchments where implemented and even in the main lower Lea. We also see a worsening of drought risk in the Ching Brook (and to a lesser extent other flashy catchments). However, in catchments whose baseflow is primarily driven by winter precipitation, we can experience improvements in drought risk from the wetter winters, although we note that the primary catchment which experiences this (Small River Lea, in green in the drought risk row for scenarios) was not calibrated due to its not falling within the focus area of this project.

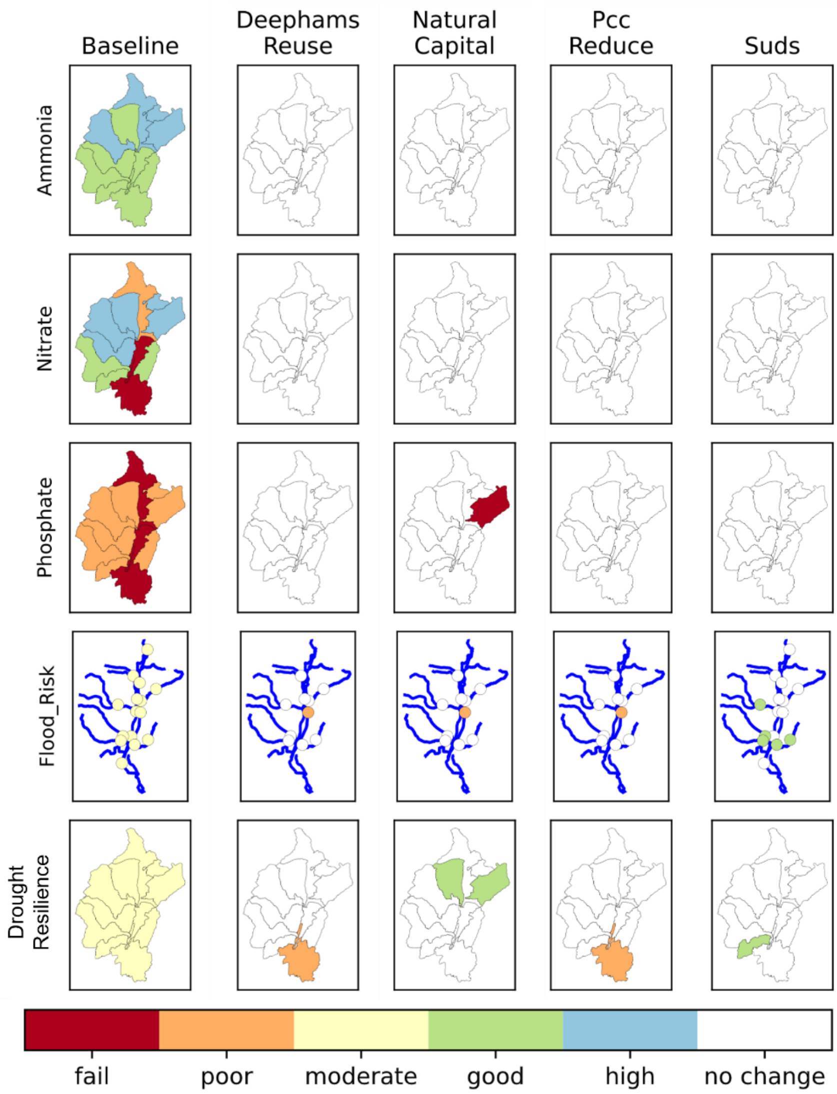
Figure D.28: Summary of scenario impacts with no abstraction licence changes and climate change set to the RCP 2.6 projection



Options across metrics

We can most easily isolate the impact of options by viewing the changes that occur when they are implemented for the baseline scenario, see Figure D.29 for water quality results.

Figure D.29: Impact of options under the baseline scenario.



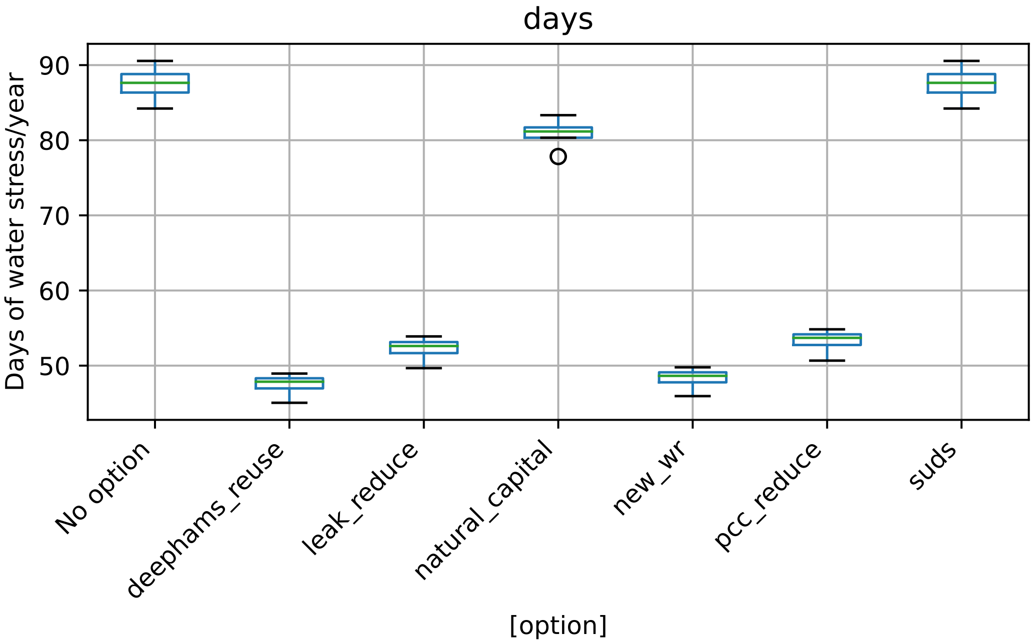
In both the Deephams reuse and per capita reductions option, we see that the low flows in the lower Lea are supported by effluent, since both options reduce effluent entering the river from Deephams, we see a resultant drop in low flows. We observe an increase in flood risk at a point downstream of the main abstractions in the Lea (small orange point in middle of flood risk map in Deephams reuse column), that results from the decreased abstractions made available by Deephams reuse. We also see this occurring in both Natural capital and PCC reduce options. We would highlight that this is likely not to be a concern because it is unlikely that Thames Water would reduce their abstractions at this location due to these options because they have the operational flexibility to maximise their licence use due to the extensive London distribution network.

Natural capital has local improvements to low flows in catchments where it is implemented, however the majority of these catchments are upstream and so the impacts are primarily not visible in this plot. We note that the phosphate increase in Cobbins Brook (red catchment in Natural Capital column and phosphate row), occurs due to the changing flow regime resulting from natural capital (higher flow during baseflow dominated periods, otherwise lower flows). However, this change is still small, with the phosphate levels before natural capital at 0.97mg/l, and 1.03mg/l after – the threshold is set at 1mg/l and so this is what drives the change.

SuDS have a range of benefits in catchments where implemented, reducing flood risk, and increasing low flows. These also result in water quality improvements of up to 10% (ammonia levels in Pymmes Brook), however they are not visible because they are insufficient to improve WFD classification.

In Figure D.30 we demonstrate that all water resources focussed options have significant impacts at improving the water resources situation. In addition, due to the increased baseflows resulting from natural capital, water resources benefits can be achieved. We highlight that, because of the sensitivity of the abstraction licence during low flows, these results are highly sensitive to parameters selected to implement natural capital, and that further improvements to baseflow can have disproportionate benefits on water resources.

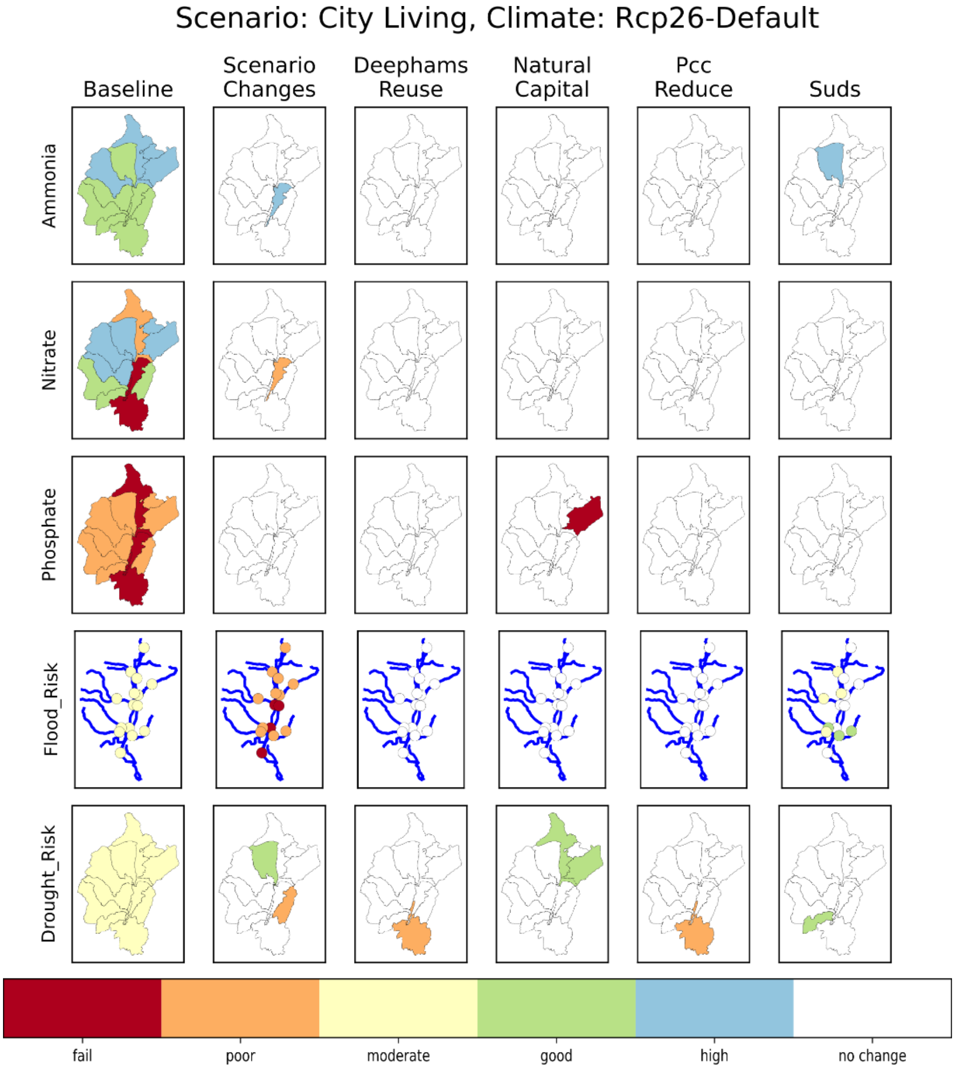
Figure D.30: Options impact on water resources



Options interactions with scenarios

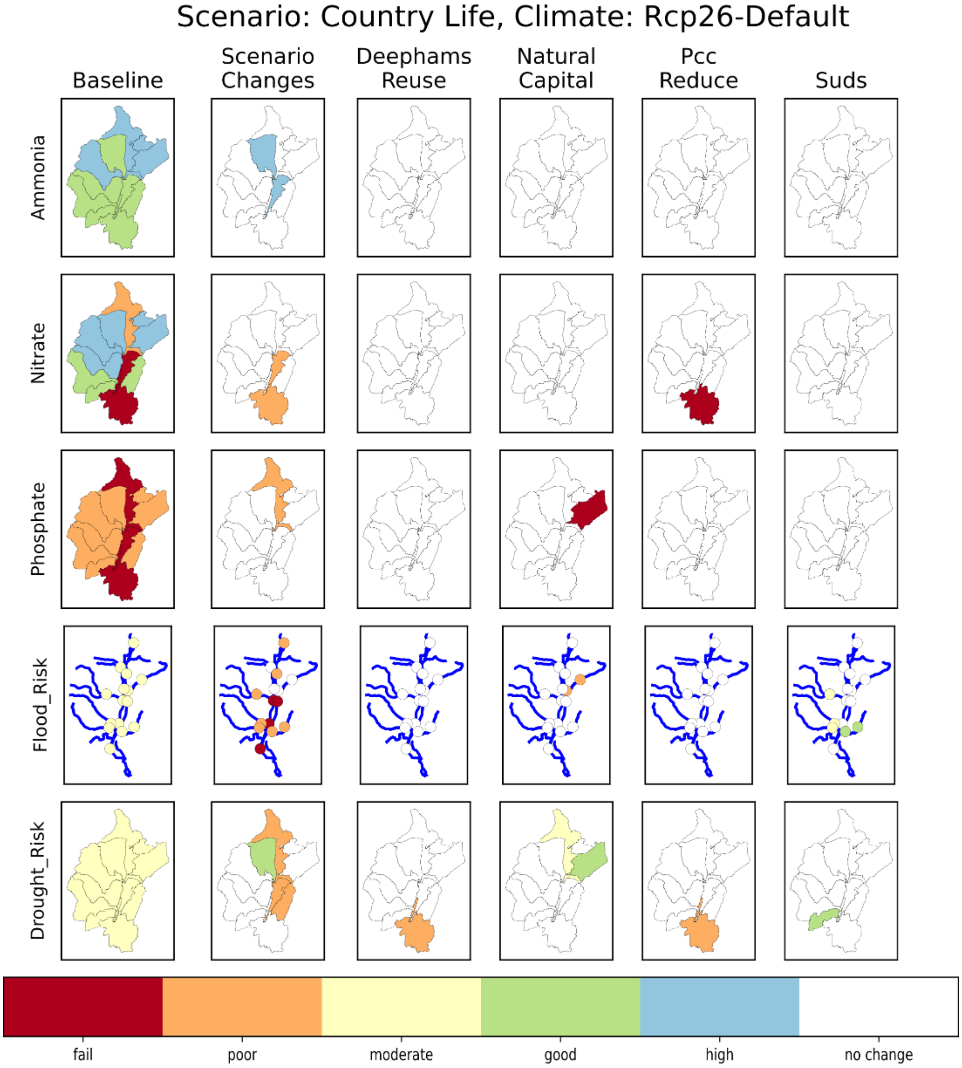
In Figure D.31 we show again the city living scenario changes, but with options simulated for this scenario rather than the baseline. In general, the mechanisms of how the option changes the water cycle are similar to Figure D.29, however we see some cases where the option has different impacts because of interactions with the city living scenario. This occurs most notably in the SuDS option, where we see many of the flood risk increases associated with licence changes and increased urban area, mitigated, or even improved relative to the baseline. We also see some improved low flows in the main Lea due to natural capital, achievable when combined with the increased effluent from city living.

Figure D.31: Summary of city living scenario and option impacts with abstraction licence changes and climate change set to the RCP 2.6 projection



In Figure D.32, we show the same but for the country life scenario. Again, we see some worsening that has been mitigated, for example, natural capital has mitigated and improved some of the worsened low flows associated with the country life scenario. In contrast, we see some cases where the option has pushed a metric past a threshold, when it was already close, for example, the reduction in low flows that result from per capita reductions that we see in Figure D.29, when combined with the population increase in country life has worsened the nitrate classification in the main Lea.

Figure D.32: Summary of country life scenario and option impacts with abstraction licence changes and climate change set to the RCP 2.6 projection

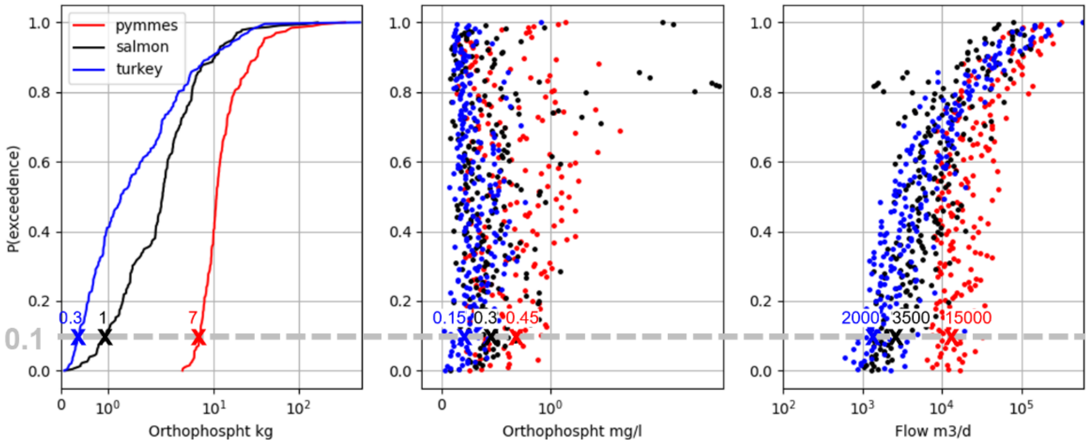


Pymmes Brook misconnection data analysis

We have separately performed an ancillary data analysis for misconnections in the Pymmes Brook. Although WSIMOD simulations were utilized to identify potential areas and mechanisms of interest, the analysis presented in this study relies solely on observational data. This is due to the substantial uncertainties associated with modelling misconnections, and so we did not want to present overconfident findings.

We demonstrate the presence of misconnections by pairing water quality sampling stations with NRFA flow gauges to calculate total phosphate (orthophosphate as phosphorus) in both Pymmes Brook and the two nearby catchments of Salmon and Turkey Brook in Figure D.33. We select phosphate because of its high levels in effluent and status as a problematic pollutant in this area, although note that similar patterns are seen when repeating the experiment for ammonia and BOD.

Figure D.33: (Left) Sampled phosphate multiplied by matched flow gauge data and converted to kg, presented as a CDF. (centre) sampled phosphate concentration, aligned with corresponding point on the CDF. (right) gauged flows, aligned with corresponding point on the CDF. The CDF at 0.1 is highlighted by a dashed grey line, reading off approximate points that are discussed below.



What is immediately apparent by inspection is the higher base levels of phosphate loading in Pymmes Brook. If a pollutant were mobilised by rainwater driven processes (whether through storm sewers or catchment runoff) only, then loading should drop to near 0 when there is minimal rainfall in a catchment, as we see in Salmon and Turkey Brook. Thus, we can expect this higher base level to be driven by misconnection. The behaviour in Pymmes Brook only converges with the behaviour in the other catchments at high loadings, where we presume behaviour is dominated by rainfall driven processes. This appears to be confirmed by the persistent baseflow we see in Pymmes Brook that is not present in the other two catchments, despite similar hydrogeology.

We can examine phosphate numbers on a ‘typical’ baseline day. If we pick a day on the CDF at 0.1 (i.e., a day when 90% of days have higher phosphate loading, and 10% have lower, see grey dashed line in Figure D.33), we extract the following approximate values:

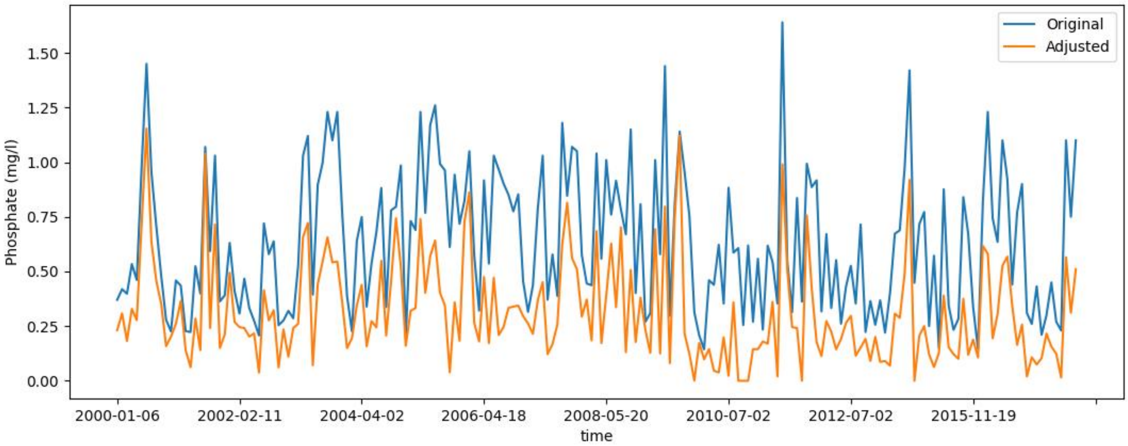
Table D.21: CDF 0.1 of phosphate loading, concentration, and flow, for the examined catchments

Catchment	Phosphate Loading (kg)	Phosphate Concentration (mg/l)	Flow (m3/d)
Pymmes	7	0.45	15000

Catchment	Phosphate Loading (kg)	Phosphate Concentration (mg/l)	Flow (m3/d)
Salmon	1	0.3	3500
Turkey	0.3	0.15	2000

Due to the significant uncertainties around infiltration, population phosphate generation, lack of data around non-population polluters, and other interactions between misconnection and rainfall processes, the true misconnection rate is difficult to estimate. However, if we assume a reasonably generous natural loading of 1.5kg/d, scaled proportionally from Salmons Brook, then 5.5kg/d (7-1.5) is the rate of phosphate loading created by misconnection. Thus, by removing this 5.5kg/d from loading and recalculating concentration we can estimate the plausible changes to in-river phosphate due to elimination of misconnection, see Figure D.34.

Figure D.34: Timeseries of phosphate in Pymmes Brook. Original data (blue) represents the raw sampled phosphate concentration. Adjusted data (orange) represents the original data transformed such that 5.5kg/d of phosphate has been removed (assumed to be the misconnection loading contribution).



We see significant water quality improvements with the removal of misconnection, on average halving the in-river phosphate concentration from around 0.6mg/l to 0.3mg/l. However, we would draw attention to the phosphate thresholds in Table D.19, and note that this change in concentration would not cause any change in WFD classification.

This finding highlights how ‘fixing catchments’ (i.e., aiming to achieve a WFD good classification) must always take an integrated approach that considers how all drivers interact to drive in-river water quality.

E. Option Case Study: SuDS

Project:	East London Subregional Integrated Water Management Strategy		
Our reference:	100108845 | 4.2 | B	**Date:**	08/06/23
Prepared by:	KM LH	**Checked by:**	LB
Approved by:	RLS		

E.1 Why are we doing a SuDS option case study?

A case study provides more context to help interpret the results from the WSIMOD modelling and what they mean for the Subregional Integrated Water Management Strategy (SIWMS). The Salmon Brook sub-catchment in Enfield has been selected as a case study to illustrate the catchment interactions when implementing Sustainable Urban Drainage Systems (SuDS) options.

E.1.1 What is the issue?

In this sub-catchment, modelling results show that both river health and flood risk deteriorate in the future scenarios we have modelled. The WFD status' of the sub-catchments in the baseline scenario and both the city living and country life future scenarios are shown in Table E.22. The thresholds for the WFD status classification of each metric are detailed in Table 3.1. A least regret option that the steering group can take ownership of to address the problem is the implementation of SuDS.

Table E.22: Threshold classifications for river health and river level metrics in Salmon Brook upstream Deephams STW sub-catchment

Metric	Measurement	Baseline	City Living (with RCP 2.6 climate change)	Country Life (with RCP 2.6 climate change)
Ammonia WFD Status	Increase/decrease in mg/l	Good	Good	Good
Nitrate WFD Status	Increase/decrease in mg/l	High	High	High

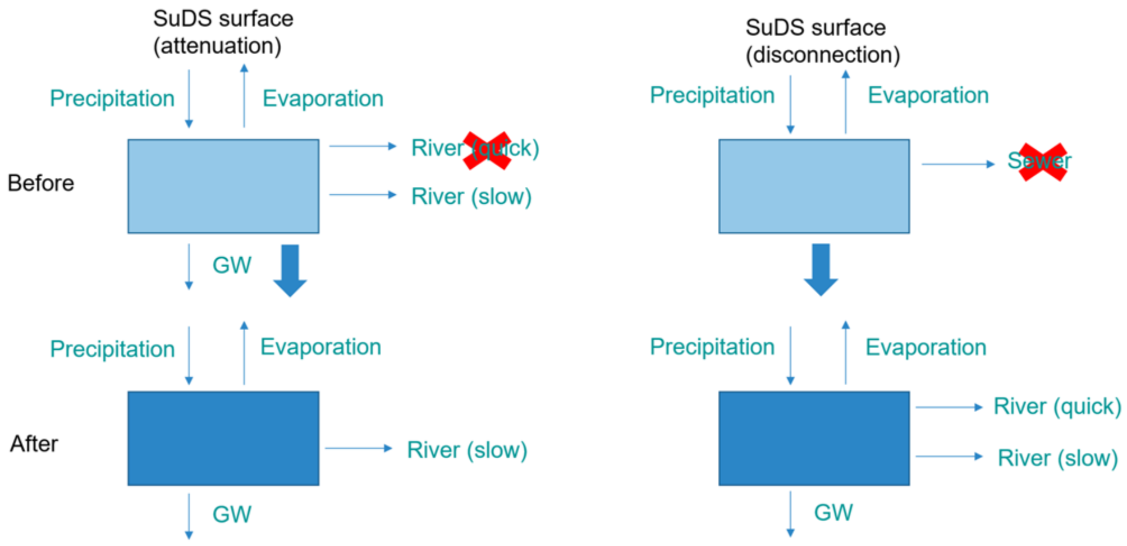
Metric	Measurement	Baseline	City Living (with RCP 2.6 climate change)	Country Life (with RCP 2.6 climate change)
Phosphate WFD Status	Increase/decrease in mg/l	Moderate	Moderate	Moderate
Q5 Flood Risk	Percentage increase/decrease in risk	Moderate	Poor	Poor
Q95 Drought Risk	Percentage increase/decrease in risk	Moderate	Moderate	Moderate

While SuDS can mitigate the increase in flood risk and river health deterioration, their implementation faces barriers as solutions put forward rarely meet necessary cost-benefit thresholds to secure funding, and ongoing maintenance requirements may present higher operational costs.

E.1.2 What are SuDS?

SuDS are used to manage rainfall closer to its source by conveying surface water and reducing the speed of runoff before it enters watercourses or sewer systems. Reducing the runoff rate of surface water (attenuation) allows a greater volume of runoff to infiltrate the soil or evaporate from the surface. Minimising the volume of water entering watercourses or sewer systems reduces the risk of fluvial flooding from rivers and sewer surcharging. Diverting surface flow away from sewer connections and conveying directly to watercourses (disconnection) also allows increased ground infiltration and reduces flow pressures on the sewer system.

Figure E.35: Urban surface water mechanisms



Methods of implementing SuDS for attenuation include landscape depression storage to slow runoff, retention basins, detention basins or riverbank enhancements. Retention basins act as a storage pond, containing an orifice above the base water level allowing controlled discharge when this water level is exceeded. Detention basins contain similar orifices allowing controlled discharge at the bottom of the basin, leaving the area dry once the stored stormwater is all conveyed. Examples include swales which are vegetative channels which allow infiltration while flows are conveyed. Detention basins are another example which are vegetative storage areas for runoff when high overland flows occur, from which the flow release to the watercourse or sewer system is controlled.

Figure E.36: Example of a swale channel

Source: Abertay University[45]

[45] Swales | Abertay University

Figure E.37: Example of a detention basin

Source: Susdrain[46]

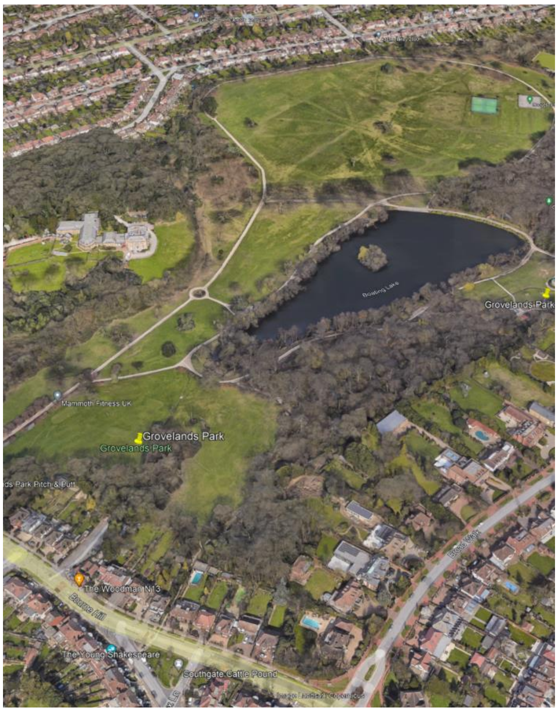
SuDS such as swales can also be used to disconnect surface runoff from impermeable surfaces such as roofs and highways by conveying them directly to water courses.

E.1.3 What measures could be implemented?

The examples discussed in Section E.1.2 can be implemented within the study area. Figure E.38 provides an example of an area to convert for SuDS attenuation in Grovelands Park. For SuDS options that disconnect flows from the sewer system, examples include permeable pavements, tree pits or green roofs to convey water away from storm water sewer networks. Figure E.39 provides an example of an area at Colosseum Retail Park to convert for SuDS disconnection options.

[46] Detention basins (susdrain.org)

Figure E.38: Potential area to implement SuDS options for attenuation at Grovelands Park



Source: Landsat/Copernicus

Figure E.39: Potential area to implement SuDS options for disconnection at Colosseum retail park

Source: ©2023 Bluesky, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies, The GeoInformatiion Group, Map Data ©2023

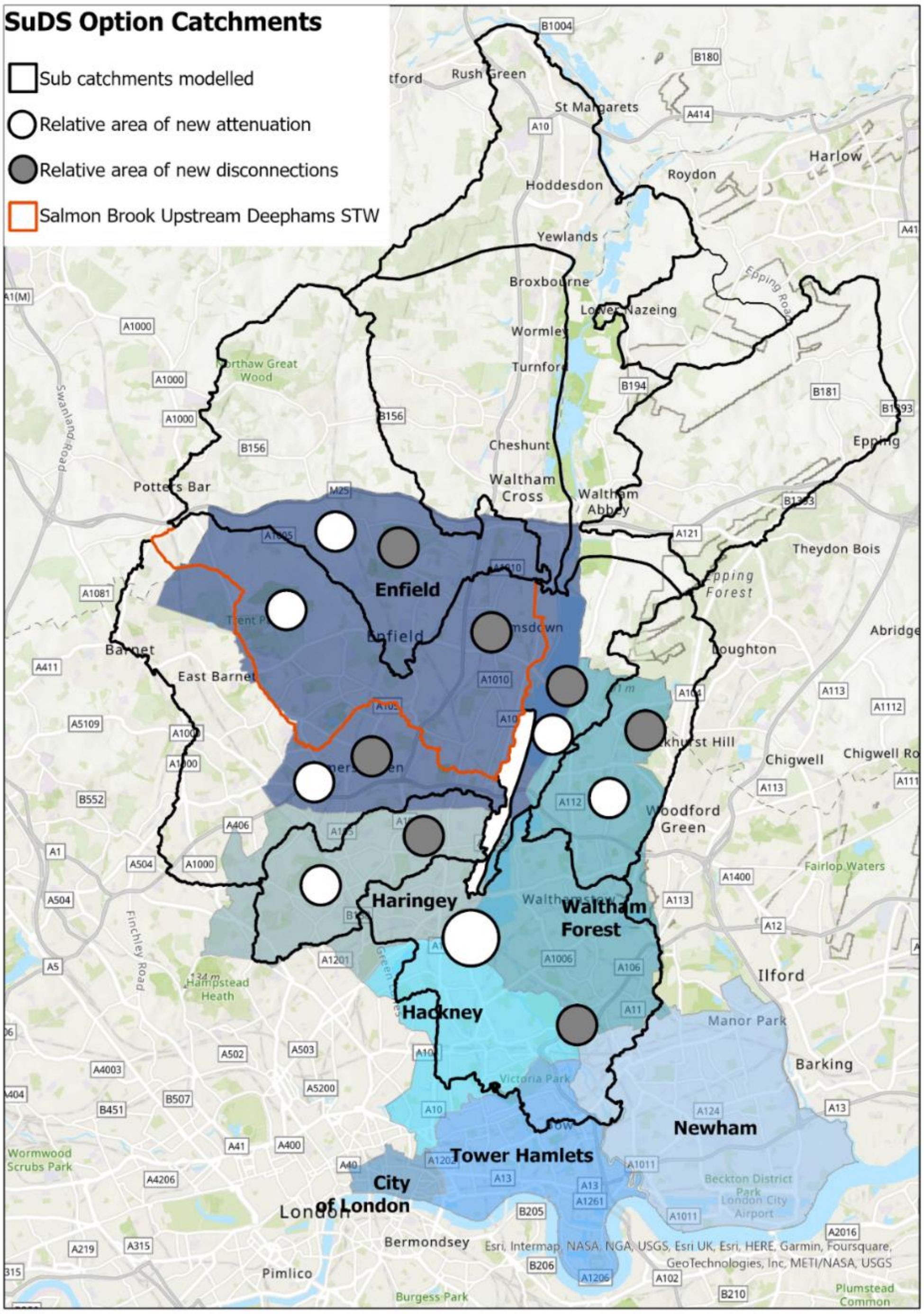
E.1.4 How have we selected sites?

The SIWMS provides an opportunity to show the interaction of SuDS at scale across the sub-region.

Figure E.40, Table E.23 and Table E.24 show the relative area of the sub-catchments that have been converted to SuDS for the integrated modelling. The total area for 'Salmon Brook upstream Deephams STW' (shown in a red outline in Figure E.40: SuDS options modelled relative to size of sub-catchment) is 3700ha, with approximately 100ha available for attenuation and 100ha available for disconnection which constitutes a total of 5% of the sub-catchment area.

SuDS options for attenuation eliminate the quick runoff from non-impervious areas, thus increasing percolation and slow runoff. SuDS options for disconnection redirects the drainage of an impervious area away from storm sewers towards rivers.

Figure E.40: SuDS options modelled relative to size of sub-catchment



Source: Environment Agency[47], Greater London Authority[48]. Based on the Ordinance Survey Map with the Sanction of the Controller of H.M Stationery Office License Number:- 100019345

[47] Lee Lower Rivers and Lakes Operational Catchment | Catchment Data Explorer

[48] Statistical GIS Boundary Files for London - London Datastore

Table E.23: Sub-catchments with areas converted to SuDS for modelling

Sub-catchment	Area for attenuation (ha)	Area for disconnection (ha)	Total Catchment Area (ha)	Percentage of sub catchment area to convert	Boroughs overlapping the sub catchment
Ching Brook	100	100	2200	9%	Waltham Forest
Lea navigation Enfield Locks to Tottenham locks	100	100	1600	13%	Enfield, Waltham Forest
Lea Tottenham Locks to Bow Locks/Three Mills Locks	200	100	4600	7%	Haringey, Hackney, Newham, Tower Hamlets
Moselle Brook	100	100	1700	12%	Haringey, Enfield
Pymmes Brook upstream Salmon Brook confluence	100	100	4100	5%	Haringey, Enfield
Salmon Brook upstream Deephams STW	100	100	3700	5%	Enfield
Turkey Brook and	100	100	4900	4%	Enfield

Input

Sub-catchment	Area for attenuation (ha)	Area for disconnection (ha)	Total Catchment Area (ha)	Percentage of sub catchment area to convert	Boroughs overlapping the sub catchment
Cuffley Brook					

For the areas converted to SuDS for modelling listed in Table E.23 to be fulfilled for the SuDS option, each of the Boroughs involved will need to retrofit the total areas of SuDS stated in Table E.24. Both the Country Life and City Living scenarios also incorporate schedule 3 of the Flood and Water Management Act. The purpose of schedule 3 is to make the incorporation of SuDS for new developments mandatory for each of the London Boroughs. To account for the SUDS implementation that will occur in the Upper Lea catchment in these scenarios, which will impact the Lower Lea, a percentage of the area has been assigned for conversion.

Table E.24: SuDS conversion for modelling within each Borough

	In Scenarios		In Options
	City Living	**Country Life**	**SuDS**
Enfield	Schedule 3 applies for new developments.	Schedule 3 applies for new developments.	700ha of retrofit SuDS across borough (8220 ha) 8% of total borough area • 4% total borough area is infiltration from green spaces (e.g. swales, detention basins etc.) • 4% total borough area is disconnection of impermeable area (e.g.

	In Scenarios		In Options
			permeable paving, green roofs etc.)
Newham	Schedule 3 applies for new developments, where model extents overlap boroughs.	Schedule 3 applies for new developments, where model extents overlap boroughs.	40ha of retrofit SuDS across modelled area of borough (320 ha) Adoption of disconnection SuDS is likely to have greatest benefit in flood risk reduction due to nature of drainage network • 5% total borough area is infiltration from green spaces (e.g. swales, detention basins etc.) • 5% total borough area is disconnection of impermeable area (e.g. permeable paving, green roofs etc.)
Waltham Forest	Schedule 3 applies for new developments.	Schedule 3 applies for new developments.	400ha of retrofit SuDS across borough (3880 ha) 10% of total borough area • 5% total borough area is infiltration from green spaces (e.g. swales,

	In Scenarios		In Options
			detention basins etc.) • 5% total borough area is disconnection of impermeable area (e.g. permeable paving, green roofs etc.)
Hackney	Schedule 3 applies for new developments.	Schedule 3 applies for new developments.	100ha of retrofit SuDS across borough (1900ha) 7% of total borough area • 3% total borough area is infiltration from green spaces (e.g. swales, detention basins etc.) • 4% total borough area is disconnection of impermeable area (e.g. permeable paving, green roofs etc.)
Haringey	Schedule 3 applies for new developments.	Schedule 3 applies for new developments.	260ha of retrofit SuDS across borough (2960 ha) 9% of total borough area

	In Scenarios		In Options
			• 4% total borough area is infiltration from green spaces (e.g. swales, detention basins etc.) • 5% total borough area is disconnection of impermeable area (e.g. permeable paving, green roofs etc.)
City of London	Outside of model boundary	Outside of model boundary	0ha of retrofit SuDS across borough (315 ha) Adoption of disconnection SuDS is likely to have greatest benefit in flood risk reduction due to nature of drainage network, as demonstrated in DWMP
Tower Hamlets	Schedule 3 applies for new developments, where model extents overlap boroughs.	Schedule 3 applies for new developments, where model extents overlap boroughs.	0ha of retrofit SuDS across borough (2160 ha) Adoption of disconnection SuDS is likely to have greatest benefit in flood risk reduction due to nature of drainage network, as demonstrated in DWMP

	In Scenarios		In Options
Upstream of Enfield/WF	1% retrofit Low growth but increase in impermeable area due to new properties in greenfield spaces	20% of impermeable area converted to greenfield runoff rates	n/a

E.1.5 What impact does this have in the sub-catchment?

Modelling results show that SuDS reduce flood risk in the Baseline, City Living and Country Life scenarios under climate change in this sub-catchment. This is caused by a combination of factors relating to climate change and abstraction license changes (as well as urban creep in City Living). River health is also improved in this sub-catchment through SuDS: as ammonia levels drop by approximately 10%. Improving river health can have second-order benefits such as reduced treatment at water abstraction sites, such as Coppermills WTW. It can then also reduce carbon impacts of the treatment process. There is also potential to enhance blue-green corridors through the implementation of SuDS and they have proven improvements on health, wellbeing and social inclusion.

E.1.6 How could these be implemented?

Modelling SuDS at scale has demonstrated water quality and quantity benefits across the subregion. For example, our modelling shows that in areas where SuDS are not implemented, they can still observe a reduction in flood risk and improvements to river health due to SuDS implemented elsewhere. These second order benefits can only be realised with the integrated modelling that we have done at the subregional scale. This demonstrates that further funding mechanisms may be unlocked to enable implementation of SuDS at scale to foster collaboration across partnerships.

Previous barriers to SuDS implementation have been around ownership and demonstration of tangible benefits. The SIWMS steering group provides an opportunity for collaboration and learning from others to support best practice sharing across the boroughs. The Environment Agency and Thames Water can also support the construction of SuDS. The river health and flood risk improvements demonstrated in this case study showcase the opportunities available through collaborative partnership to achieve the collective ambition of sustainability across the subregion.

F. Model Boundaries

Project:	Sub-regional Integrated Water Management Strategy – East London		
Our reference:	100108845│0.2│A	**Your reference:**	GLA 82062
Prepared by:	LB	**Date:**	29 July 2022
Approved by:	BB	**Checked by:**	RLS
Subject:	Model Boundaries		

F.1 Introduction

This technical note sets out the review of the various system boundaries that will contribute to the Sub-Regional Integrated Water Management Strategy (SIWMS) covering several Boroughs in East London.

There is an opportunity, at this stage of the project, to review the boundaries which were set in the Invitation to Tender (ITT). The various boundaries refer to:

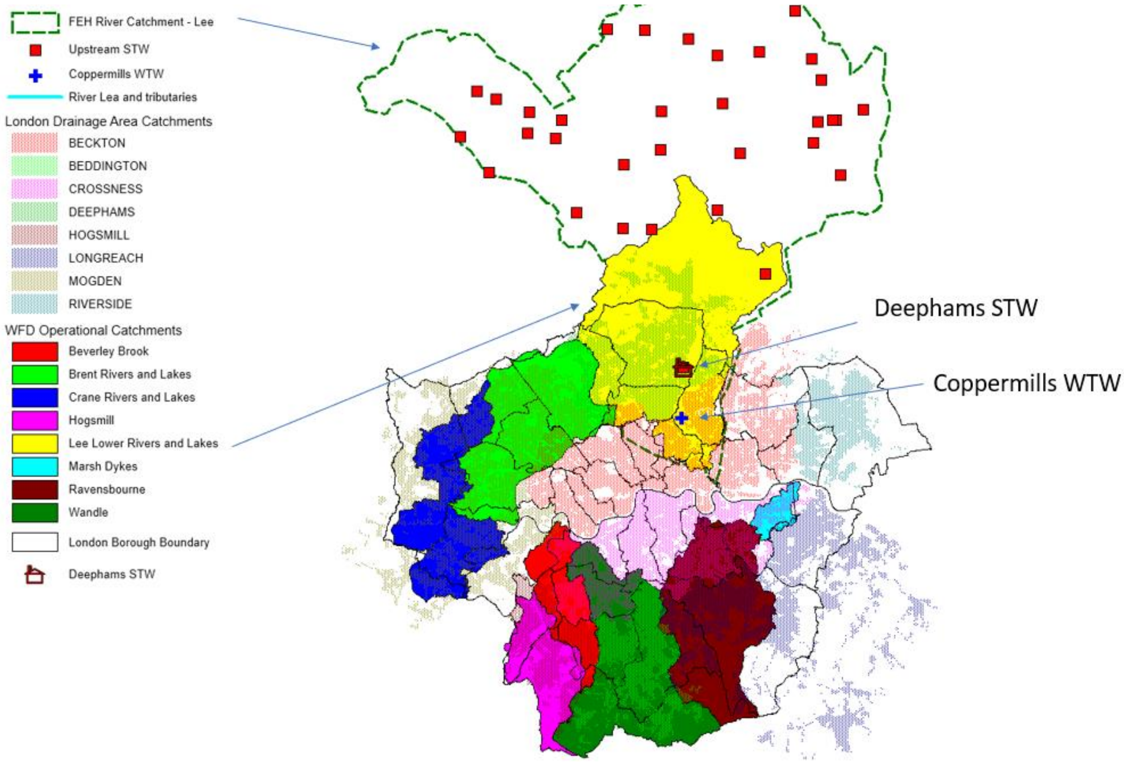
5. London Borough (LB) boundaries including:
   a. LB Enfield
   b. LB Waltham Forest
   c. LB Hackney
   d. LB Haringey
   e. LB Tower Hamlets
   f. LB Newham
   g. City of London
6. Drainage (wastewater) catchment boundaries
7. River basin boundaries

These will be used in developing the model to assess the baseline performance of the system, potential options and cost-benefit of the portfolio of options.

F.2 Challenges of system

There are a number of challenges with the intersection of the various systems. The river catchments and sewer networks do not align, nor do they align with the Borough boundaries, which is demonstrated in Figure F.41.

Figure F.41: System boundaries

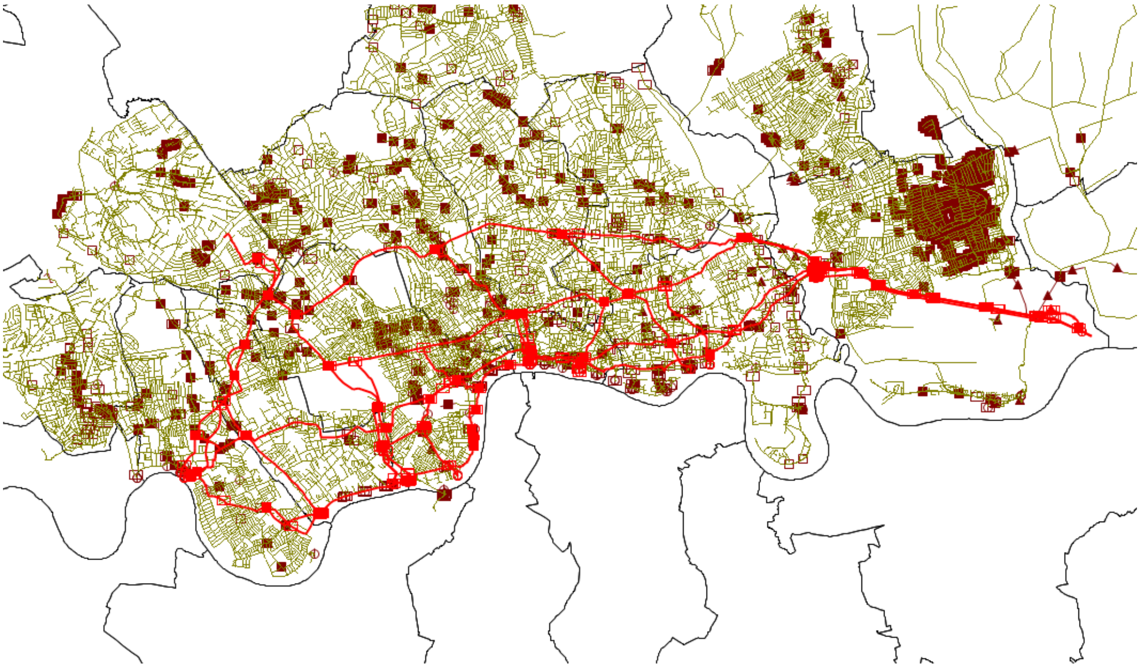


Source: MML

In order to consider the best range of options, we need to determine the best intersect of the various boundaries which achieves the objectives of the initial pilot project, without adding too much complexity to the model extents.

The drainage pathways of Beckton and Crossness will always pose a difficult question for the scope of the project: their key drainage pathways are from west to east, but they intersect lost rivers which flow from north to south in Beckton, and from south to north in Crossness. The Crossness and Beckton catchments, also intersect across administrative boundaries. Furthermore, as the lost rivers are now mixed with sewerage system, there is some question of their water quality and the impact on the receiving River Thames.

Figure F.42: Example of interconnectivity of Beckton drainage catchment



Source: InfoWorks ICM model (Thames Water)

The River Lea, and other catchments which drain to the Thames have hydrological catchments which extend beyond the London Borough boundaries, and therefore the extents of the Greater London Authority (GLA) boundaries. Considering the wider catchment may identify other sewage treatment works or water treatment works which may affect the water quality of the waterbody.

Key drivers and influencers may include Deephams Sewage Treatment Works (STW) and Coppermills Water Treatment Works (WTW) which are within the scope of the current phase of the project.

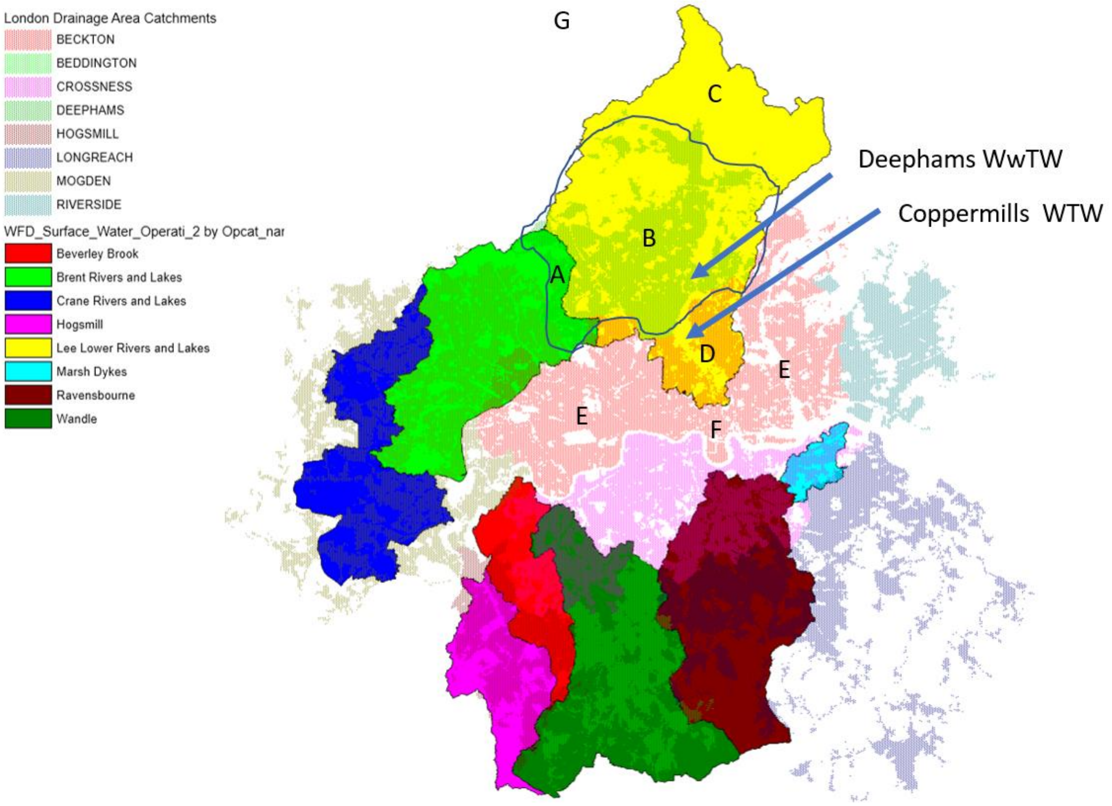
F.3 Detailed Review of System Boundaries

We overlayed the river basin boundaries and wastewater network boundaries to determine areas of potential overlap. These are shown in Figure F.43 and are described based on their boundaries below:

- A: Area of Deephams where surface water catchment drains to River Brent
- B: Area of Deephams where surface water catchment drains to River Lea
- C: Surface water catchment only drains to River Lea
- D: Area of Beckton where surface water catchment drains to River Lea
- E: Area of Beckton where surface water catchment drains to lost rivers/River Thames

- F: Area of Beckton where downstream benefits of River Lea may be tangible

Figure F.43: Combined System Boundary Map



Source: Thames Water, WFD River Basin Maps

There are various combinations which could be explored within the scope of the current project. It will be best to define the areas of potential benefit for assessment and inclusion within the modelling scope.

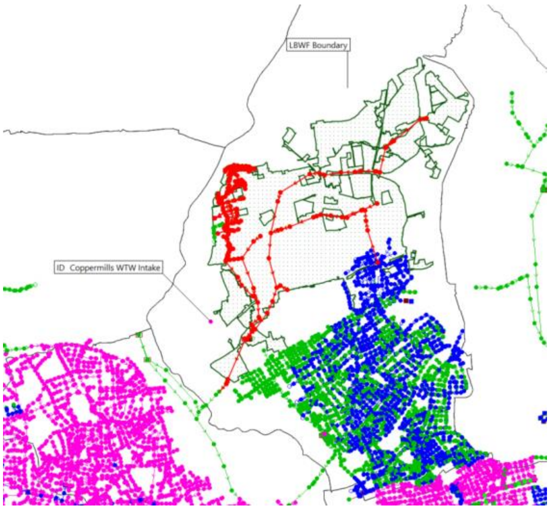
Table F.25: Boundary Options

Option ref	Components	Description	Benefits	Limitations
1	ABC	Deephams catchment (A and B) and Lower Lea Valley	Single wastewater catchment	Does not address upstream pollutant sources (G) Does not consider downstream benefits (F)
2	ABCG	Deephams catchment (A and B) with upstream	Includes upstream catchment pollutant sources	Does not consider Coppermills WTW (D)

Option ref	Components	Description	Benefits	Limitations
		River Lea (C and G)		Does not consider downstream benefits (F)
3	ABCDG	Deephams catchment (A and B), partial modelling of Beckton catchment (D) and full extents of WFD extents of River Lea (C and G)	Models the full Lea catchment and considers Coppermills WTW. Also includes Abbey Mills Pumping Station which has an overflow to River Lea.	Does not consider downstream benefits (F)
4	ABCDEFG	Complete modelling of Beckton (D, E and F), Deephams (A and B), and River Lea (C and G)	Full understanding of wider benefits on catchment, and sewer connectivity across Beckton.	Requires calibration between WSIMOD and InfoWorks ICM catchment model. May not fully represent ancillaries.

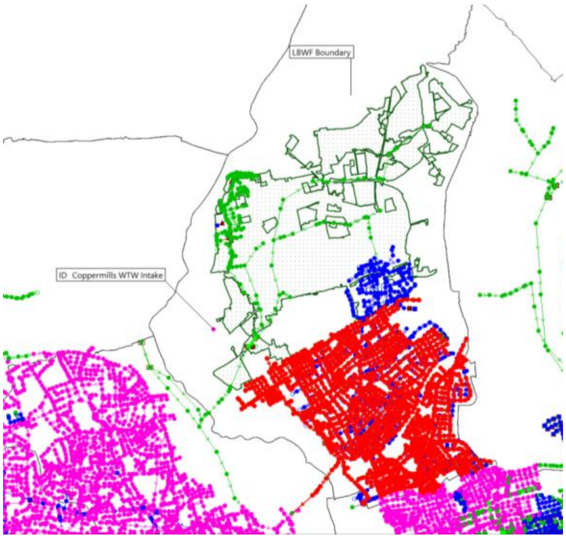
The boundaries selected sit outside of the boroughs. The London Borough of Enfield and London Borough of Haringey fall completely within the Option 3 boundary. The London Borough of Waltham Forest is partly covered by the boundary. Alternatively, we could extend the definition of the sewer catchment boundary to include the Waltham Forest Borough boundary, incorporating the additional foul network shown in red in Figure F.45.

Figure F.44: Sewer Network to Coppermills WTW



Source: Beckton ICM model (sewer network)

Figure F.45: Sewer Network covering LBWF



Source: Beckton ICM model (sewer network)

Lost rivers will be a recurring problem: whilst historical river boundaries, they now receive overflows from the combined system and therefore have a pollution impact on receiving watercourses. Over time, the river route and hydrological boundary has been somewhat warped by the urban growth of Greater London. Their impact on the receiving Thames, and potential improvements, are likely to form a significant part of the strategy and it will therefore be important to incorporate these into the baseline modelling and any future options.

F.4 Recommended Option

Our preferred option for this phase of work is to build the geographical model extents based on Option 3. The extents have been modified to include Coppermills WTW, and to include the wastewater drainage catchments which fall within the Waltham Forest administrative boundary (Figure F.44 and Figure F.45). The upstream contributors to the River Lea will also be modelled.

The advantage of modelling Area G will provide a sensitivity analysis to understand how far upstream catchments need to be modelled - which will inform future phases of the project.

F.5 Future Phases of Work

This pilot phase will inform the design of future work. Due to the sewer networks adjacent to the Thames cutting across the river boundaries there will be interface problems in all cases where an attempt is made to model a single river catchment or sewer network. We propose that this is resolved by modelling larger areas such as all of the area to the North or the South of the Thames in one phase of work. Ultimately there will be a need to combine these models in order to get a comprehensive understanding of how to address flooding and water quality modelling of the Thames main river.

G. Data Viewing Platform

Project:	East London Subregional Integrated Water Management Strategy		
Our reference:	100108845│7.1│C	**Date:**	14/05/2023
Prepared by:	KM	**Checked by:**	LB
Approved by:	RLS		

G.1 Introduction

This technical note sets out the potential requirements for the data viewing platform, which was undertaken in Task 7 of the Subregional Integrated Water Management Strategy (SIWMS). The purpose of the platform is to aid interpretation and enable implementation of the SIWMS.

G.1.1 Purpose

This annex summarises a review of the requirements and the availability of data and documents for the SIWMS data viewing platform. It does not involve platform development. This review will inform future development of the data viewing platform as a separate project.

The aim is for this platform to eventually support the steering group with the ongoing delivery of the SIWMS. It will be essential in prolonging the lifetime of SIWMS beyond the scope of the current project and providing steering group members with a sense of ownership of the current strategy and options.

The purpose of this technical note is to:

- Clarify ambition of SIWMS and the data viewing platform (Section G.1.2)
- Identify the users and user benefits of the data viewing platform (Section G.2)
- Recommend key functions for the data viewing platform (Section G.3)
- Present key data sources of the data viewing platform (Section G.4.1)
- Discuss platform and data maintenance and update requirements (Section G.4.1.5)
- Confirm how data might be shared across the various parties/steering group members (Section G.5)

- Suggest alignment and integration with other digital tools (Section G.6)
- Suggest future ambition for the digital viewer platform (Section G.7)

G.1.2 Ambition setting for SIWMS

A shared ambition for the SIWMS was agreed amongst the steering group following feedback from the workshop held on 07 October 2022 during the pilot project. The outcome of this feedback is summarised in Table G.26.

Table G.26: Summary of ambition setting for SIWMS and data viewing platform

Resume of ambition	Justification
Alignment	Ensures consistency in datasets and assumptions across different plans
	Aids alignment of planning frameworks and delivery strategy
Clarity	Single source for stakeholders to view and share data to aid investment decisions
Collaboration	Identify common risk hotspots from baseline analysis
	Identify common risks from scenario analysis
Implementation	Identify impacts from option analysis on different scenarios
	Identify areas where largest benefits can be achieved through implementation

During the workshop held on 27 February 2023, the steering group agreed that the data viewer could help achieve the ambition of the SIWMS by:

- Providing a "single source of truth" which shows all options under consideration by different organisations in an area where all interested parties can view the outcome of an intervention or decision
- Showing the benefits of different options for consideration by the project sponsor
- Providing common data assumptions, modelling results and sources in one place
- Identifying opportunities for collaborative action

Therefore, the data viewing platform should enable the SIWMS to be implemented and shared across steering group members.

G.2 Users of the data viewer

G.2.1 Platform users

For the data viewing platform to foster collaboration, it should provide access across all steering group members. There may be different levels of access for different users or groups of users. These users will include:

- Local authorities: Newham, Enfield, Haringey, Hackney, Tower Hamlets, Waltham Forest, City of London
- Greater London Authority
- Environment Agency
- Thames Water
- Ofwat
- Natural England

All users will need to be able to view and interpret the results of the SIWMS through the data viewing platform. However, each user will have different capabilities and requirements from the platform to fulfil their current roles and responsibilities. The development of the data viewer platform should consider current roles but include sufficient flexibility so that future roles and responsibilities for the users may be incorporated at a later date. The current roles are discussed in Section G.2.2.

G.2.2 User benefits

Types of users which will require access to the platform are listed in Table G.27. The table also lists the benefits the user types will gain from the data viewer. Potential examples are given for how users might use the information provided by the data viewer. The frequency of access suggests the timescales at which major updates will need to occur, or ad hoc reviews of the risks identified as part of the SIWMS and the impact of interventions considered.

Table G.27: User Types and Benefits

User Type	Key benefits from data viewer	Potential examples	Frequency of access
Environment/flood risk officer	• Support climate mitigation measures • Help prioritise and secure funding for flood risk projects	• Look at risk areas in my borough • Identify potential for co-funding interventions upstream of my risk area	Planning applications to review current and future risk (ad hoc)

User Type	Key benefits from data viewer	Potential examples	Frequency of access
	• Communicate multi-benefits of flood mitigation schemes • Input and update Strategic Flood Risk Assessments (SFRAs) and Local Flood Risk Management Strategies (LFRMS) • Demonstrate confidence and effectiveness of Nature-based Solutions (NbS)/Sustainable drainage systems (SuDS) features	• Co-ordinate and extend activities in my borough by looking for downstream beneficiaries. Identify potential co-founders for work in my borough, such as downstream boroughs who co-benefit from my intervention.	Strategy updates (5-yearly) Strategy reporting requirements (1-yearly)
Highways/Infrastructure officer	• Prioritise projects • Increase delivery of integrated projects with multiple benefits • Seek opportunities for collaboration • Maintain and improve existing assets	• Look at works proposed in my area • Identify potential for SuDS and collaborative street works who may co-fund my planned streetworks	When alerts are received (ad hoc) When new streetworks or infrastructure projects are planned (ad hoc)
Regulator/NGO	• Identify opportunities to consolidate options • Technical evidence to support responses to water company plans • NGOs can review data and potential options to promote aligned activities	• See how approved and potential plans are progressing • See how risk might change in future and highlight opportunities for partnership working • Catchment partnerships can see what is planned in their area to see if	Review of business case (5-yearly) Review of funding applications (ad hoc)

User Type	Key benefits from data viewer	Potential examples	Frequency of access
		they can contribute volunteers to expediate project	
Planning officer	• Technical evidence for local plan/policy guidance • Technical support for planning decisions • Implementation of greening new developments • Improvements to delivering water efficiency targets	• Compare location of new planning applications with opportunities for other water systems upgrades • Evidence base for planning activities (e.g. PCC reductions or SuDs).	Review of planning applications (ad hoc) Review and update of local plans Updates to strategic planning policy
Water Company	• Evidence base to support accelerated delivery on the ground • Support and input to business planning • Centralise data and build support for projects • Help work out how to deliver major ambition/targets through collaboration • Identify collaborative funding streams and opportunities	• Keep others up to date of proposals for new streetworks • See streetworks proposed by others • Identify where co-funding opportunities are • Highlight opportunity areas for other roles • Monitor performance of assets and their impact on wider water system	Business plan submission (5-yearly) Additional funding releases (ad hoc)

Users of the platform may wish to extract reports and information to feed into other deliverables. This could be considered as part of the specification requirements for the data viewer. However, we recognise that different users will have different requirements for their own statutory reporting.

G.3 Data viewer requirements

This section outlines the minimum viable product (MVP) for the data viewing platform as well as the requirements of the tool discussed with the steering group. This includes the key functions and the platform architecture outlined below. The underlying data to support these requirements are discussed in Section G.4. Any additional feedback or outcome as a result of the 90-day action recommendations from the SIWMS should be considered when developing the data viewing platform.

G.3.1 Minimum Viable Product (MVP) needed to display modelling outputs

The minimum viable product (MVP) is the ability for the tool to display the outputs of the modelling and the results of the study in a way that is understandable. This requires some very basic functionality for the user to locate themselves spatially by switching on boroughs and boundaries and toggle between scenarios and options.

This section outlines the MVP needed to display the findings of the Study:

- Display of the ‘postage stamp’ modelling outputs for a scenario
- Ability to toggle between scenarios
- Ability to toggle between options
- Ability to switch on GIS layers (Borough Boundaries, GLA boundary, systems boundary)
- The data required for this will be the GIS layers and the raw results of the modelling outputs. This will require some post-processing to ensure the format is compatible with the data viewing platform. Appendix I provides a data collection register of data inputs and data outputs, along with data format, used in the pilot project.

G.3.2 Key functions of the data viewing platform discussed with steering group

This section outlines the functions we recommend the data viewer platform should perform (in addition to those outlined in the MVP) to ensure the platform helps realise the ambition of the SIWMS and improve the longevity of the strategy. Recommended functions are discussed in the context of the four themes of the project’s aspiration: alignment, clarity, collaboration and implementation. These functions have been discussed and agreed with the project steering group.

G.3.2.1 Alignment

The data viewer should include functions which aid alignment and consistency across different plans. It should facilitate communication of the strategy amongst different levels of management across the steering group. For this, we propose the following functions:

- Identify the drivers of change which the strategy, or elements of the strategy, responds to and the corresponding plans which control these factors
- Showcase portfolio of proposed options as covered in the MVP (least regrets, principal options, and other options) and their timings for implementation (additional functionality from MVP)
- Identify other plans which the strategy supports or enhances
- An analytical function where users can see the timestamp for planning cycles. This would be an interactive version of Figure 6.1. Users could click on a planning document node and see which plans it feeds into. Users could also receive a notification when a key discussion point is approaching (as outlined in Section 5.6) to facilitate integrated adaptive planning.

G.3.2.2 Clarity

The data viewer platform should support clear and concise ways of communicating the SIWMS. Information should be shared with the platform users in a way that is easy to access and interpret. As a single source of truth, it will support the business case for investment and implementation. For this, we propose the following functions:

- Clarity around the assumptions made and where these have come from to improve consistency across strategies for scenario planning. This can be done via a side bar or pop-up information box discussed in Section G.4.1.2.
- Provide readily available data to monitor the progress of the strategy and alignment of pathways
- Identify trigger points and deviation points aligned to adaptive planning pathways
- An analytical tool which converts API datasets into trigger point thresholds to inform future modelling options of adaptive planning decisions.

G.3.2.3 Collaboration

To facilitate collaboration, the data viewer should identify current and future spatial risk hotspots from the scenario analysis. It should highlight roles and responsibilities of different data creators and data users. We therefore propose the following functions:

- Present results from baseline and future scenario analysis (as covered in the MVP)
- Highlight who has committed to doing what and where

- Inform whether these findings can be linked with other work (e.g. streetworks-style improvements)
- An analytical function where users can set criteria to identify who else works in these areas. This can be done via filtering for different views (such as water quality). The steering group have identified that it would be useful for the data viewing platform to have saved viewed for different roles to focus on what they need to know.

G.3.2.4 Implementation

To facilitate implementation of the SIWMS, we propose the following functions:

- An information feature on options (e.g. the timing of options, where they are being implemented, who is responsible for delivering them)
- Results to showcase linked benefits across borough boundaries (as covered in the MVP)
- Coordination of catchment-wide planning
- An information feature where users can access interpretation guidance around how to interpret the data
- An information feature on modelling assumptions and their implications.

G.3.3 Functions considered and discounted

The following functions were discussed with the steering group and elected not to be required:

- No need for built-in analytical function which runs WSIMOD on the platform to test options and assess impacts
- No need for wider user group sharing if a reporting mechanism can be agreed on
- Whilst these functions are out of scope for the original data viewing platform, they can be revised during future iterations.

G.3.4 Summary of data viewer functions

Table G.28 provides a summary overview of the data viewer requirements for the MVP stage, steering group requires, and future ambition and integration.

Table G.28: Overview of data viewing platform requirements across the different phases of platform development

Data viewer phases	Phase 1: Minimum Viable Product	Phase 2: Steering group requirements	Phase 3: Future aspirations	Phase 4: Future integration
Functionality: Spatial	• Display of the 'postage stamp' modelling outputs for a scenario • Display of the 'postage stamp' modelling outputs for an option • Display all options with ability to toggle between scenarios (switching scenarios on and off) • Display all options with ability to toggle between options (switching options on and off) • Ability to switch on GIS layers (Borough Boundaries, GLA boundary, systems boundary)	• Same as previous phase	• Same as previous phases with refreshed results of scenario and options from future modelling	• Same as previous phase

Data viewer phases	Phase 1: Minimum Viable Product	Phase 2: Steering group requirements	Phase 3: Future aspirations	Phase 4: Future integration
Functionality: Temporal	• None	• Timeline filter which shows the timings of option implementation • Timeline filter which displays relevant planning cycles • An interactive version of the planning timelines diagram	• Adaptive planning options	• Same as previous phase
Functionality: Analytical	• None	• Identify the plans which control the drivers of change for scenarios and options	• Asset intelligence from other sources such as Environment Agency's API datasets, Thames Water Event Duration Monitoring mapping tool. • Email notification of new discussion point based on planning cycles	• Build on asset intelligence from other sources to build-in trigger point notifications to inform adaptive planning. • Email notification of new discussion point based on trigger point analysis (water metric data) as well as planning cycles (growth/option development data).

Data viewer phases	Phase 1: Minimum Viable Product	Phase 2: Steering group requirements	Phase 3: Future aspirations	Phase 4: Future integration
Other Features	• An information feature for interpretation guidance and modelling assumptions and implications •	• An information feature to identify who works in what areas • Bookmark feature to set the view on criteria relevant to the role of the user (e.g. water quantity viewer option for flood risk user)	• Same as previous phase	• An information feature which identifies other plans across other sectors (e.g. energy, transport) which the strategy supports or benefits.
Data sets needed (and format)	• GIS layers to map various authority boundaries, catchment areas and water company operating areas together. • Raw results from SIWMS pilot are in csv format and will require post-processing for data platform purposes.	• An interactive version of planning timelines diagram (Figure 6.1 from main report)	• API datasets, an interactive version of adaptive planning outline (Figure 5.1 from main report).	• Digital Twin integration.
Arrangement with consultants at end of project	• Provide raw modelling results for post-processing and GIS	N. A.	N.A.	N. A

Data viewer phases	Phase 1: Minimum Viable Product	Phase 2: Steering group requirements	Phase 3: Future aspirations	Phase 4: Future integration
	boundary layers used in pilot project.			

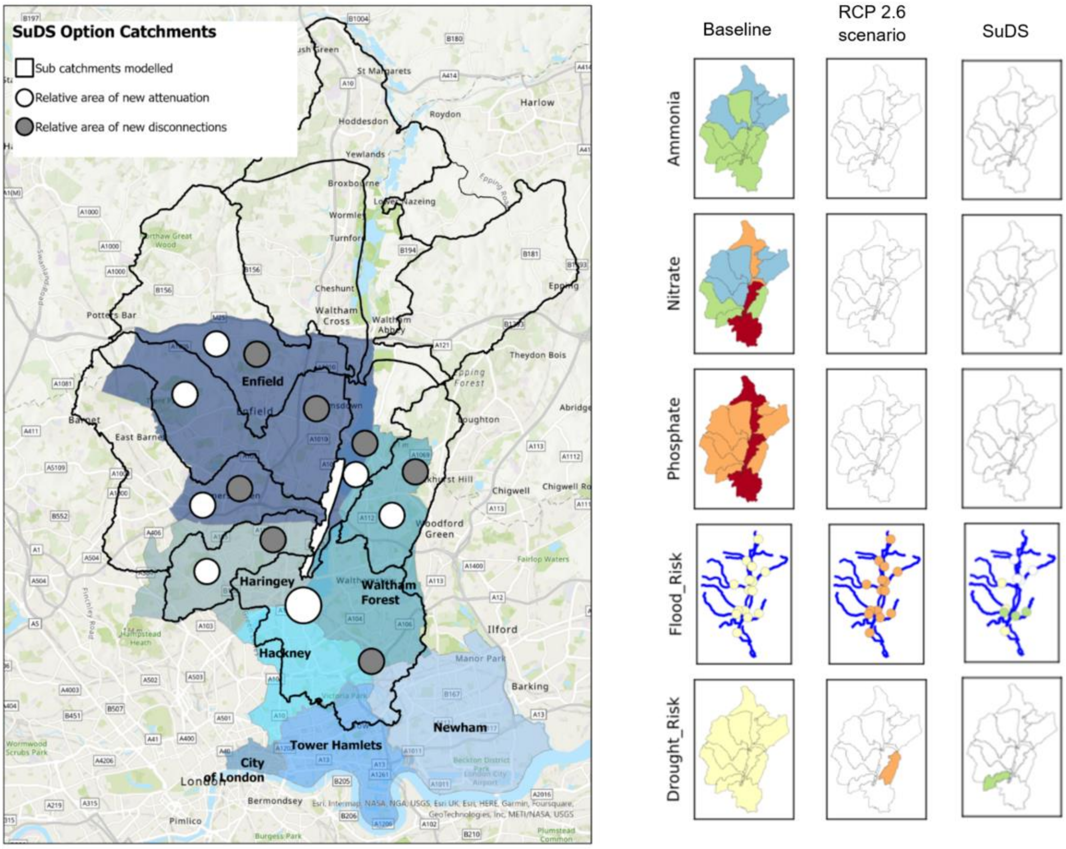
G.3.5 Platform architecture

To support this ambition, we strongly recommend that the data viewing platform includes spatial (GIS) and temporal data with set views and reporting features. It would also be useful for the steering group to demonstrate how metrics change under certain conditions or parameters. For example, the change in water metric values impacts for the different climate change projections.

Examples of platform architecture for consideration include:

- ArcGIS Online and Story Map features (see Figure G.46)
- Moata Smart Water/Geospatial (see Figure G.47 and Figure G.48)
- PowerBI (see Figure G.49)
- Esri StoryMaps – Experience Builder (see Figure G.50)

Figure G.46: Example of GIS function to show where options have been implemented and where the benefits are

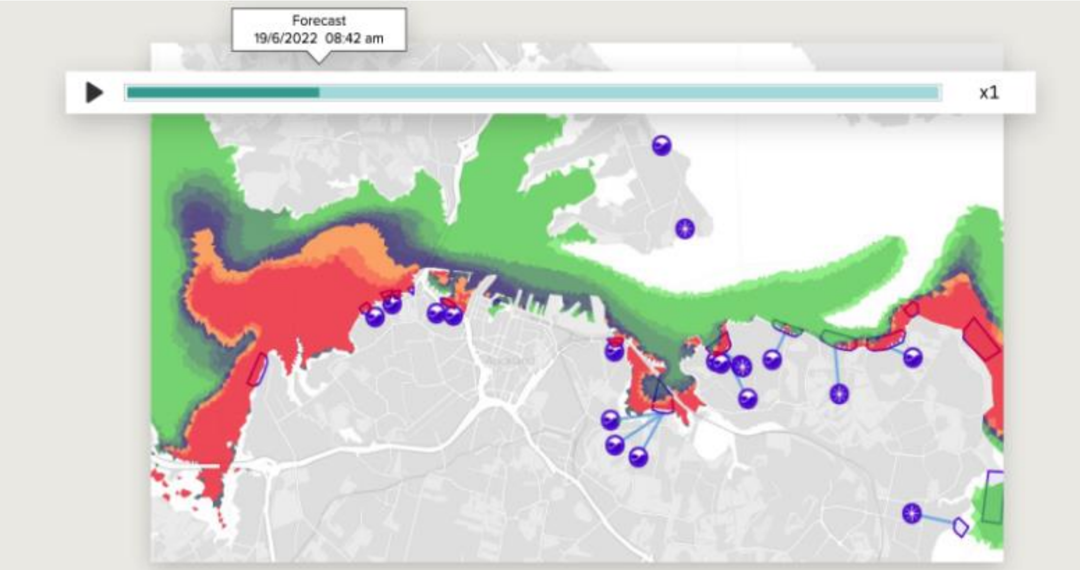


Source: Environment Agency[49], Greater London Authority[50]. Based on the Ordinance Survey Map with the Sanction of the Controller of H.M Stationery Office License Number:- 100019345. Scenario results are outputs from the SIWMS main report.

[49] Lee Lower Rivers and Lakes Operational Catchment | Catchment Data Explorer

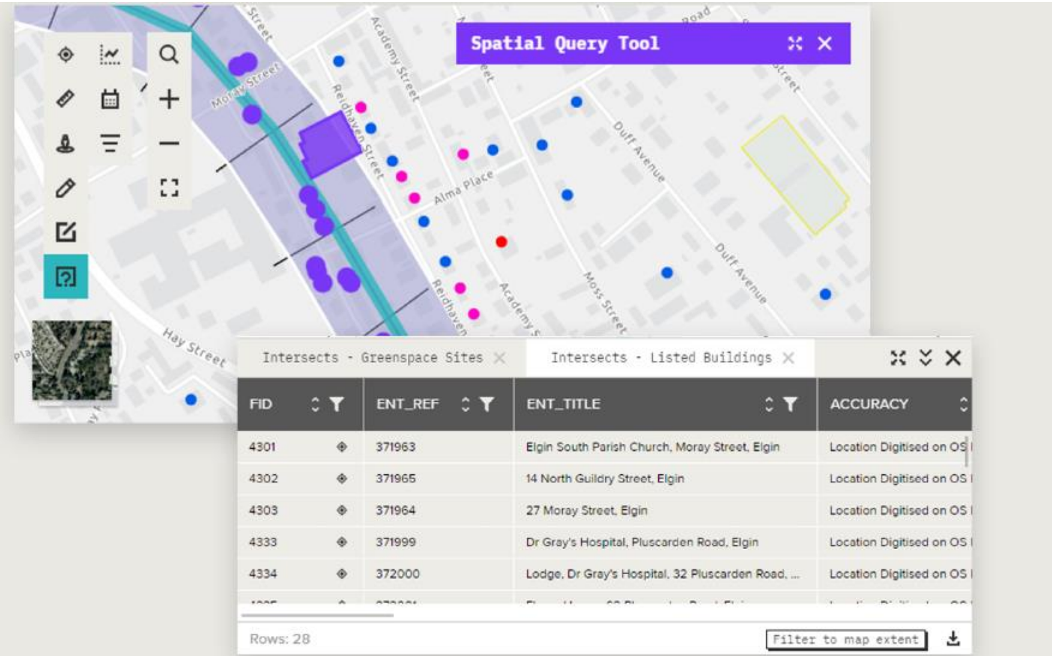
[50] Statistical GIS Boundary Files for London - London Datastore

Figure G.47: Example of predictive water quality from Moata Smart Water tool



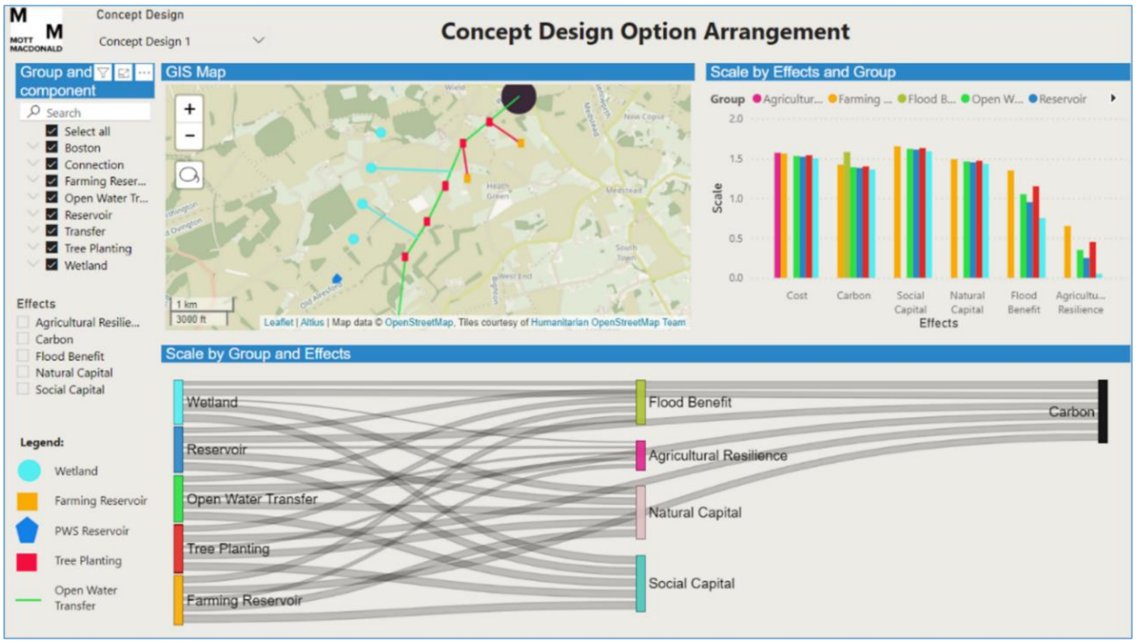
Source: Moata Smart Water learn more - Mott MacDonald

Figure G.48: Example of a spatial query feature using Moata Geospatial



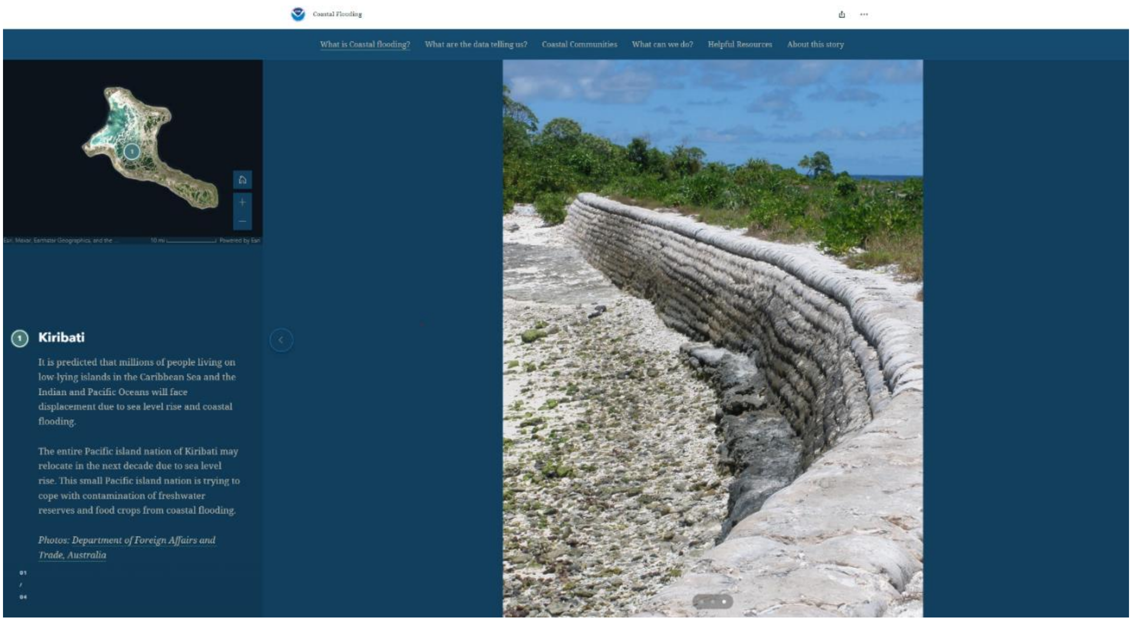
Source: Moata Geospatial learn more - Mott MacDonald

Figure G.49: Example of PowerBI architecture to demonstrate the benefits of different options on different metrics



Source: Mott MacDonald

Figure G.50: Example of ESRI StoryMap Experience builder to demonstrate the interactive features for SIWMS



Source: Coastal Flooding (arcgis.com)

G.4 Data Management

This section outlines the data required to underpin these functions. It provides an overview of the data collated and produced during the pilot SIWMS, and the data required for ongoing maintenance and development of future SIWMS.

G.4.1 Data collated and produced during pilot SIWMS

G.4.1.1 Data collected

Appendix I provides a data collection register which was used to inform the pilot SIWMS. The data collection register outlines where the data was collected from, whether the data is public or secure, the format of the data, and whether the data is used as an input or output of the project. In summary, data collection involved:

- Collection of GIS layers to map various authority boundaries, catchment areas and water company operating areas together
- Collection of planning documents for review of options and scenarios which would influence the water environment of the study area
- Collation of datasets to extract values applicable to the study and modelling, such as population projections, water quality and flow gauge data, etc.

We recommend that the data viewing platform should have all the GIS layers used in the baseline study, including the study area boundaries and administrative boundaries as standard.

G.4.1.2 Data used to determine scenarios

Appendix A details the data used to create the scenarios used in the pilot SIWMS. In summary, this included:

- Growth projections
- Climate change projections
- WINEP programme
- Creep (i.e. increase to impermeable areas as a result of minor renovations/developments)
- Modelling parameters and assumptions

The input data for the scenario development is not required in the data viewing platform. However, we recommend the platform has a side bar that is visible to users when displaying scenario results that summarises the assumptions used in each scenario. This will be informed by the input data listed in the Appendix I and the scenario approach detailed in Appendix A. Links can be provided to source websites for further information.

To display the ‘postage stamps’ used to communicate the impact of scenarios on the water metrics measured, the following data is required:

- GIS shapefiles of the sub-catchments
- Water quality and water quantity threshold classifications
- Modelled results

This will require some post-processing of the raw modelled data which is currently in csv format for all scenarios. Selected scenario results are currently available as ‘postage stamp’ svg images. Appendix I provides more information on data outputs.

G.4.1.3 Data used to determine options

Appendix B details the data used to screen options and how options were modelled for the SIWMS. In summary, this included:

- Identification of options from water and planning frameworks
- Location and scalability of options
- Identification of second-order benefits (not captured through modelling)
- Modelling parameters and assumptions

The input data for the option development is not required in the data viewing platform. However, we recommend that the data viewing platform should have a side bar that is visible to users which describes the main assumptions used to model each option. This will be informed by the input data listed in the Appendix I and the option identification and analysis outlined in Appendix B. The option information feature outlined in Section G.3.2.4 would also support the business case for option implementation. Links can be provided to source websites for further information.

To display the ‘postage stamps’ used to communicate the impact of options on the water metrics measured, the following data is required:

- GIS shapefiles of the sub-catchments
- Water quality and water quantity threshold classifications
- Modelled results

This will require some post-processing of the raw modelled data which is currently in csv format for all scenarios. Selected scenario results are currently available as ‘postage stamp’ svg images. Appendix I provides more information on data outputs.

G.4.1.4 Summary of base data results

The steering group have identified that having the following data would be useful to include in the data viewing platform:

- The baseline risk map based on waterbody outputs from WSIMOD
- Catchment performance under difference scenarios to identify risk hotspots
- Catchment performance under difference scenarios with options to demonstrate benefits
- Data and platform maintenance
- The format of this data is outlined in Appendix I.

G.4.1.5 Updates to base data

To meet the data viewing platform's aim of ensuring the longevity of the SIWMS, updates to the base data will be required. Data will be available through updates to the different strategies published across water management. This should be reflected in the data viewing platform. Table G.29 outlines the source and owner of data which will require updates. This process will be manual, but the future ambition should be as automated as possible to reduce the impact on resourcing and/or site hosts.

This information will inform future modelling and adaptive pathways. The plans which informed the data input for the SIWMS should be reviewed every 5-7 years which aligns with statutory planning. Figure G.51 in the main report highlights the different planning timelines and the interactions between them. Whilst the discussion points for future adaptive pathways are based on planning timelines, this does not mean there should be a delay until plans are published as this would risk missing another five year planning cycle before an option can be implemented.

Table G.29: Source data required to be updated in the data viewing platform to support the longevity of SIWMS

Owner	Plan	Data area
Thames Water	DWMP	Water quality, water quantity data, water quantity options and inform adaptive planning review
Thames Water	WRMP	Water resources data, water resource options
WRSE	WRSE: Best Value Planning	Inform adaptive planning review and water resource options
Environment Agency	RBMP	Water quantity and water quality data
Environment Agency	FRMP	Water quantity data

Owner	Plan	Data area
Local Authorities	Local Plans	Growth projections and opportunity areas, policy
Local Authorities	LFRMS	Water quantity data and options

G.4.1.6 Updates to base modelling

Modelling should be repeated in alignment with substantial changes to strategies aligned with adaptive planning. With the steering group, it was agreed this should take place every 5-7 years to align with statutory planning publications.

The purpose of continued modelling is to see what has changed since last time. This includes both scenario trajectory as well as option development. Users will want to see from the data viewing platform what has changed since the previous analysis. For example, what new risks are emerging? What risks no longer require mitigation? To support this, users will want to review the following for future scenarios:

- If assumptions in scenarios are still relevant
- If growth projections are similar or align with previous growth projections
- New emerging opportunity areas
- New technology to improve water use and/or water treatment
- New environmental or flood risk legislation which may change level of acceptable risk or drive future investment
- If monitoring indicates that we are on a different pathway for our adaptive plan
- If any of the options have been implemented

This can then inform changes to scenario modelling.

Users will also want to review the following for future options:

- If new options have emerged from current plans/strategies
- If options have been removed from current plans/strategies
- If further refinements could be made to how options are represented (e.g. natural capital, misconnections) due to increased certainty following investigations or research
- This can then inform changes to option modelling. Options can then be reviewed against existing portfolio of least-regret, principal and other options to see if prioritisation changes.

- This will be quite a significant update so this should be considered in funding of future updates. This will be vital to ensure that data does not become obsolete. This can then feed into next wave of statutory plans and inform evidence base on a rolling basis.

G.5 User access to data and information

Most of data collated for the SIWMS uses existing publicly available data. However, some secure data has been used. Examples of secure data include:

- Thames Water flooding history data
- Thames Water asset data
- Thames Water consent data

As the data viewing platform access will be restricted to members of the steering group, a common data sharing agreement should be sought amongst all parties. Data earmarked as secure (see Appendix I) should be treated as such with appropriate confidentiality and/or non-disclosure agreements to restrict access across multiple users. Standard processes may be developed such that flooding risk data (for example) can be automated and anonymised at a scale appropriate for the subregion. Once the GLA take ownership of the MVP stage of the data viewing platform, current NDA's should be reviewed appropriate to the data type used from the data collection register.

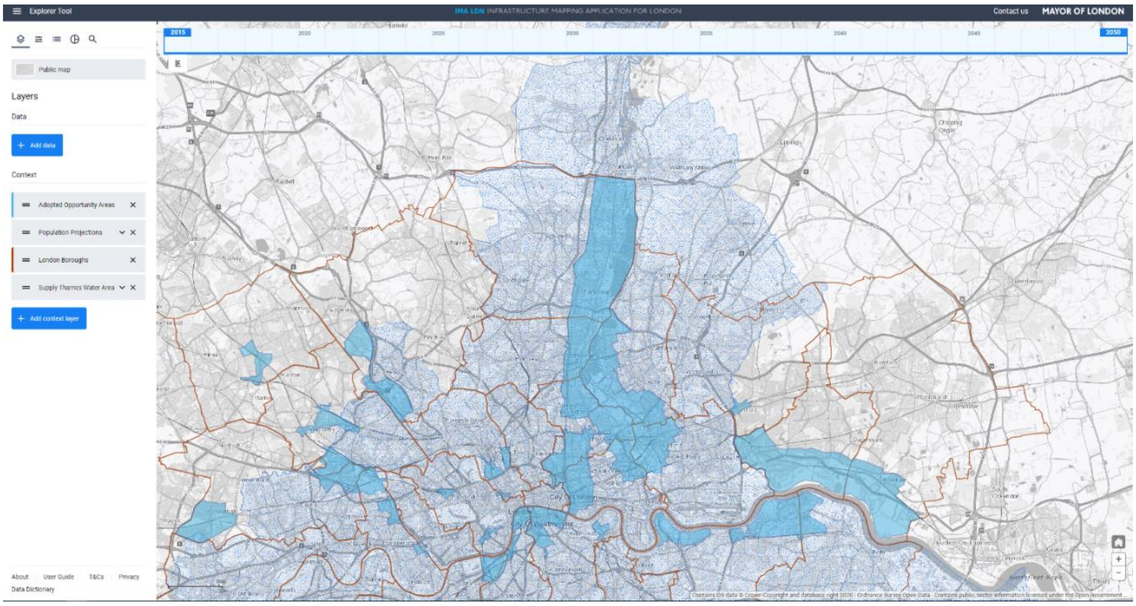
G.6 Alignment and integration with other digital tools

G.6.1 Existing and emerging tools

We see this data viewing platform as a stand-alone platform, as agreed with the steering group. However, we recommend maximising the data which the GLA already owns, or making use of Application Programming Interfaces (APIs) from other datasets where possible. This can help facilitate the adaptive planning. A critical part of adaptive pathway planning is to understand when an alternative pathway is more likely than the core pathway for which the strategy was developed. This could be a benign pathway (where risks are lower than anticipated) or an adverse pathway (where risks are higher and different interventions may be more appropriate). Alignment with other digital tools and datasets can help understand future growth and evolving risk to better inform future pathways.

We recommend linking the data viewing platform with the useful sections of the existing Infrastructure Mapping Application (IMA) (see Figure G.51). For example, a link to the IMA could provide users with improved visibility of London's growth until 2050 which would help inform future scenario development to facilitate the adaptive planning. The environmental data (such as flood zones or supply flow monitoring zones) could help contextualise the water quantity findings of the WSIMOD modelling results.

Figure G.51: Infrastructure Mapping Application (IMA)



Source: https://maps.london.gov.uk/ima/

We recommend integrating the data viewing platform with wider environmental datasets (e.g. Environment Agency's real time Flood Data River Levels) to facilitate understanding of water quality and water quantity risks across the subregion. To understand how this picture of risk is changing, it is important to set monitoring points and trigger levels, above which action may be required and new decision points should be considered. The definition of trigger levels is dependent on the scenarios and defining appropriate time horizons, which was not in the scope of this project. To supplement this understanding, a wide range of data and monitors may be required which will need to be installed across the subregion. Existing API datasets could support this for water quantity related risks. For example, the data viewing platform could connect with the Environment Agency's real time Flood Data River Levels/River Flow API to view the data[51], or Met Office data could be used to identify likely pathways related to climate change based on historical trend information: allowing organisations to decide if further action needs to be taken to meet changing risks. For water quality risks, the data viewer could provide a link to the Environment Agency's Catchment Data Explorer[52] to view water environment information for an area.

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[51] Real-time API reference (data.gov.uk)

[52] Thames River Basin District | Catchment Data Explorer

G.7 Future potential for the data viewing platform

In addition to the core users from the steering group listed in Section G.2.2, which aligns to current user functions, we recognise that this may encourage users to continue to work in their silos. Therefore, a future ambition for the data viewing platform should consider functionality to reinforce collaboration and communication across specific user profiles. We considered realigning roles to water managers (consisting of those users with a statutory duty to manage water or flood risk assets) and water advocates, such as catchment partnership groups, non-governmental organisations (NGOs) and citizen science groups who may assist in gathering information and driving change in the catchment without having a direct responsibility or statutory obligation. This would help a wider user pool to feel more engaged and actively support schemes to drive them forward where it may be of interest to them and ultimately achieve wider benefits

Whilst these user profiles have been considered based on current profiles, it is important to recognise the ambition of the SIWMS to move away from siloed working. The ongoing maintenance of the data viewing platform should be flexible to future ways of working. For example, user profiles could be linked so that when information is updated related to a specific responsibility, an email notification can be shared to organisations working in this sector.

The data viewing platform could also link and support other London-related plans, such as subregional transport, energy or digital strategies which could provide a coordinated infrastructure planning function. This provides an exciting opportunity for the SIWMS to utilise digital tools to support sustainability across the region.

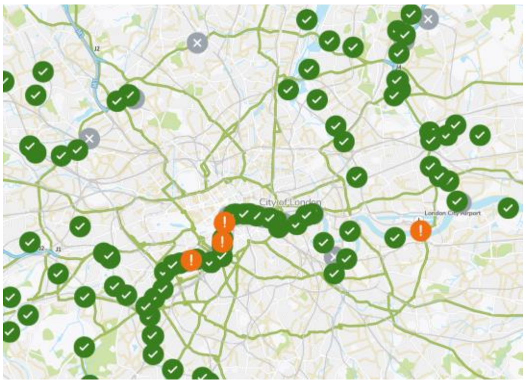
Future potential of tools

Digital tools continue to emerge which may support or contribute to our understanding of water management across London. In future iterations of the data viewer, there could be linkages with existing tools or emerging tools to enhance its functionality. Some potential tools are listed below:

Thames Water's Event Duration Monitoring (EDM) mapping tool

This shows where combined sewer overflows are located across Thames Water's region. It identifies locations where spills to the environment have occurred. This could be linked with in-river water quality sampling data to understand the impacts of CSO spills on water quality, and also to track if measures are having an impact on reducing the frequency of CSO spills. There is more data available within Thames Water which may be shared through restricted access to improve this understanding further.

Figure G.52: TW EDM map

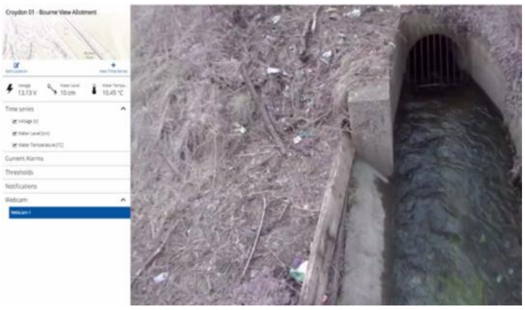


Source: EDM Map | Storm discharge data | River health | Thames Water

Surface water monitoring through Kisters

Link to monitoring and alarm systems for surface water management across a wider geographical region. Improve knowledge of where surface water flood risk is likely to occur, through enhanced flood forecasting, by linking to rainfall and river level data in one place. The system can be used during a flooding event to drive operational responses to reduce the impacts of flooding. It can also be used to monitor the performance of interventions such as SuDS to further develop the case for future investments.

Figure G.53: Example of Kisters dashboard



Source: London smart city sensor network - KISTERS

Future-proofing the data viewer

The data viewer will be designed with current needs in mind, but may wish to draw on a wider data pool in the future. As such, it is recommended that this functionality for future adaptation be included in its core specification.

Digital twins

Digital twins are digital models of physical systems connected via live data streams with potential feedback to the physical system. They indicate how physical systems are operating and could operate under different scenarios. As infrastructure is increasingly understood as a system itself, then the use of digital twins is expected to increase.

As SIWMS is developed with a digital platform then it would be valuable to envisage how the platform could evolve into a digital twin in future. A key concept in the long-term planning of digital platforms is the likely emergence of a range of interconnected digital twins for different systems. Designing for future interconnection and interoperability of digital twins should be borne in mind as the platform is developed. The Gemini principles provide guidance for collaborative development of a more digital, interconnected future of infrastructure systems in Britain.[53]

For the SIWMS, there are two significant potential developments of digital twins for consideration. Firstly, the future development of a set of digital twins for infrastructure in London should be considered. This would enhance planning and operation of infrastructure systems across water, transport, power, health, communications. The CReDo project provided a demonstration of how interconnected digital twins enhance infrastructure resilience in urban contexts.[54] Real time modelling of interconnected scenarios enables more effective responses to critical events. Understanding cascading impacts of critical events across infrastructure systems allows preventative planning and the design of measures to enhance resilience.

Secondly, as this project has shown, there are potential benefits of working in upstream catchments in order to create effective environmental benefits within London. As work is undertaken to enhance capabilities to engage farmers and landowners at scale to produce results across the landscape, then a suitable digital capability will be required. By using geospatial digital twins large scale management of nature-based solutions implemented by thousands of farmers will be achievable. The use of machine learning will enhance our capability to attribute impact to nature-based solutions. These tools are currently under development in the highly innovative context of collaborative land management, green finance and nature-based solutions. The future development of the data viewer for the SIWMS should keep these potential futures in mind as the project is taken further.

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[53] See: https://www.cdbb.cam.ac.uk/system/files/documents/TheGeminiPrinciples.pdf

[54] https://digitaltwinhub.co.uk/credo/

H. No Abstractions

Project:	Subregional Integrated Water Management Strategy – North East London		
Our reference:	100108845 | 4.3 | A		
Prepared by:	LB	**Date:**	14/04/2023
Approved by:	RLS	**Checked by:**	KM
Subject:	Review of the impact of removing future abstraction changes on scenarios and options		

H.1 Introduction

Mott MacDonald (MM) has been commissioned by the Greater London Authority (GLA) to develop a Subregional Integrated Water Management Strategy (SIWMS) as a pilot region in north east London.

The aim of this project is to integrate planning and infrastructure across water resources, wastewater, water quality and flooding to create a Subregional Integrated Water Management Strategy (SIWMS). This is a non-statutory, dynamic, planning level framework which remains responsive to changing conditions, as opposed to the delivery of a static plan. It provides a coordinated strategy to support cross-organisational collaboration to deliver sustainability across the subregion.

The Subregional Integrated Water Management Strategy (SIWMS) identified in Section 3.2.4 that:

"Two variations on proposed abstraction licence changes (moderate reductions in City Living and severe reductions in Country Life) have far-reaching impacts, providing some water quality improvements in the Lower Lea compared to the Baseline. Water resources are a significant risk under both scenarios, but particularly under Country Life. Flood risk is also increased significantly, particularly in the City Living scenario. Phosphate levels remain high in both scenarios."

The impact of the abstractions is so large that we simulated additional scenarios to determine what would be the critical factors and risks should the abstraction reduction regime be postponed beyond the time horizon of 2050.

This technical note summarises the findings of the investigations: both on the impact of scenarios but also the impact on option performance. This technical note is intended as an Appendix to the wider SIWMS, and should be read in conjunction with the main report.

H.2 Impact on scenario results

All five scenarios set out in Section 3 of the report were investigated. Results from the model are analysed based on six metrics: five of which are assessed throughout the model area (drought risk, flood risk, ammonia, nitrate and phosphate) and water stress is measured separately based on availability of water at Coppermills STW. Drought risk and flood risk relate to water quantity metrics (Q5 and Q95 respectively); and ammonia, nitrate and phosphate relate to water quality metrics.

For the purpose of this section, we report on the water quantity and water quality metrics per scenario to highlight key differences found in performance of those scenarios. We measure the percentage difference between the baseline scenario in two cases: the first relates to the scenario inclusive of abstraction reductions; the second is compared against the scenario with abstraction reductions removed.

Unrealised Urbanisation

Unrealised urbanisation is influenced least by the abstraction changes, as these are the same as the baseline, variances are within 1% of the baseline as shown in Figure H.54 and Figure H.55. Therefore there are no significant changes in terms of risk as a result of removing abstractions.

Figure H.54: Unrealised Urbanisation with abstraction reductions

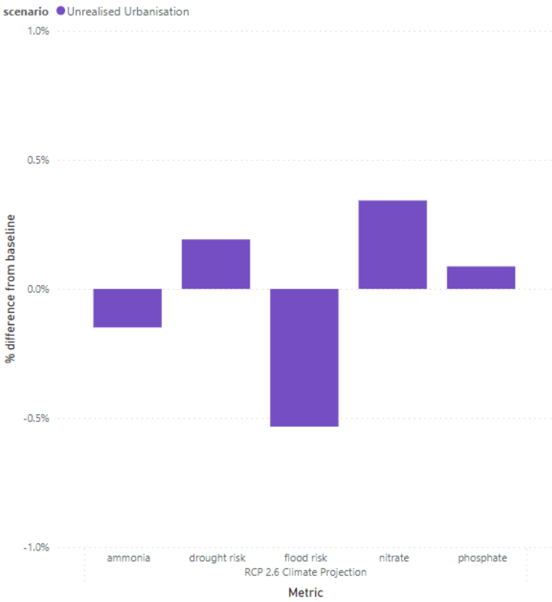
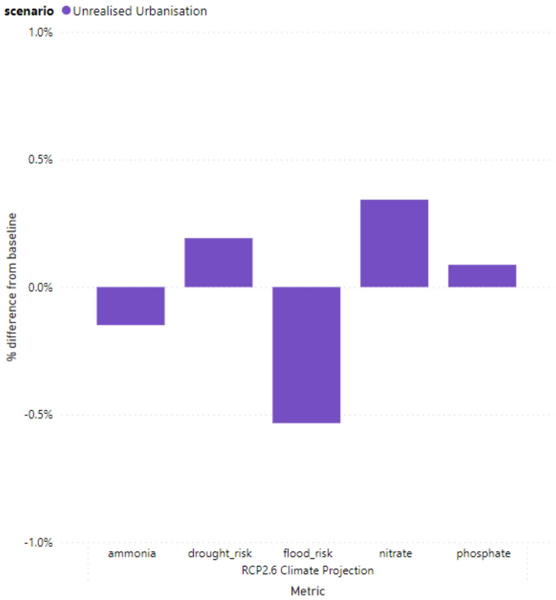
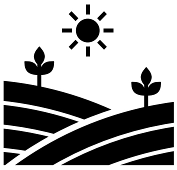


Figure H.55: Unrealised Urbanisation without abstraction reductions



Country Life



Flood risk is significantly reduced with no abstractions in Country Life (Figure H.57) compared with the scenario which includes abstractions (Figure H.56). Other changes in the upstream catchment, such as development and growth, also appears to provide benefits. Phosphate improves, but by a lesser amount, in the no abstractions scenario. Phosphate improvements are driven by WINEP programme enhancements in the upper catchment. Ammonia and nitrate deteriorate rather than improve, as a result of increased growth in the upper catchment. Drought risk remains similar to the ‘with abstractions scenario’ as low flows remain similar and are driven by climate change.

Figure H.56: Country Life with abstraction reductions

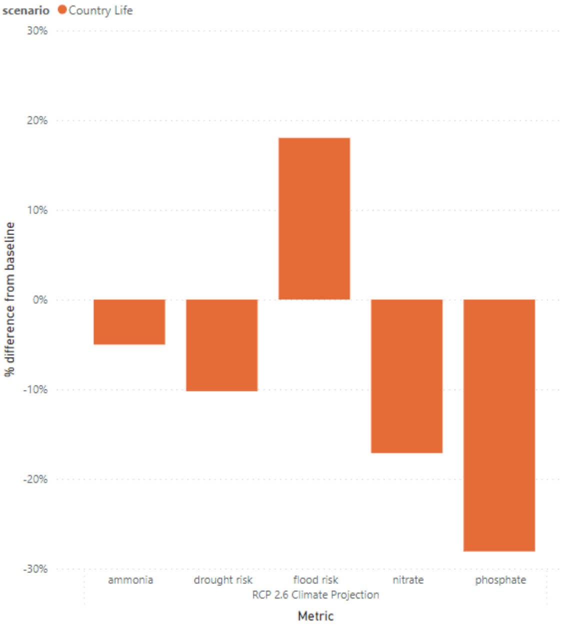
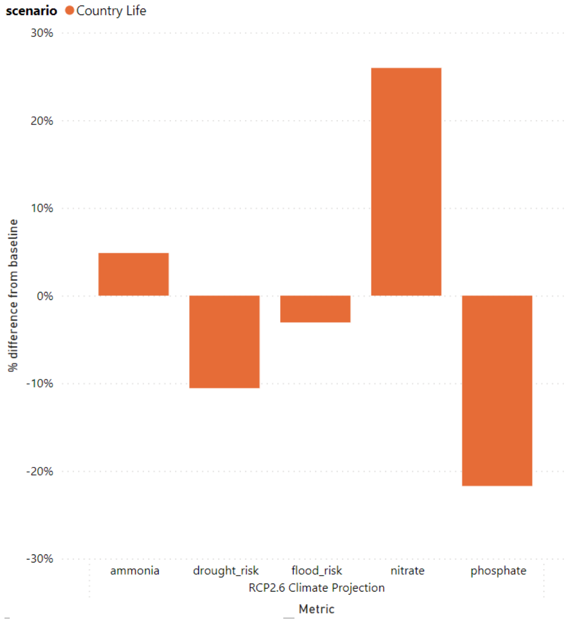
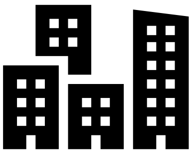


Figure H.57: Country Life without abstraction reductions



City Living



In the City Living scenario without abstractions, other influences over the metrics are very small, ranging to +/- 2% and are therefore considered negligible (Figure H.59). This is very different to the ranges observed in the scenario where abstraction reductions are considered (Figure H.58).

Figure H.58: City Living with abstraction reductions

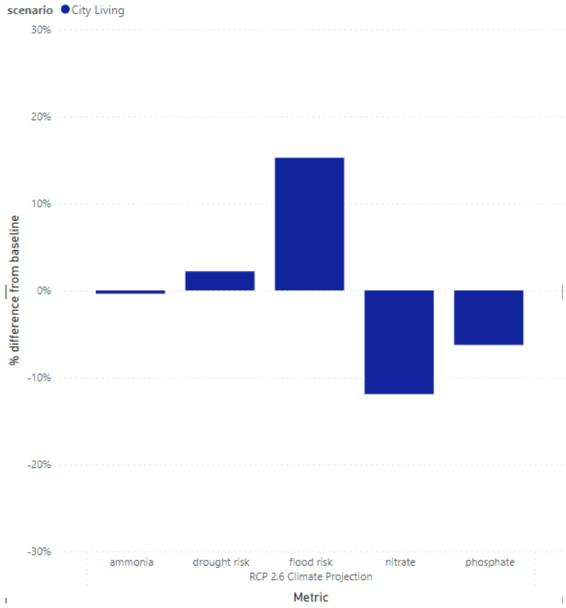
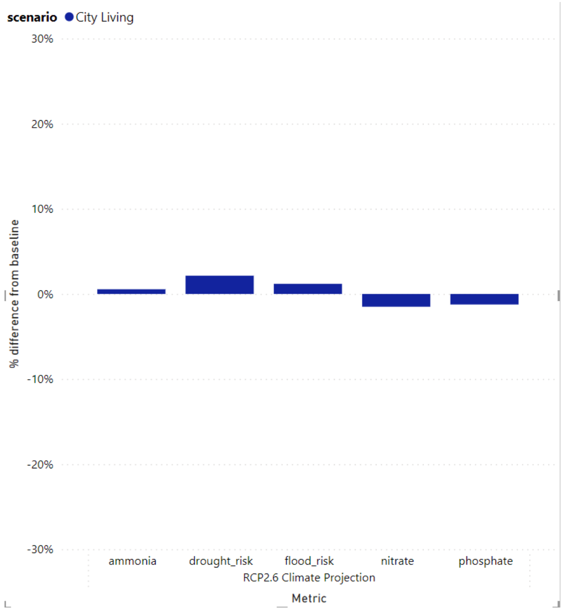


Figure H.59: City Living without abstraction reductions



Prosperous Growth

Flood risk is significantly reduced with no abstractions (Figure H.61), and even seems to improve by other changes in the upstream catchment and growth. Phosphate improves, but by a lesser amount, in the no abstractions scenario. Phosphate improvements are driven by WINEP programme enhancements in the upper catchment. Ammonia and nitrate deteriorate further, as a result of increased growth in the upper catchment. Drought risk remains similar to the 'with abstractions scenario' (Figure H.60) as low flows remain similar and are driven by climate change.

Figure H.60: Prosperous Growth with abstraction reductions

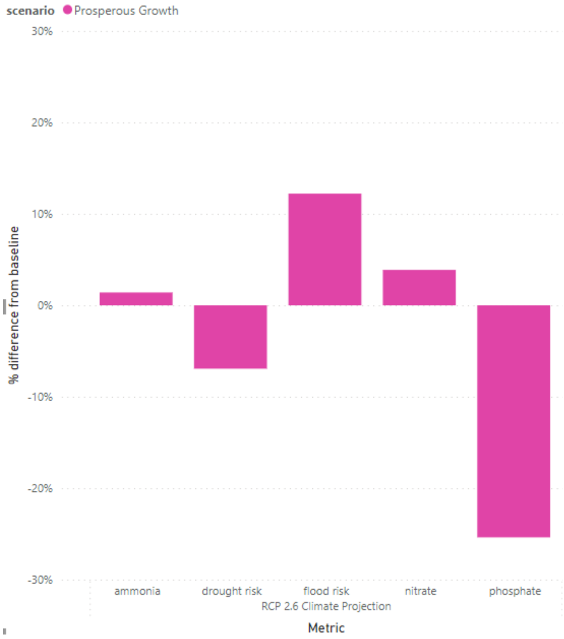
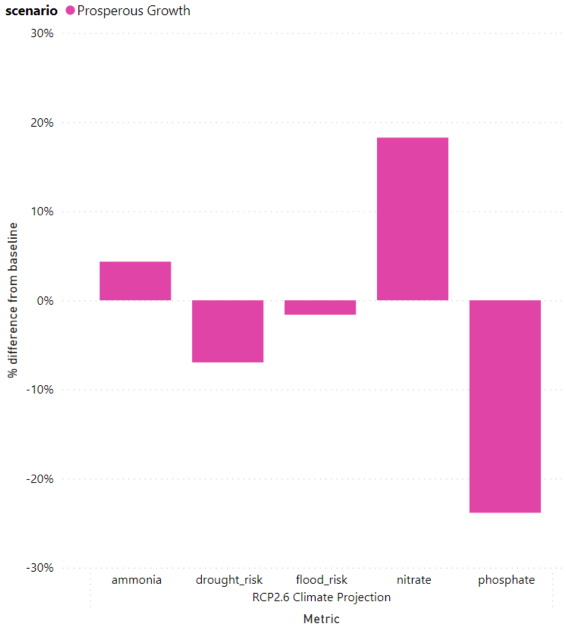


Figure H.61: Prosperous Growth without abstraction reductions



Environmental Priority

Flood risk is significantly reduced with no abstractions (Figure H.63), and even seems to improve by other changes in the upstream catchment and growth. Phosphate improves, but by a lesser amount, in the no abstractions scenario. Phosphate improvements are driven by WINEP programme enhancements in the upper catchment. Ammonia and nitrate deteriorate rather than improve, as a result of increased growth in the upper catchment. Drought risk remains similar to the 'with abstractions scenario' (Figure H.62) as low flows remain similar and are driven by climate change.

Figure H.62: Environmental Priority with abstraction reductions

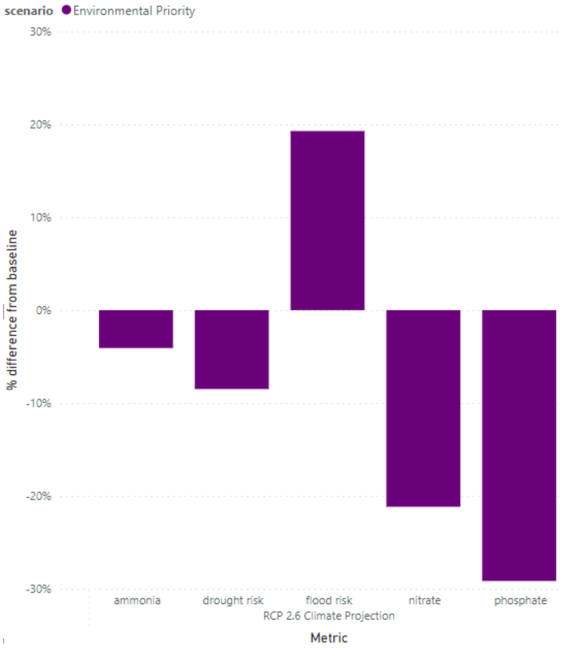
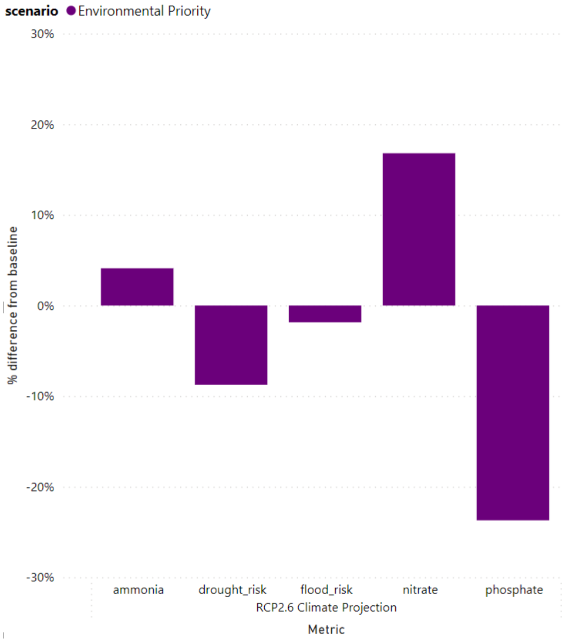


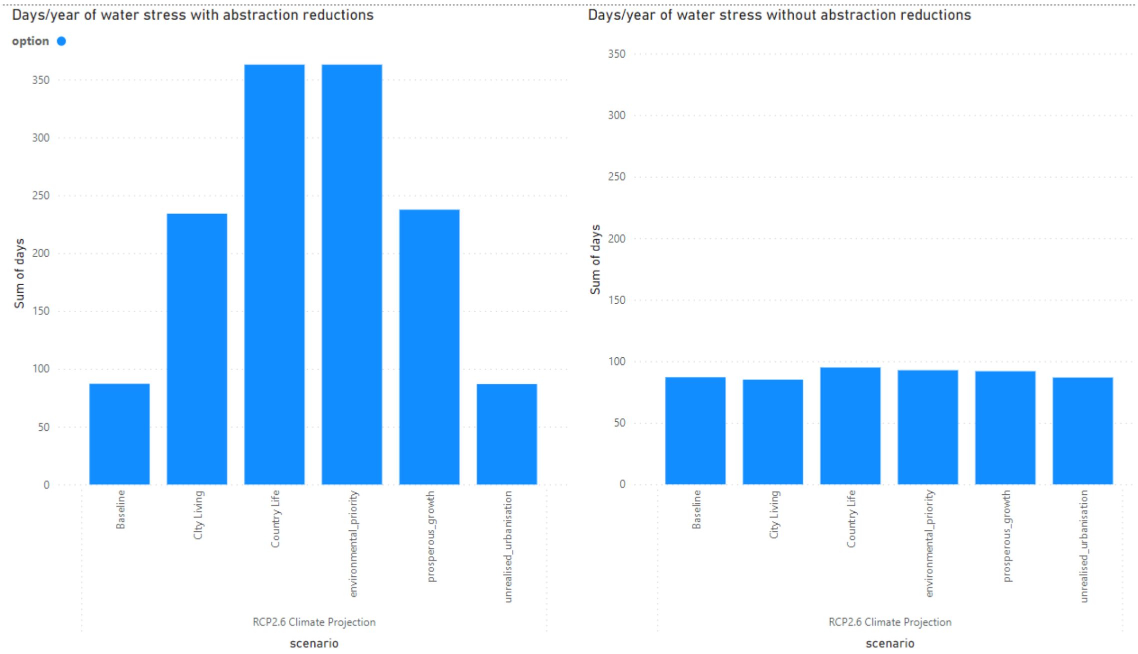
Figure H.63: Environmental Priority without abstraction reductions



H.2.1 Water stress

Days of water stress are reduced significantly as a result of abstractions being removed from the scenarios. The results are tabulated in Figure H.64 for comparison.

Figure H.64: Days of water stress with and without abstraction reductions in scenarios



H.2.1.1 Scenario trends

When including the abstractions, modelling results at the threshold level (as opposed to relative value changes) suggested that the Baseline and Unrealised Urbanisation are similar, City Living and Prosperous Growth are similar, and Country Life and Environmental Priority are similar.

However, when abstraction restrictions are removed, the differences between scenarios are more subtle. The following scenarios can form two groups as they have similar impacts:

- City Living undergoes the greatest change, as this is now more similar to that of the Baseline and Unrealised Urbanisation scenarios. This is due to the focus of growth being in the lower reaches of the River Lea and therefore having a smaller influence over the catchment as a whole.
- Environmental Priority, Prosperous Growth and Country Life now appear to have more similar trends, with deterioration in nitrate and ammonia, but improvements in flood risk (due to other environmental schemes such as upstream attenuation measures and SuDS as part of new developments) and phosphate (due to the WINEP programme measures in the upper Lea catchment). Water stress is reduced significantly as a result of removing the abstractions from scenarios.

H.3 Impact on option performance

We summarise how the six catchment-wide modelled options perform in Section 4.3 and Section 4.4. The modelled options are as follows:

- SuDS
- Deephams Reuse
- Water resource options (London WRZ)
- Metering options
- Natural Capital
- Leakage reduction

The following sections describe the key differences in performance between our subregional assessment with abstractions included in the scenarios, compared against the performance of the options without abstractions.

Options have not been modelled to assess the cumulative impact of the proposed options: they have all been modelled in isolation.

Option results are interpreted within the context of the scenario changes. For water quality and water quantity metrics, changes are based on % change compared against the scenario ‘do nothing’ option.

We looked at results and option performance for the City Living and Country Life scenarios, for consistency with the main report.

H.3.1 Water quality performance

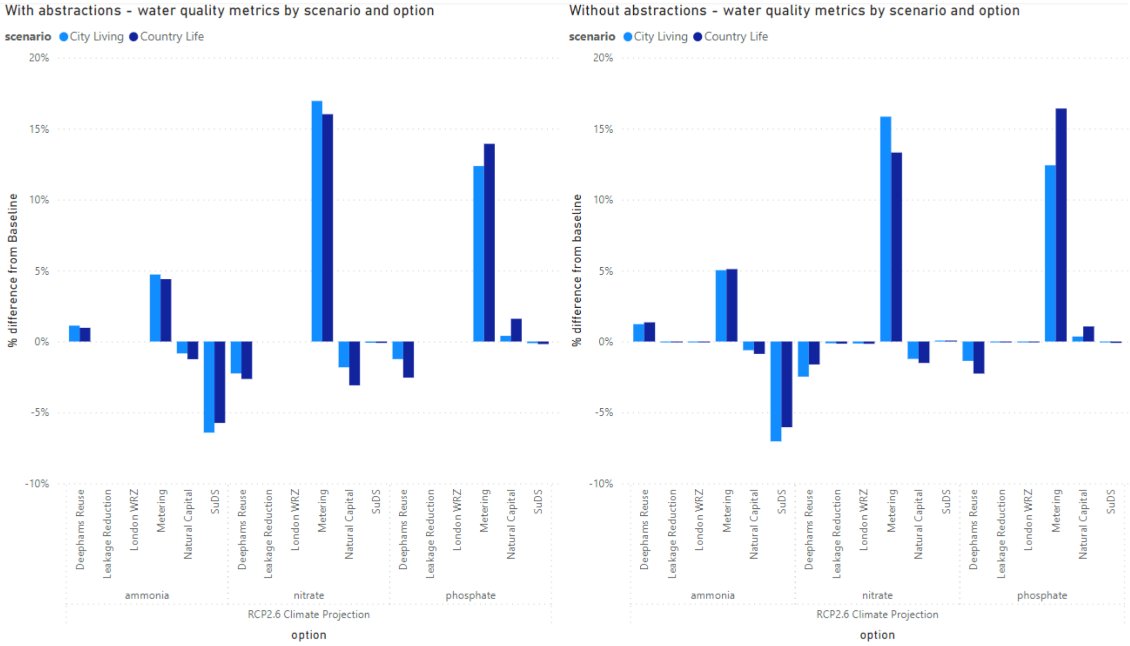
Figure H.65 shows the differences in water quality compared with and without abstractions. The options perform in a similar way with abstractions removed, in terms of differential between the baseline, with some changes in terms of absolute values.

Metering continues to provide some deterioration related to ammonia, phosphate and nitrate, as a result of reduced flows in the water system. Whilst pollutant loads are still the same, there is less volume of water to dilute them. This does not change significantly between the parameters.

SuDS continue to provide benefits to ammonia although other water quality benefits are negligible.

Other options do not demonstrate significant changes in terms of the benefits they provide, over and above those highlighted in the SIWMS report.

Figure H.65: Comparison of water quality metrics, compared against the baseline in the City Living and Country Life scenarios, with and without abstractions



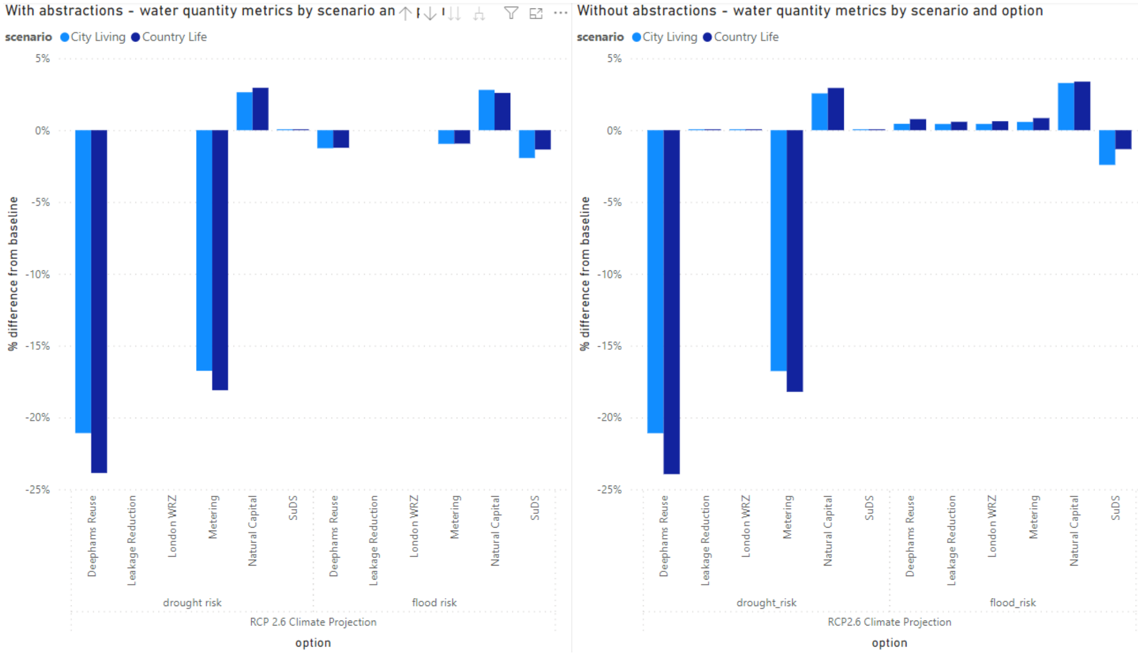
H.3.2 Water quantity performance

Figure H.66 shows the differences in water quantity compared with and without abstractions. The options perform in a similar way with abstractions removed, in terms of differences between the baseline, with some changes in terms of absolute values.

Drought risk remains similar for all variants of the scenarios and options: this is driven by climate change, rather than abstractions so there are no significant changes.

For flood risk, SuDS continue to provide a benefit. What becomes more apparent is that the water resource options, such as London WRZ, metering, leakage reduction and Deephams Reuse options, have an impact on increasing flood risk slightly. This is related to the reduced abstractions in the river: either through reduction in demand through leakage reduction and metering options; or alternative water resources such as Deephams Reuse and London WRZ.

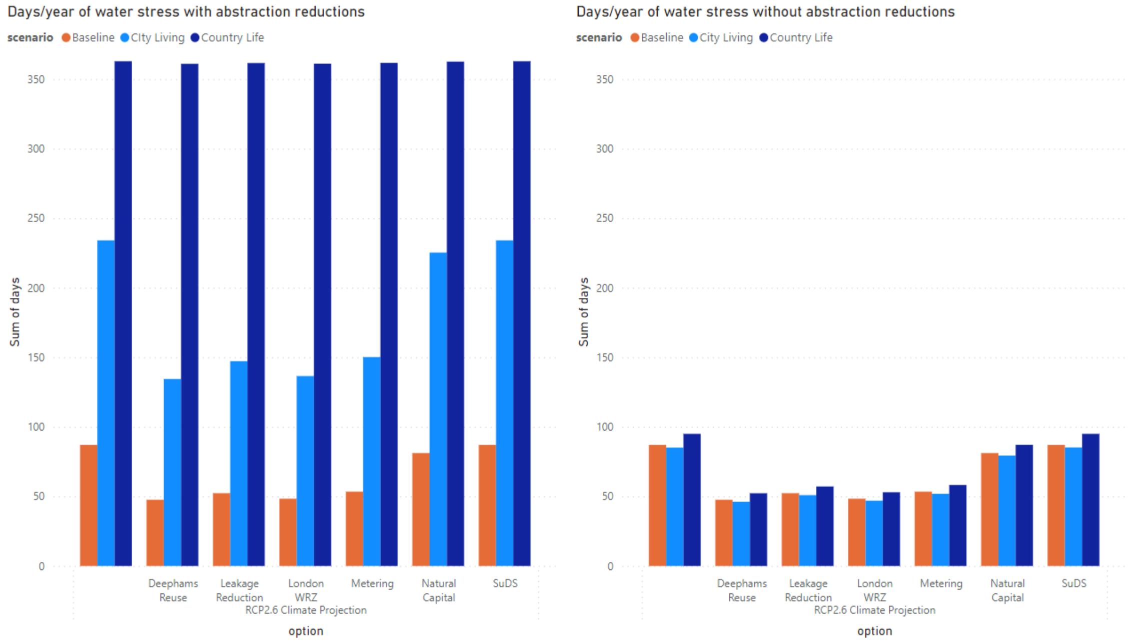
Figure H.66: Comparison of water quantity metrics, compared against the baseline in the City Living and Country Life scenarios, with and without abstractions



H.3.3 Water stress performance

Days of water stress are reduced significantly as a result of abstractions being removed from the scenarios. The results are tabulated in Figure H.67 for comparison. This figure demonstrates the clear advantage that leakage reduction and metering can have on reducing water stress: the total days of water stress are similar to both Deephams Reuse and the London WRZ options, without the need for such significant investment. Should abstractions go ahead at this scale, a combination of water resource options may need to be implemented to sustain water supply.

Figure H.67: Option performance showing days of water stress with and without abstraction reductions



H.4 Conclusions

We have shown the performance with and without the abstractions in the scenarios and compared these against the original modelling results. We have presented results which are cumulative for the subregion to provide a high-level comparison. There may be more subtle variances at a sub-catchment level.

Water quality deteriorates as a result of removing the abstractions: some phosphate benefits are provided by the WINEP programme, but this is not significant enough to drive a threshold change in WFD parameters. Options provide similar trends in performance compared against the baseline, with SuDS continuing to provide an improvement to ammonia levels in the water system. Metering continues to provide some water quality issues that may need additional interventions, or a combination of options, to offset.

Water quantity improves as a result of removing the abstractions: flood risk is improved as there is less flow in the water system in high flow conditions. This is partly achieved where there is significant development in the upstream catchment, resulting in more uptake in SuDS features and therefore attenuating flows upstream. Drought risk, or low flow conditions, do not change significantly as this is largely driven by climate change. Options continue to perform in similar ways compared to the baseline scenarios with very minor changes to flood risk (within 1%) in most cases.

Water stress improves significantly as flows can be abstracted from the River Lea to meet demand. There is little variation across scenarios, and this is driven largely by growth in the upper and lower Lea regions. The options perform better against water stress with no abstractions, providing more resilience for water supply. Where a combination of water resource options were required to offset water stress with abstraction licence changes: now the results show that leakage reduction and metering perform well as standalone options.

I. Data Collection register

Purpose of this register is to keep a record of data obtained and used on the project

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
100108845/INC/01	5.drain_london_borough_bound	Image	Input	Greater London Authority	Email from GLA	12/07/2022	Maps out the drain London group boundaries into 8 groups	Secure
100108845/INC/02	Drain London boundaries.msg	Email	Input	Greater London Authority	Email from GLA	12/07/2022	Used the d=Drain London Boundaries to decide which London Boroughs would be suitable to include in the project	Secure
100108845/INC/03	SIWMS Boundaries.png	Image	Input	Greater London Authority	Email from GLA	12/07/2022	Details boroughs within group 4 from the drain London groups which is the main focus of project along with City of London in group 3	Secure
100108845/INC/04	city-of-London-riverside-strategy	PDF	Input	City of London	https://www.cityoflondon.gov.uk/services/environmental-health/climate-action/flooding/city-of-london-riverside-strategy	16/08/2021	Details the city of London's strategy to improve the flood defences (improving barriers and raising river edge protections) along the river Thames in response to climate change, whilst improving pedestrian access along the whole riverside length	Public
100108845/INC/05	climate-action-climate-resilience-flood-risk-sfra-assessment-2017	PDF	Input	City of London	https://www.cityoflondon.gov.uk/assets/Services-Environment/climate-action-climate-reslience-flood-risk-sfra-assessment-2017.pdf	01/11/2017	Reviews river Thames flood defences against breaching along with tidal, fluvial and groundwater assessments. Incorporates Thames Water sewer modelling in assessment of surface water flood risk. Assess risk of water main bursting. Identifies measures to reduce flood risks. Reviews flood risk policies and potential consequences of flooding.	Public
100108845/INC/06	climate-action-climate-resilience-flood-risk-sfra-critical-infrastructure-2017	PDF	Input	City of London	https://www.cityoflondon.gov.uk/assets/Services-Environment/climate-action-climate-reslience-flood-risk-sfra-critical-infrastructure-2017.pdf	24/11/2017	Maps critical infrastructure in proximity of the Thames within the City of London area	Public
100108845/INC/07	climate-action-climate-resilience-flood-risk-sfra-env-	PDF	Input	City of London	https://www.cityoflondon.gov.uk/assets/Services-Environment/climate-action-climate-reslience-flood-risk-	28/07/2017	Maps surface water flood risk in the City of London area by the River Thames	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
	angency-risk-of-flooding-surface-water-mapping-2017				sfra-env-agency-risk-of-flooding-surface-water-mapping-2017.pdf			
100108845/INC/08	climate-action-climate-resilience-flood-risk-strategy-sea-2014	PDF	Input	City of London	Flooding document library - City of London	01/01/2014	Assesses the Local flood risk management strategy of City of London to ensure it accounts for the Social, Environmental and Economic objectives of the area according to the SEA directive	Public
100108845/INC/09	flood-emergency-plan-guidance-note.pdf	PDF	Input	City of London	https://www.cityoflondon.gov.uk/assets/Services-Environment/flood-emergency-plan-guidance-note.pdf	01/06/2020	Provides guidance on flood emergency plan requirements for new developments in the City of London area, which are dependent on the flood risk in the area of the new development.	Public
100108845/INC/10	local-flood-risk-management-strategy-2021-2027	PDF	Input	City of London	https://www.cityoflondon.gov.uk/assets/Services-Environment/local-flood-risk-management-strategy-2021-2027.pdf	01/02/2021	Outlines City of London's flood risk assessment and their strategy to reduce this risk, while building resistance and resilience to ensure swift recovery in the case of a flood event	Public
100108845/INC/11	flooding-information-local-flood-risk-management-strategy-2016	PDF	Input	London Borough of Enfield	https://new.enfield.gov.uk/services/environment/flooding-information-local-flood-risk-management-strategy-2016.pdf#:~:text=The%20London%20Borough%20of%20Enfield%20Local%20Flood%20Risk,risk	01/03/2016	Identifies key sources of flood risk in Enfield breaks down the boroughs strategy to manage the local flood risk in terms of gathering flood risk information, maintaining and protecting properties/assets and reducing runoff rates	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
					%20and%20impact%20of%20flooding%20across%20the%20borough.			
100108845/INC/12	flooding-information-preliminary-flood-risk-assessment	PDF	Input	London Borough of Enfield	https://www.enfield.gov.uk/__data/assets/pdf_file/0018/5463/flooding-information-preliminary-flood-risk-assessment.pdf	02/06/2011	Documents future flood risks and the identifies the extent of the flood risk areas in Enfield and the methodology used in assessing this.	Public
100108845/INC/13	flooding-information-strategic-flood-risk-assessment	PDF	Input	London Borough of Enfield	https://new.enfield.gov.uk/services/environment/flooding---information---strategic-flood-risk-assessment.pdf	01/02/2008	Aims to inform Local development documents and emergency planners in the borough and give guidance on site specific flood risk assessments.	Public
100108845/INC/14	flooding-information-surface-water-management-plan	PDF	Input	London Borough of Enfield	https://docslib.org/doc/538356/surface-water-management-plan-london-borough-of	05/01/2012	Aims to provide detailed understanding of the flood risk in the area and Identifies critical drainage areas and makes suitable surface water management recommendations	Public
100108845/INC/15	level-2-strategic-flood-risk-assessment-pdf	PDF	Input	London Borough of Enfield	https://new.enfield.gov.uk/services/planning/planning-information-level-2-lb-enfield-strategic-flood-risk-assessment.pdf	01/07/2013	Improves upon the previous 2008 SFRA. Appraises existing flood defences and flood risk management infrastructure, maps floodplains where required and distribution of flood risk, locates critical drainage areas and identifies SWMP necessities. Enables Exception and Sequential tests to be applied	Public
100108845/INC/16	Hackney-Level-2-SFRA-Report-Final.pdf	PDF	Input	London Borough of Hackney	https://geosmartinfo.co.uk/wp-content/uploads/2020/03/Hackney-Level-2-SFRA-Report-Final.pdf	01/09/2010	Assesses impacts of current and future sources of flooding, aims to enable planning policy identification to manage flood risk within the borough, enables Exception and Sequential tests to be applied, allows specific development sites to identify flood risks	Public
100108845/INC/17	Hackney-SWMP-Draft.pdf	PDF	Input	London Borough of Hackney	https://www.queenelizabetholympicpark.co.uk/~/media/lldc/l	04/03/2013	Aims to provide detailed understanding of the flood risk in the area and Identifies critical	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
					ocal%20plan/local%20plan%20examination%20documents/borough%20evidence%20base%20documents/beb18%20hackney%20surface%20water%20management%20plan%20final%20draft%202013.pdf		drainage areas and makes suitable surface water management recommendations	
100108845/INC/18	local-flood-risk-management-strategy.pdf	PDF	Input	London Borough of Hackney	https://consultation.hackney.gov.uk/communications-and-consultation/local-flood-risk-management-strategy-consultation/supporting_documents/hackneylocalfloodriskmanagementstrategy.pdf	01/02/2016	Aims to improve flood risk knowledge, make sustainable policy and planning decisions, maintain and improve flood defence infrastructure, provide local understanding of flood risk, ensure emergency plans are up to date	Public
100108845/INC/19	20190730_haringey_lfrms.pdf	PDF	Input	Haringey London	https://www.haringey.gov.uk/sites/haringeygovuk/files/20190730_haringey_lfrms.pdf	Unknown	Identifies critical Drainage areas, improves flood risk understanding and clarifies roles and responsibilities, confirm elements which contribute to surface water management, aims to prevent developments from increasing flood risk, encourages maintenance of privately owned flood defences, develop processes to maintain cleanliness and maintenance of water courses	Public
100108845/INC/20	haringey_local_suds_standards_v3.1.pdf	PDF	Input	Haringey London	https://www.haringey.gov.uk/sites/haringeygovuk/files/haringey_local_suds_standards_v3.1.pdf#:~:text=As%20well%20as%20ensuring%20schemes%20comply%20with%20the,b	Unknown	Haringey's adopted SuDS standards	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
					e%20the%20primary%20focus%20of%20the%20technical%20assessment.			
100108845/INC/21	haringy_swmp_draft_v2.pdf	PDF	Input	Haringey London	https://vdocument.in/surface-water-management-plan-haringey-surface-water-management-plan-drain.html?page=1	24/08/2011	Identifies critical drainage areas in Haringey and potential measures to reduce flood risk	Public
100108845/INC/22	north_london_strategic_flood_risk_assessment_2008	PDF	Input	Mouchel	https://www.islington.gov.uk/~/media/sharepoint-lists/public-records/transportandinfrastructure/information/adviceandinformation/20152016/20150814northlondonstrategicfloodriskassessment	01/08/2008	Assesses flood risk for Enfield, Barnet, Haringey, Hackney, Waltham Forest, Islington, Camden identifying risk areas	Public
100108845/INC/23	sfra_document_high_res_red_0.pdf	PDF	Input	JBA consulting	https://www.haringey.gov.uk/sites/haringeygovuk/files/strategic_flood_risk_assessment_sfra_level_2_report.pdf	01/02/2015	Flood risk assessment for Haringey identifying risk areas	Public
100108845/INC/24	DLT2-GP4-ActionPlan-TowerHamlets.xls	Excel	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/DLT2-GP4-ActionPlan-TowerHamlets.xls	Unknown	Action plan for flood risk management in Tower Hamlets proviing potential options	Public
100108845/INC/25	DLT2-GP4-TowerHamlets-PFRA.pdf	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-	10/05/2011	Preliminary Flood risk assessment for Tower Hamlets to identify risk areas	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
					protection/Monitoring/DLT2-GP4-TowerHamlets-PFRA.pdf			
100108845/INC/26	DLT2-GP4-TowerHamlets-SWMP-V2.0-Merged	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/DLT2-GP4-TowerHamlets-SWMP-V2.0-Merged.pdf	07/07/2011	Identifies critical drainage areas in Tower Hamlets and potential measures to reduce flood risk	Public
100108845/INC/27	LBTH-SuDS-Guidance-up-to-date.pdf	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/LBTH-SuDS-Guidance-up-to-date.pdf	Unknown	Tower Hamlet's adopted SuDS standards	Public
100108845/INC/28	Local_Flood_Risk_Management_Strategy.pdf	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/Local_Flood_Risk_Management_Strategy.pdf	01/11/2017	Identifies critical Drainage areas, improves flood risk understanding and clarifies roles and responsibilities regarding surface water management in Tower Hamlets	Public
100108845/INC/29	Tower_Hamlets_LFRMS_Appendix_B.pdf	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/Tower_Hamlets_LFRMS_Appendix_B.pdf	01/11/2017	Maps of flood risk areas in the Borough.	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
100108845/INC/30	MC_3049_shapefile	Shapefile	Input	DEFRA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Shapefiles for Thames River Basin District WFD operational catchments	Public
100108845/INC/31	London_SHLAA_2017_approvals_and_allocations.zip	Shapefile	Input	Greater London Authority	https://data.london.gov.uk/dataset/shlaa-2017-approvals-allocations	01/01/2017	Determines the quantity and suitability of land potentially available for housing development in London	Public
100108845/INC/32	London-plan-opportunity-areas	Website	Input	Greater London Authority	https://data.london.gov.uk/dataset/london-plan-opportunity-areas	01/01/2015	Site links to a planning constraints map of London, informing project decisions on what work is allowed to be undertaken	Public
100108845/INC/33	opportunity_areas	Shapefile	Input	Greater London Authority	https://data.london.gov.uk/dataset/opportunity_areas	01/01/2019	Shapefiles visualising the identified Opportunity areas and documenting the space availability	Public
100108845/INC/34	suds-opportunity-mapping-tool	PDF	Input	Greater London Authority	https://data.london.gov.uk/dataset/suds-opportunity-mapping-tool	01/12/2018	Aids in understanding SuDS potential in a given area, approximating surface water volume to be managed and approximating costs.	Public
100108845/INC/35	Draft river basin management plan summary programmes of measures	Excel	Input	Environment Agency	Draft river basin management plan summary programmes of measures.xlsx (live.com)	22/10/2021	Reviewed for information on current conditions, targets and measures for the EA RBMP.	Public
100108845/INC/36	Export_Output	Shapefile	Input	Thames Water	Received via Secure Transfer	Unknown	Shapefiles of TW DWMP risk zones for mapping	Secure
100108845/INC/37	Risk_Zone_2_4	MapInfo .TAB file	Input	Thames Water	Received via Secure Transfer	Unknown	Shapefiles of TW DWMP risk zones for mapping	Secure
100108845/INC/38	RiskArea	Geodatabase	Input	Thames Water	Received via Secure Transfer	Unknown	Shapefiles of TW DWMP risk zones for mapping	Secure
100108845/INC/39	Moore Brook Culvert.icmt	InCopy Markup Template	Input	Thames Water	Received via Secure Transfer	Unknown	Moore Brooke Culvert Model for review	Secure
100108845/INC/40	Isle of Dogs IWMP	PDF	Input	Greater London Authority	https://data.london.gov.uk/dataset/isle-of-dogs-and-south-	02/10/2020	Reviewed for water management options in the study area	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
	Technical Appendix				poplar-integrated-water-management-plan			
100108845/INC/41	Isle of Dogs and South Poplar Integrated Water Management Plan	PDF	Input	Greater London Authority	https://data.london.gov.uk/dataset/isle-of-dogs-and-south-poplar-integrated-water-management-plan	03/10/2020	Reviewed for water management options in the study area	Public
100108845/INC/42	Integrated Impact Assessment - Royal Docks and Beckton Riverside - Feb 2022	PDF	Input	Greater London Authority	https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/opportunity-areas/londons-opportunity-areas/royal-docks-and-beckton-riverside-opportunity-area	01/02/2022	Reviewed for measures in the opportunity area and growth predictions	Public
100108845/INC/43	Royal-Docks-Digital-Connectivity-Study-2022	PDF	Input	Royal Docks	https://www.royaldocks.london/opportunity/the-place-developments	07/02/2022	Reviewed for measures in the opportunity area and growth predictions	Public
100108845/INC/44	10050614-XX-XX-RP-DE-0001-01-Enfield SuDS Schedule Technical Note	PDF	Input	Thames Water	Microsoft Word - 10016816-ARC-XX-XX-DE-RP-0002-01-SuDS Features, Technical Note.docx (susdrain.org)	01/12/2020	Reviewed for SuDS specific Appendices	Public
100108845/INC/45	Enfield 1.5D Network Model(2)	InCopy Markup Template	Input	Thames Water	Received via Secure Transfer	Unknown	Network Model to review connectivity	Secure
100108845/INC/46	DWMP Output - Postcodes and numbers	Excel	Input	Thames Water	Received via Secure Transfer	17/08/2022	Reviewed for risk awareness in the area	Secure

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
	of properties at risk of flooding (1 in 30I, 1 in 30E, Resilience)							
100108845/INC/47	DWMP Output - Proposed Measures	Excel	Input	Thames Water	Received via Secure Transfer	17/08/2022	Reviewed for information on TW drainage measures within the catchment	Secure
100108845/INC/48	River Lea STW FE Data 2017 - 2022	Excel	Input	Thames Water	Received via Secure Transfer	17/08/2022	Reviewed for TW sewage data applicable to the catchment	Secure
100108845/INC/49	Study Boundary Region Sewer Records	Shapefile	Input	Thames Water	Received via Secure Transfer	17/08/2022	Reviewed for TW sewage data applicable to the catchment	Secure
100108845/INC/50	River Lea STW SDAC Boundaries	Shapefile	Input	Thames Water	Received via Secure Transfer	17/08/2022	Reviewed for TW sewage data applicable to the catchment	Secure
100108845/INC/51	ASFHD CDA Shapefiles	Shapefile	Input	Thames Water	Received via Secure Transfer	Unknown	Shapefiles of SFHD flooding properties on the 12th and 25th of July 2021	Secure
100108845/INC/52	CDA Maps	Images	Input	Local SWMPS	TW_CDA.xlsx	Unknown	CDA maps extracted from local SWMPS of London Boroughs	Secure
100108845/INC/54	LFRZ Maps	Images	Input	Local SWMPS	TW_CDA.xlsx	Unknown	CDA maps extracted from local SWMPS of London Boroughs	Secure
100108845/INC/55	London Models CDA Shapefile	Shapefile	Input	Internal	https://mottmac.sharepoint.com/:f:/r/teams/pj-f7283/do/GIS/02%20Data/Water.gdb?csf=1&web=1&e=a3P2Us	24/08/2022	Shapefile of the identified CDAs in London, produced for the 2021 Flood Review project based on CDA maps in SWMPs	Secure
100108845/INC/56	TW_CDA	Excel	Input	Local SWMPS	TW_CDA.xlsx	Unknown	Compilation of CDA map obtained from SWMPS of each London Borough	Secure
100108845/INC/57	Lea Lower Rivers and Lakes	Shapefile	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Shapefile of London's river water bodies and associated water quality data	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
	Operational Catchment							
100108845/INC/58	London AWBs	Shapefile	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Shapefile of London's river water bodies and associated water quality data	Public
100108845/INC/59	WFD_London.zip	Shapefile	Input	EA	Water Quality of London's Rivers and Other Waterbodies - London Datastore	01/01/2016	Shapefile of London's river water bodies and associated water quality data	Public
100108845/INC/60	OC_2033_shapefile	Shapefile	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Shapefile of London's river water bodies and associated water quality data	Public
100108845/INC/61	OC_3275_c3-draft-plan_shapefile	Shapefile	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Shapefile of London's river water bodies and associated water quality data	Public
100108845/INC/62	NewhamSurfaceWaterManagementPlan.pdf	PDF	Input	London Borough of Newham	https://www.newham.gov.uk/downloads/file/153/surfacewatermanagementplan	28/01/2019	Assesses CDA's and measures to manage surface wate flood risk	Public
100108845/INC/63	BEB16 Waltham Forest SWMP.pdf	PDF	Input	London Borough of Waltham Forest	https://www.walthamforest.gov.uk/sites/default/files/2021-12/ke133-draft-surface-water-management-plan-sept2011.pdf	01/09/2011	Assesses CDA's and measures to manage surface wate flood risk	Public
100108845/INC/64	NewhamFloodRiskManagementStrategy.pdf	PDF	Input	London Borough of Newham	Newham Local Flood Risk Management Strategy	01/09/2015	Reviewed for Flood Risk management measures in Newham	Public
100108845/INC/65	Thames Water WRMP 2019.pdf	PDF	Input	Thames Water	executive-summary.pdf (thameswater.co.uk)	01/01/2019	Reviewed TW Water Resource forecasts and options	Public

Our Ref.	Title	Data Format	Data Input/ Output	Originator Ref	Source (website address)	Published/received Date	Application - how are we using it?	Secure/ publicly available
100108845/INC/66	Waltham Forest Adopted Local Flood Risk Management	PDF	Input	London Borough of Waltham Forest	Adopted Local Flood Risk Management.pdf (walthamforest.gov.uk)	01/04/2015	Reviewed for Flood Risk management measures in Waltham Forest	Public
100108845/INC/67	OC_2033_challenges.csv	Excel	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Reviewed for waterbody data for the study area on classifications and pollutant sources	Public
100108845/INC/68	OC_2033_classifications.csv	Excel	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Reviewed for waterbody data for the study area on classifications and pollutant sources	Public
100108845/INC/69	OC_3275_challenges.csv	Excel	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Reviewed for waterbody data for the study area on classifications and pollutant sources	Public
100108845/INC/70	OC_3275_classifications.csv	Excel	Input	EA	Thames River Basin District | Catchment Data Explorer	22/08/2022	Reviewed for waterbody data for the study area on classifications and pollutant sources	Public
100108845/INC/71	Summary of the draft river basin management plans - GOV	PDF	Input	EA	https://www.gov.uk/government/publications/summary-of-the-draft-river-basin-management-plans/summary-of-the-draft-river-basin-management-plans	22-Oct-21	provides an overview of the draft river basin management plans for the river basin districts in England.	Public
100108845/INC/72	LIT_10228_THAMES_FRMP_SUMMARY_DOCUMENT.pdf	PDF	Input	Thames Water	Thames river basin district flood risk management plan - GOV.UK (www.gov.uk)	17/03/2016	Summary of the FRMP contents	Public
100108845/INC/73	LIT_10229_THAMES_FRMP_PART_A.pdf	PDF	Input	Thames Water	Thames river basin district flood risk management plan - GOV.UK (www.gov.uk)	17/03/2016	Background to the FRMP and Thames district wide information	Public

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100108845/INC/ 74	LIT_10230_THAMES_FRMP_PART_B.pdf	PDF	Input	Thames Water	Thames river basin district flood risk management plan - GOV.UK (www.gov.uk)	17/03/2016	Information on sub areas within the district	Public
100108845/INC/ 75	LIT_10231_THAMES_FRMP_PART_C.pdf	PDF	Input	Thames Water	Thames river basin district flood risk management plan - GOV.UK (www.gov.uk)	27/03/2016	Table of all FRM measures to be carried out by Boroughs/agencies in the district	Public
100108845/INC/ 76	Managing flood risk_ roles and responsibilities _ Local Government Association	PDF	Input	DEFRA	https://www.local.gov.uk/topics/severe-weather/flooding/local-flood-risk-management/managing-flood-risk-roles-and	Unknown	Defines Lead Local Flood Authority responsibilities	Public
100108845/INC/ 77	pb14218-llfa-funding-201410	PDF	Input	DEFRA	Defra funding for Lead Local Flood Authorities in England for 2014-15 (publishing.service.gov.uk)	01/03/2013	Identifies level of fundings for different LLFAs	Public
100108845/INC/ 78	Water industry national environment programme (WINEP) methodology - GOV.UK.html	Website	Input	EA	Water industry national environment programme (WINEP) methodology - GOV.UK (www.gov.uk)	11/05/2022	Provides WINEP Methodology and timeline of delivery dates	Public
100108845/INC/ 79	CaBA-CSRG-Strategy-APPENDICES-FINAL-12.10.21-Low-Res	PDF	Input	CaBa	Chalk Stream Strategy - CaBA (catchmentbasedapproach.org)	01/01/2021	Reviewed for chalk stream restoration measures will impact the study area	Public

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100108845/INC/80	PR24-and-beyond_Performance-commitments-for-future-price-reviews	PDF	Input	OFWAT	PR24 and beyond: Performance commitments for future price reviews - Ofwat	23/11/2021	Reviewed for performance commitments in PR24 which will impact the study area	Public
100108845/INC/81	cityplan-2036-march-2021	PDF	Input	City of London	City Plan 2036 March 2021 (cityoflondon.gov.uk)	01/03/2021	Draft of the boroughs Local Development plans	Public
100108845/INC/82	policies-map-A-2021	PDF	Input	City of London	City Plan 2036 March 2021 (cityoflondon.gov.uk)	01/03/2021	Map of policy areas	Public
100108845/INC/83	policies-map-B-2021	PDF	Input	City of London	City Plan 2036 March 2021 (cityoflondon.gov.uk)	01/03/2021	Map of policy areas	Public
100108845/INC/84	ELP-2039-Reg-18-for-consultation-Planning	PDF	Input	London Borough of Enfield	A4 Portrait white with continuation page (enfield.gov.uk)	01/06/2021	Draft of the boroughs Local Development plans	Public
100108845/INC/85	Draft-Policies-Map-Planning	PDF	Input	London Borough of Enfield	https://www.enfield.gov.uk/__data/assets/pdf_file/0022/12667/Draft-Policies-Map-Planning.pdf	01/06/2021	Map of policy areas	Public
100108845/INC/86	appendix-1-LP33-adoption-july-2020	PDF	Input	London Borough of Hackney	appendix-1-LP33-adoption-july-2020.pdf - Google Drive	01/07/2020	Local Development plans for the borough	Public
100108845/INC/87	appendix-2-policies-map-LP33	PDF	Input	London Borough of Hackney	appendix-2-policies-map-LP33.pdf - Google Drive	01/07/2020	Map of policy areas	Public
100108845/INC/88	haringey_local_plan_nov_2017_web_friendly	PDF	Input	London Borough of Haringey	haringey_local_plan_nov_2017_web_friendly.pdf	01/07/2017	Map of policy areas	Public

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100108845/INC/89	NewhamLocalPlan2018_5	PDF	Input	London Borough of Newham	newham-local-plan-2018-pdf-	01/12/2018	Local Development plans for the borough	Public
100108845/INC/90	Local_Plan_Policies_Map_2018	PDF	Input	London Borough of Newham	https://www.newham.gov.uk/downloads/file/1110/local-plan-policies-map-2018-pdf-	01/12/2018	Map of policy areas	Public
100108845/INC/91	TH_Local_Plan_2031_accessibility_checked	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Strategic-Planning/Local-Plan/TH_Local_Plan_2031_accessibility_checked.pdf	01/01/2020	Local Development plans for the borough	Public
100108845/INC/92	Policies-Map-15-01-2020	PDF	Input	London Borough of Tower Hamlets	https://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Strategic-Planning/Local-Plan/Policies-Map-15-01-2020.pdf	15/01/2020	Map of policy areas	Public
100108845/INC/93	Local_Plan.gdb.zip	Geodatabase	Input	London Borough of Tower Hamlets	ldf@towerhamlets.gov.uk	15/01/2020	Shapefiles for map of policy areas	Secure
100108845/INC/94	Final Draft Local Plan_July2019_Web optimised_Part1	PDF	Input	London Borough of Waltham Forest	New Local Plan preparation | London Borough of Waltham Forest	01/11/2021	Draft of the boroughs Local Development plans	Public
100108845/INC/95	WF Policies Map (Adoption Version)reduced version	PDF	Input	London Borough of Waltham Forest	Layout: A0 Proposals Map (walthamforest.gov.uk)	13/12/2013	Map of policy areas	Public

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100108845/INC/96	EA_flood_risk_water_quality_objections_list_2016-17_to_2021-22	Excel	Input	EA	Environment Agency objections to planning applications based on flood risk and water quality - GOV.UK (www.gov.uk)	25/08/2022	List of objections to measure which may impact the study area	Public
100108845/INC/97	statistical-gis-boundaries-london.zip	Shapefile	Input	Greater London Authority	Statistical GIS Boundary Files for London - London Datastore	21/05/2014	Shapefiles of London Borough Boundaries	Public
100108845/INC/98	2022-10-17 Second Interim Report (2nd draft)	PDF	Input	Greater London Authority	Email from GLA	08/09/2022	Interim Report for the Royal Docks & Beckton Riverside IWMS	Secure
100108845/INC/99	Interim Report v2 (1)	PDF	Input	Greater London Authority	Email from GLA	09/09/2022	Interim Report for the Royal Docks & Beckton Riverside IWMS	Secure
100108845/INC/100	NewhamSFRA2017_part1	PDF	Input	London Borough of Newham	Emily Craven Report London Borough of Newham Level 1 & 2 Strategic Flood Risk Assessment 2017-01-11	25/09/2017	Strategic Flood Risk Assessment for London Borough of Newham	Public
100108845/INC/101	Provisional_Agricultural_Land_Classification_(ALC)_(England)	Shapefile	Input	Natural England	Provisional Agricultural Land Classification (ALC) (England) | Provisional Agricultural Land Classification (ALC) (England) | Natural England Open Data Geoportal (arcgis.com)	03/12/2021	Shapefiles for Natural England agricultural land classifications map	Public
100108845/INC/102	EA_NitrateVulnerableZone	Shapefile	Input	DEFRA	Defra Spatial Data Download	01/01/2021	Shapefiles for NVZ zones	Public

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	s2021Designations_SHP_Full							
100108845/INC/103	Drinking_Water_Safeguard_Zones_(Surface_Water)	Shapefile	Input	EA	Defra Data Services Platform	12/05/2021	Shapefiles for Drinking water safeguard zones	Public
100108845/INC/104	the_london_plan_2021	PDF	Input	GLA	The London Plan 2021 | London City Hall	01/03/2021	Th London Plan 2021 which details opportunity area plans within the city	Public
100108845/INC/105	Consented_Discharges_to_Controlled_Waters_with_Conditions (2)	Access Database	Input	EA	Consented Discharges to Controlled Waters with Conditions (data.gov.uk)	28/07/2020	Details consented discharges to controlled waters from different catchments and the sources of discharge	Public
100108845/INC/106	Final_CDAs_2017.DAT	MapInfo .TAB file	Input	Enfield	Email from Enfield Borough Council	14/10/2022	Shapefiles of Enfield's CDAs	Secure
100108845/INC/107	flood risk maps for surface water	Shapefile	Input	EA	Flood risk maps for surface water: how to use the map - GOV.UK (www.gov.uk)	12/12/2013	Maps showing surface water flood risk	Public
100108845/INC/108	IMPLEMENTATION THEMES.pptx	Powerpoint	Input	GLA	Received via Secure Transfer	01/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region.	Secure
100108845/INC/109	East London crypto matrix	GIF	Input	Thames Water	Received via Secure Transfer	16/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region.	Secure
100108845/INC/110	Lea Valley Crypto 20yr	Excel	Input	Thames Water	Received via Secure Transfer	16/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region.	Secure
100108845/INC/111	Lea Valley Raw and Stored Water Network	Powerpoint	Input	Thames Water	Received via Secure Transfer	16/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region and validation with the intergrated modelling	Secure
100108845/INC/112	Nitrates	Excel	Input	Thames Water	Received via Secure Transfer	16/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region.	Secure

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100108845/INC/113	West London crypto matrix	GIF	Input	Thames Water	Received via Secure Transfer	16/11/2022	Reviewed for awareness of speicfc water quality issues in the TW region.	Secure
100108845/INC/114	ONS Table 2 2018.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/115	Summary Projections.xlsx	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/116	table21.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/117	table217032020155604.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/118	table22.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/119	table23.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/120	table24.xls	Excel	Input	Office for National Statistics	National population projections - Office for National Statistics	21/10/2019	Population growth projections for the study area	Public
100108845/INC/121	Beckton-catchment-strategic-plan	PDF	Input	Thames Water	beckton-catchment-strategic-plan.pdf (thameswater.co.uk)	Unknown	DWMP strategy for the Beckton area	Public
100108845/INC/122	deephams-catchment-strategic-plan	PDF	Input	Thames Water	deephams-catchment-strategic-plan.pdf	Unknown	DWMP strategy for the Deephams area	Public

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					(thameswater.co.uk)			
100108845/INC/123	STW Effluent data - Water Quality	Excel	Input	Thames Water	Email from Thames Water	2018 - 2022	The final effluent data includes 15min time-varying data for: - Ammonia - BOD - COD - Nitrates - Suspended Solids - Temp - And in some cases, phosphate Data was received after baseline report was issued. Limited use, to be confirmed with GLA	Secure
100108845/INC/124	Water_Industry_National_Environment_Programme	Excel	Input	WINEP	Water Industry National Environment Programme (data.gov.uk)	20/08/2020	Reviewed for WINEP measures impcating the study area	Public
100108845/INC/125	EnvAct_IMP1_P_Reductions_TW_200722Update (3)	Excel	Input	Thames Water	Email from Thames Water	24/06/2022	STW discharge and emission set out by the environment act for AMP7	Secure
100108845/INC/126	TW potential UWWTR P schemes in PR24 (1)	Excel	Input	Thames Water	Email from Thames Water	01/05/2022	Reviewed for potential wastewater treatment schemes which would impact the study area	Secure
100108845/INC/127	MC_3105_shapefile	Shapefile	Input	EA	Lea Upper Management Catchment | Catchment Data Explorer	22/08/2022	Shapefiles for the upper Lea WFD catchment	Public
100108845/INC/128	7-Resource-Options	PDF	Input	TW	7-Resource-Options.pdf (thames-wrmp.co.uk)	01/11/2022	WRMP Section on water resource option appraisal	Public
100108845/INC/129	subcatchments.zip	CSV/geojson	Output	ICL	Email from ICL	17/01/2023	Raw modelling results from Imperial and aggregated results.	Secure

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100108845/INC/130	full results with catchment id	CSV	Output	ICL	Email from ICL	20/01/2023	This catchment data is for the full results only so it supersedes the previous full results, but it supplements the aggregated results (because you can use this spreadsheet to assign the catchment in the aggregated version)	Secure