Method Statement: Best Value Planning

January 2022

Title	Method Statement: Best Value Planning
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Summary of areas where substantive changes have been made as a result of consultation feedback	Consultation feedback received from: - River Thames Society - Cotswold Canals Trust - Environment Agency - Oxfordshire County Council Updates to the method statement have been made to make the process clearer, and have closer alignment with other WRSE method statements.
Summary of areas where substantive changes have been made as a result of the revised Water Resource Planning Guidelines (WRPG)	N/A
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A consultation on the WRSE Method Statements was undertaken in Autumn 2020 – the consultation details can be viewed on the WRSE engagement hq platform at https://wrse.uk.engagementhq.com/method-statements.

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Executive Summary

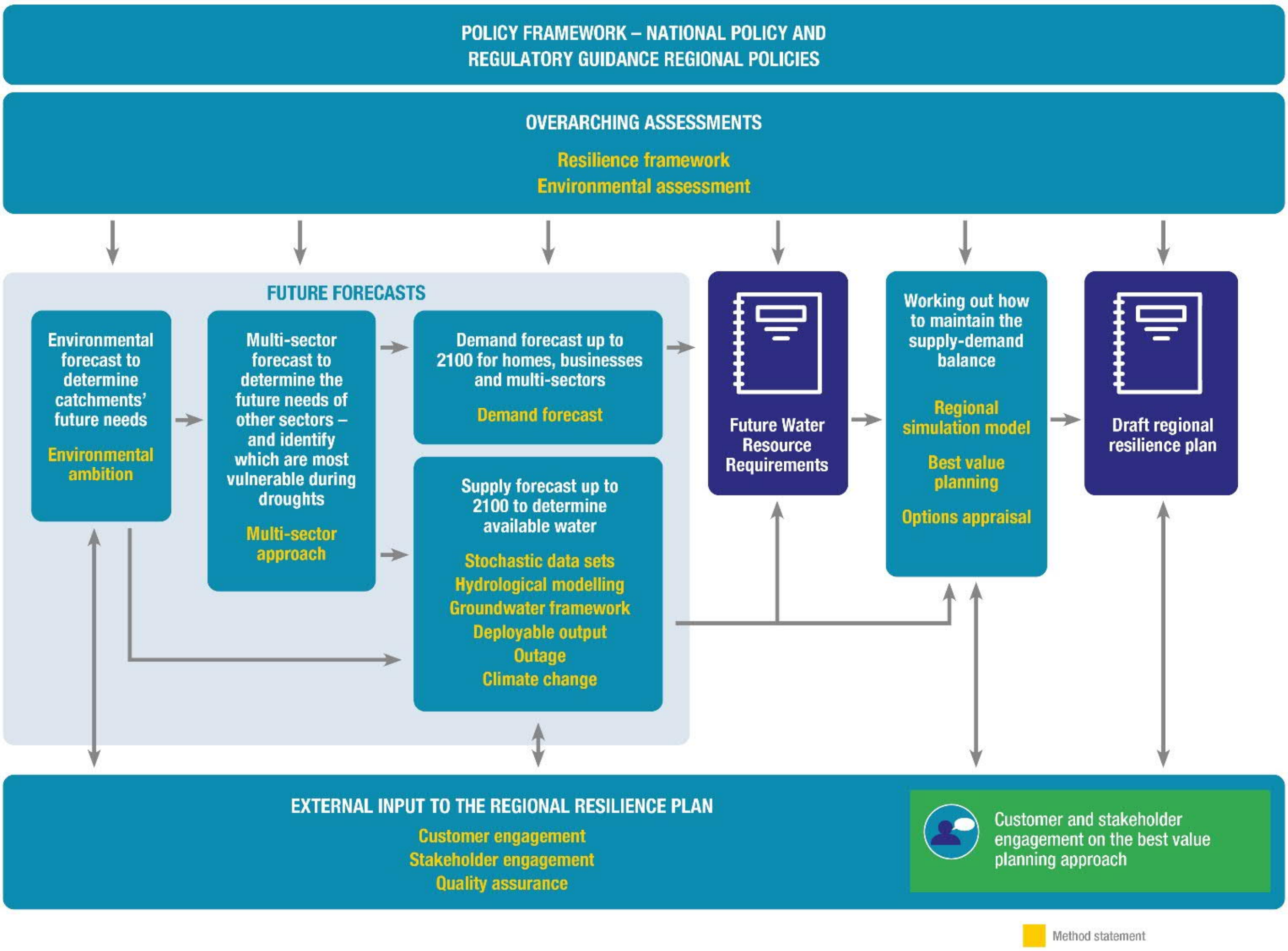
Water Resources South East (WRSE) is developing a multi-sector, regional resilience plan to secure water supplies for the South East until 2100.

We have prepared and consulted on the method statements that set out the processes and procedures we will follow when preparing all the technical elements for our regional resilience plan. This updated version reflects, as far as possible, the views and requirements of customers and stakeholders raised during the consultation. It has also been reviewed and updated to align with guidance published since work initially commenced on the regional plan, including the updated EA Water Resources Planning Guidline, the EA supplementary guidance on Best Value Planning and the UKWIR Best Value Planning Framework.

Figure ES1 illustrates how this best value planning method statement will contribute to the preparation process for the regional resilience plan.

The scale and complexity of water resources planning for the South East of England supports the use of advanced decision-making methods to ensure that a robust solution is reached. This method statement explains our approach to best value planning and the decision support tools we have used to develop a best value, adaptive regional plan.

Figure ES1: Overview of the method statements and their role in the development of the plan



Our approach has seven key stages:

Stage 1 - We validate the input data received from individual companies. This includes baseline supply demand positions, uncertainties and the feasible options identified as potentially being available to resolve any water supply deficits over the planning period. We use problem characterisation to understand the challenges and complexities across the South East of England. A data landing platform underpins all data flows across this process to support robust governance, quality assurance and reporting.

Stage 2 - We define the decision-making framework, set our objectives and the value criteria we will use to define best value.

Stage 3 - We use integrated risk modelling to explore and define problems to be solved for regional water planning allowing exploration of uncertainties or risks. From this work we identify a core and a most likely baseline scenario, together with a range of more or less extreme alternative futures (known as a situation 'tree').

We then use real options and adaptive planning methods within the WRSE investment model to identify a range of investment programmes (i.e. combinations of options) that resolve the integrated risk problems to 2100. These solutions can be described using a number of criteria including cost, resilience, environmental impact and customer preference.

Stage 4 - We use a visualisation tool to help illustrate and understand complex information and enable comparison of the alternative investment programmes produced by the investment model. This allows us to consider how different criteria affect outcomes and consider best value in the round. From this work we will select a shortlist of reasonable alternative programmes for further investigation.

Stage 5 - We undertake further assessment and stress-testing of the shortlisted programmes including system simulation, environmental and wider resilience testing.

Stage 6 - We use the information provided through the previous stages to select WRSE's preferred programme – i.e. our draft best value regional plan.

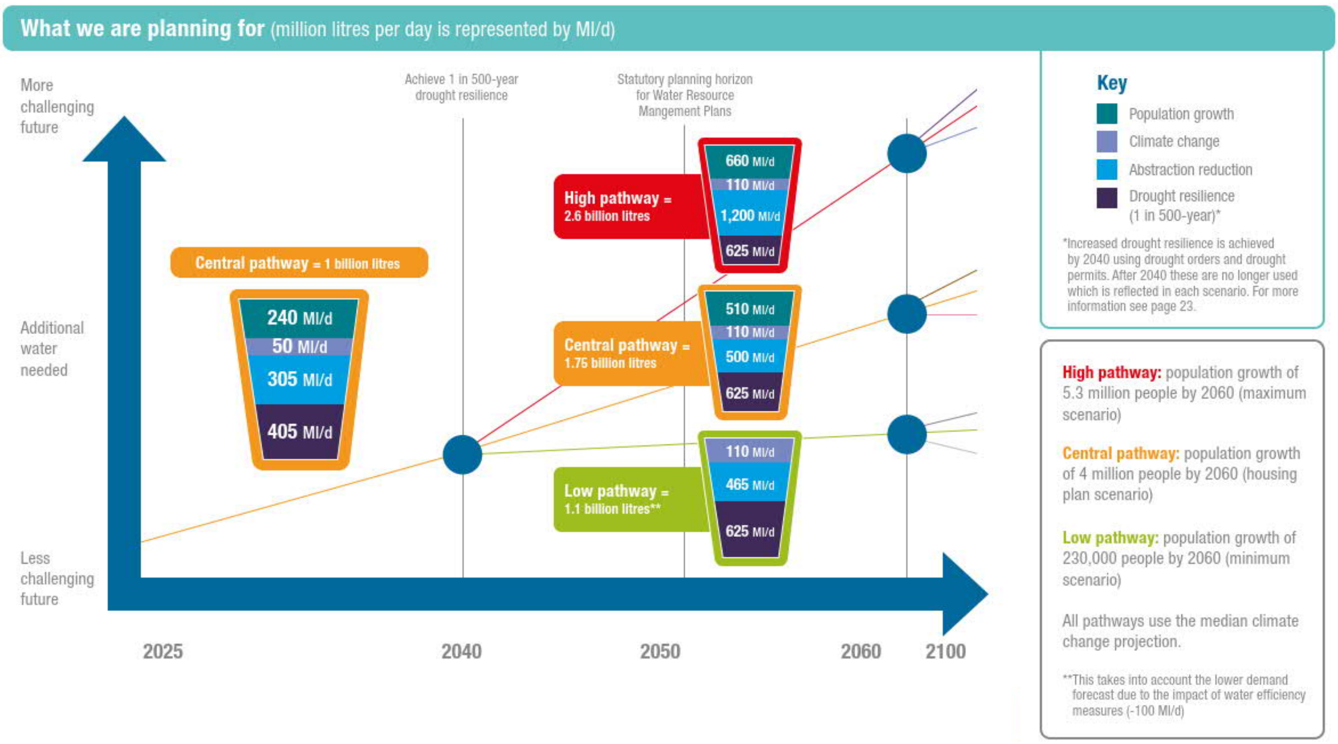
Stage 7 - We consult on our draft best value regional plan.

1 Introduction and timeline

Introduction

1.1 By 2050, the South East of England is forecast to experience a shortfall in water resources needed to ensure a resilient water supply for the public, other users and the environment. This deficit was estimated to be between 1000[1] and 1750[2] Ml/d in 2020, but through updated assessments has now been estimated to be up to 2,600 Ml/d by 2050 (see WRSE updated Future Water Resource Requirements report and Figure 1 below).

Figure 1: Future water resource requirements for South East England.



1.2 We believe that the scale and complexity of water resources planning for the South East of England requires us to use advanced decision-making methods, (in accordance with industry guidance), to ensure that a robust solution is reached.

[1] March 2020, Future water resource requirements for South East England, WRSE.
[2] March 2020, *National Framework*, Environment Agency

1.3 This method statement explains the best value planning (BVP) approach we are following and the decision support tools we are using to identify and test potential investment programmes and enable selection of a best value adaptive plan for the region. Our best value plan will also be an adaptive plan.

1.4 The approach was developed in line with key industry guidance and methodologies:

- Water Resources Planning Guideline (July 2021)[3]
- UKWIR (2002) Economics of Balancing Supply and Demand (EBSD)
- UKWIR (2016) WRMP 2019 Methods – Decision Making Process Guidance
- UKWIR (2020) Deriving a Best Value Water Resources Management Plan

1.5 We have consulted with and taken on board the comments of our stakeholders and customers throughout the development of our BVP approach, including:

- Draft Method Statements consultation July-Oct 2020
- Best Value Planning consultation February-March 2021

Timeline

1.6 The overall timeline and milestones for the decision-making process to support the regional planning process is shown in Table 1.

Table 1: Milestones

Date of Delivery	Activity
July 2020	Method statements produced for consultation
Oct 2020	Policies and preferences agreed
Winter 2020/21	Initial resilience planning for the South East region
Summer 2021	Update Future Water Resource Requirements for South East England
Summer 2021	Publish updated Method Statements, and confirm the policies and preferences that we will embed in our regional plan
Autumn 2021	Preparation and reconciliation of draft regional plans to ensure alignment across England
January 2022	Publish WRSE emerging Regional Plan for consultation
May 2022	Present the main issues raised in the consultation and how they will be addressed

[3] https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline

Summer 2022	Publish our final draft Regional Plan
Autumn 2022	WRSE water companies will submit their draft Water Resources Management Plans 2024 ahead of public consultation
Spring 2023	Water companies publish their revised draft Water Resources Management Plans
Summer/Autumn 2023	WRSE will publish its final multi-sector, regional resilience plan

Structure

1.7 The structure of the remainder of this method statement is as follows, setting out our approach and following each of the stages through to the identification of a best value, adaptive plan.

- Section 2 – The Best Value Planning approach
- Section 3 – Stage 1: Input Data Validation
- Section 4 – Stage 2: The Decision-Making Framework
- Section 5 – Stage 3a: Integrated Risk Modelling
- Section 6 – Stage 3b: Investment Modelling and programme visualisation
- Section 7 – Stage 4: Shortlisting
- Section 8 – Stage 5: Testing the shortlisted programmes
- Section 9 – Stage 6: Selecting the preferred programme
- Section 10 – Stage 7: Consultation on the Best Value Plan for the South East of England

1.8 There are also a set of appendices that provide additional information on the decision support tools and data control.

2 Best Value Planning

What is a 'best value plan'?

2.1 A best value plan, in the context of water resources planning, is one that considers a range of factors (not exclusively financial cost). As a minimum any plan must meet the legislative and regulatory requirements (including securing a supply of wholesome drinking water for customers) and other policy expectations in an efficient, affordable and deliverable way. A best value plan seeks a solution that not only secures supplies for customers, but also increases the overall benefit to customers, the wider environment and society as a whole.

2.2 This could result in a water resource programme being chosen for the regional plan, which isn't the most cost efficient, but delivers additional value as defined through the best value criteria.

2.3 The scale and complexity of challenges we face, and the significant uncertainties, means that we have chosen to use advanced decision making methods and develop a plan that can adapt to different future scenarios. In this way we can show how our proposals would change under different "futures" and set out when key decisions need to be made to manage the uncertainty.

2.4 We set out our approach and the decision support tools we have used to help develop a best value, adaptive plan below.

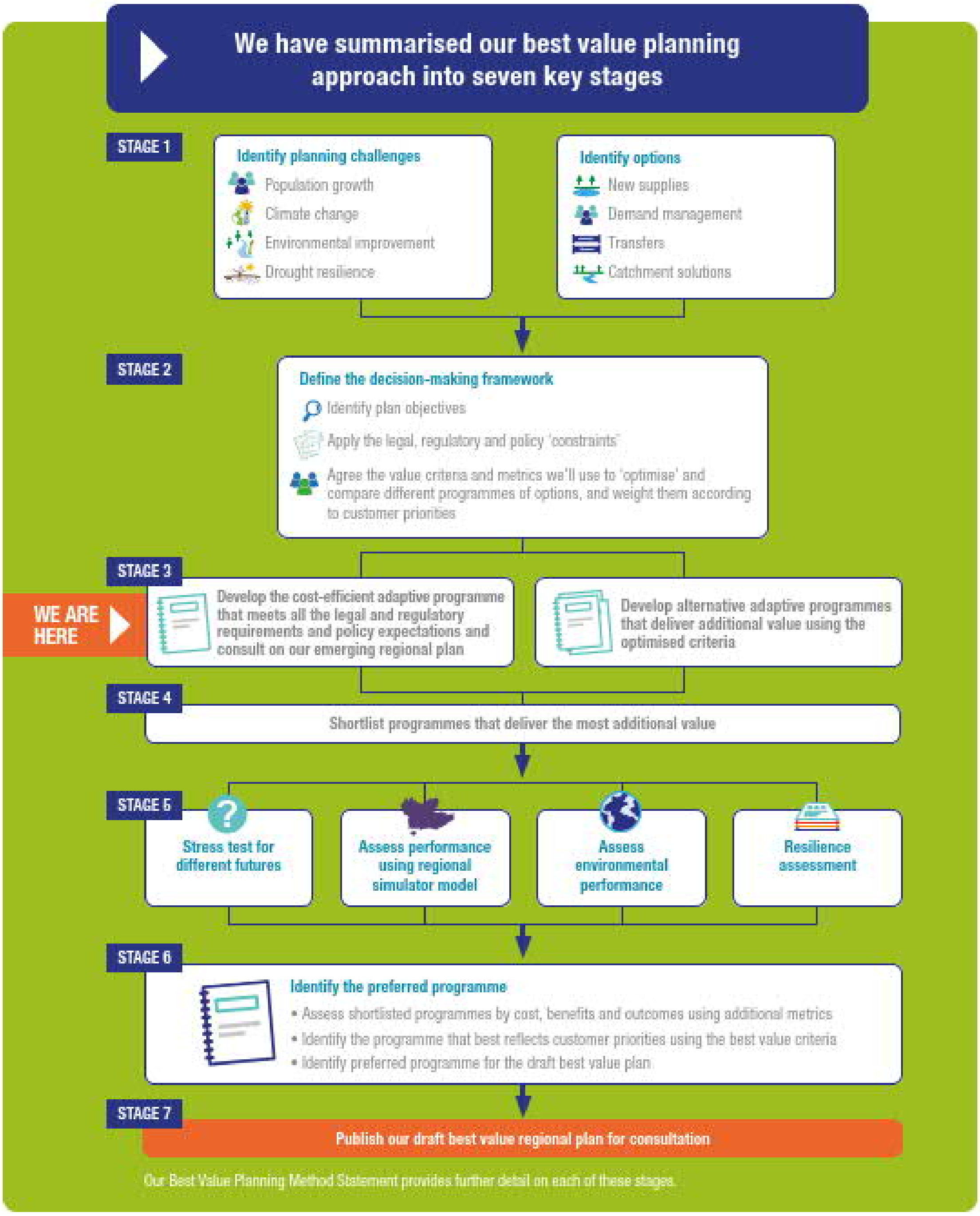
Our approach

2.5 Our approach for generating, testing and presenting the best value regional plan can be summarised into seven key stages, as shown in

2.6 Figure 2.

2.7 These stages incorporate what was otherwise set out in the more detailed 16-step process for the development of a plan described in the WRSE Resilience Framework. The aspects of our 16-step process are shown or referenced in this method statement to show their alignment with each best value planning stage.

Figure 2: Our Best Value Planning approach – process overview



Stage 1: Data Validation (see Section 3)

2.8 In the data validation stage, we use a tool called the data landing platform (DLP) to collate the input data required to feed our risk and investment models.. This is sourced from our member companies or developed ourselves in conjunction with them. The input data is checked before it is submitted to the DLP by the organisation that developed it. In the main this data falls into two categories:

- Information used to identify the planning challenges (i.e. data that enables us to identify the problem)
- Information on potential options that could be used to meet the planning challenges [i.e. data on our options to solve the problem).

Stage 2: Decision Making Framework (see Section 4)

2.9 In order to develop a Best Value plan, we first need to set its objectives – these are the specific goals that our regional plan must aim to deliver relating to 'Best Value'. We've used insight from water company customers and stakeholders across the South East to help us understand their priorities, so our objectives are representative of what matters most to them.

2.10 We have also consulted on a range of other policies for the region that will also been considered when generating the Best Value plan.

2.11 Each objective will be represented by a set of value criteria (i.e. categories against which the objective can be tested) which, in turn, will each have an associated metric that will measure the additional value it delivers. We will use the criteria and metrics to assess the different water resource programmes that are produced through our investment modelling.

2.12 In this stage we will set out our objectives, criteria and metrics, making it clear what things our plan must do (constraints), and on which metrics we can optimise to help us to make decisions on which programme best meets those objectives and delivers best value.

Stage 3: Solution Development (see Sections 5 and 6)

2.13 In this stage we explain the range of modelled potential alternative future scenarios and how we develop programmes of options to meet those futures, including key policy delivery dates.

2.14 We have split this stage in two, with Section 5 covering the Integrated Risk Model (IRM) (Stage 3a), which develops the alternative futures; and Section 6 covering the Investment Model (IVM) (Stage 3b), which develops the programmes of options to meet the futures.

Stage 4: Assess and Shortlist solutions (see Section 7)

2.15 Stage 3 will produce a large number of potential water resource programmes.

2.16 In Stage 4 we explain how we'll use a visualisation tool to help us display, filter and identify a shortlist of alternative solutions for further investigation, potentially trading-off performance against each of the value criteria in order to shortlist a set of high performaning varied solutions overall.

Stage 5: Test shortlisted solutions (see Section 8)

2.17 In Stage 5 the shortlisted solutions will be examined in more detail to see how they perform and how robust they are. Specifically we will undertake:

- Stress testing (i.e. how would the solution change in the face of an alternative future, or if key options were no longer available, delayed or didn't deliver expected benefits)
- System simulation (i.e. does the combination of options perform as expected in a simulation.)
- Environmental review (i.e. examining a wider set of environmental metrics and considering in combination effects)
- Resilience review (i.e. examining a wider set of system resilience metrics as set out in the Resilience Framework).

2.18 We will share the shortlisted programmes with stakeholders and customers. Each and every shortlisted programme will demonstrate additional value and could therefore constitute a best value plan. Stakeholders and customers will have the opportunity to consider these alternative 'best value plans', including how they would trade-off between value criteria, and confirm their priorities.

Stage 6: Select plan (see Section 9)

2.19 In Stage 6 we will select a single preferred best value programme, taking into account our technical work, outcomes of engagement with stakeholders and customers, and all associated environmental and other pertinent information. We will determine which programme we consider to be our preferred best value plan.

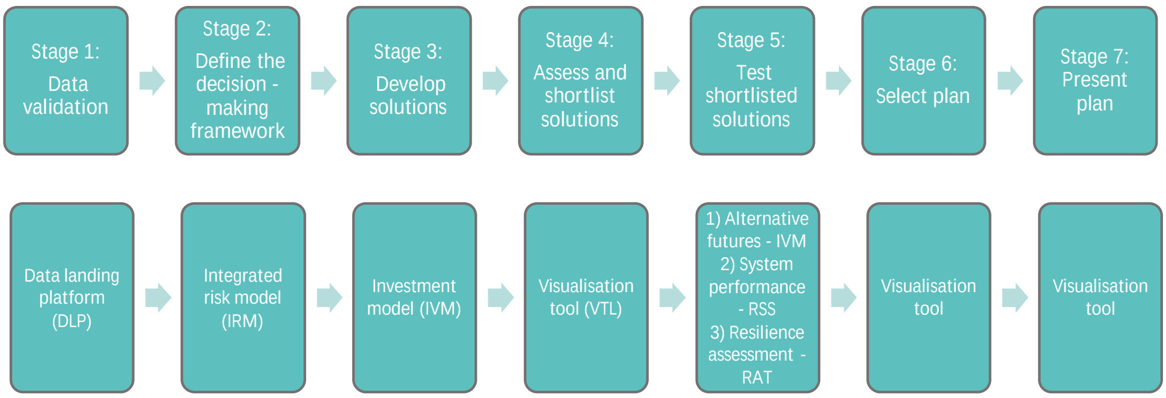
Stage 7: Consultation on the draft plan (see Section 10)

2.20 Our preferred best value plan will be an adaptive plan, showing how the proposals take account of different futures and when key decisions need to be made in order to deliver solutions that meet key policy delivery dates. We will undertake public consultation on our proposals and then take account of feedback in finalising our plan.

Our decision support tools

2.21 We have developed a number of decision support tools to assist the undertaking of stages of the best value planning process as summarised in Figure 3.

Figure 3: The decision support tools used at each Stage



2.22 We explain these tools and the relationship between them in our detailed description of the stages later in this document.

Key decision points

2.23 There are a number of key decision points throughout the BVP planning and delivery stages. They can be split into:

- Decisions made in developing the plan itself;
- Decision points relating to the delivery of the plan, such as confirming when key policy objectives will be delivered
- Timing of decisions required in the lead up to delivery.

2.24 The latter point is an important part of the adaptive planning process and real options analysis. Once we have identified candidate programmes it will be possible to develop the timeline for decisions on investigation, planning, construction and operation and set out that timescale for the preferred plan in Stage 6.

2.25 Firstly though we need to set out the decisions that will need to be made in the development of the plan and who will make them, as set out in Table 2 below. Our approach is to ensure a robust decision making process at each critical point in the staged process.

Table 2: Key decision points in developing the best value plan

Decision Point	When?	What?	Who?	Reviewed by	Signed off
DP1	Stage 2: Pre-modelling	- Problem characterisation & selection of modelling approach - The decision-making framework, objectives, criteria and metrics.	PMB	SAB	SLT
DP2	Stage 3: Modelling	- 3a) Creation and testing of single future situations and situation trees - 3b) Choice and number of run types to produce solutions.	PMB	SAB	
DP3	Stage 4: Shortlisting	Shortlisting a range of best value programmes for further assessment.	PMB	SAB	
DP4	Stage 5: Performance testing	Identifying themes emerging from the performance testing and how they inform the selection of the preferred best value programme.	PMB	SAB	
DP5	Stage 6: The Preferred Programme	Selection of the preferred best value programme.	PMB	SAB	

PMB – Project Management Board[4]; SAB – Stakeholder Advisory Board; SLT – Senior Leadership Team

2.26 The role and make-up of our governance hierarchy is explained in Figure 3. Further details on the engagement and governance structure can be found in Method Statement 1327 WRSE Stakeholder Engagement and our Governance Policy.

2.27 As well as the formal public consultation process and the engagement undertaken throughout the development of the plan, the role of the Stakeholder Advisory Board (SAB) is particularly important as it provides a layer of independent external scrutiny to our decision-making. The SAB will work with the SLT to ensure that the multi-sector, regional resilience plan meets the needs of all water users, the environment and supports the regional economy.

2.28 The SAB will also produce a report for SLT on how the alternative water resource programmes perform for customers and stakeholders to help inform its decision making. The minutes of the meetings held by the SAB can be found on the WRSE website.

[4] In this context the water company PMB members are reflecting the considered view of their company developed from consultation within their organisations.

2.29 The SLT will ultimately make the final decision on which programme will form the draft regional plan for consultation. Its decision making will be informed by the technical modelling undertaken by WRSE, expert judgment and selection justification from PMB (as scrutinised by SAB who may also make additional recommendations), plus wider input from the member water companies and the views of customers and stakeholders.

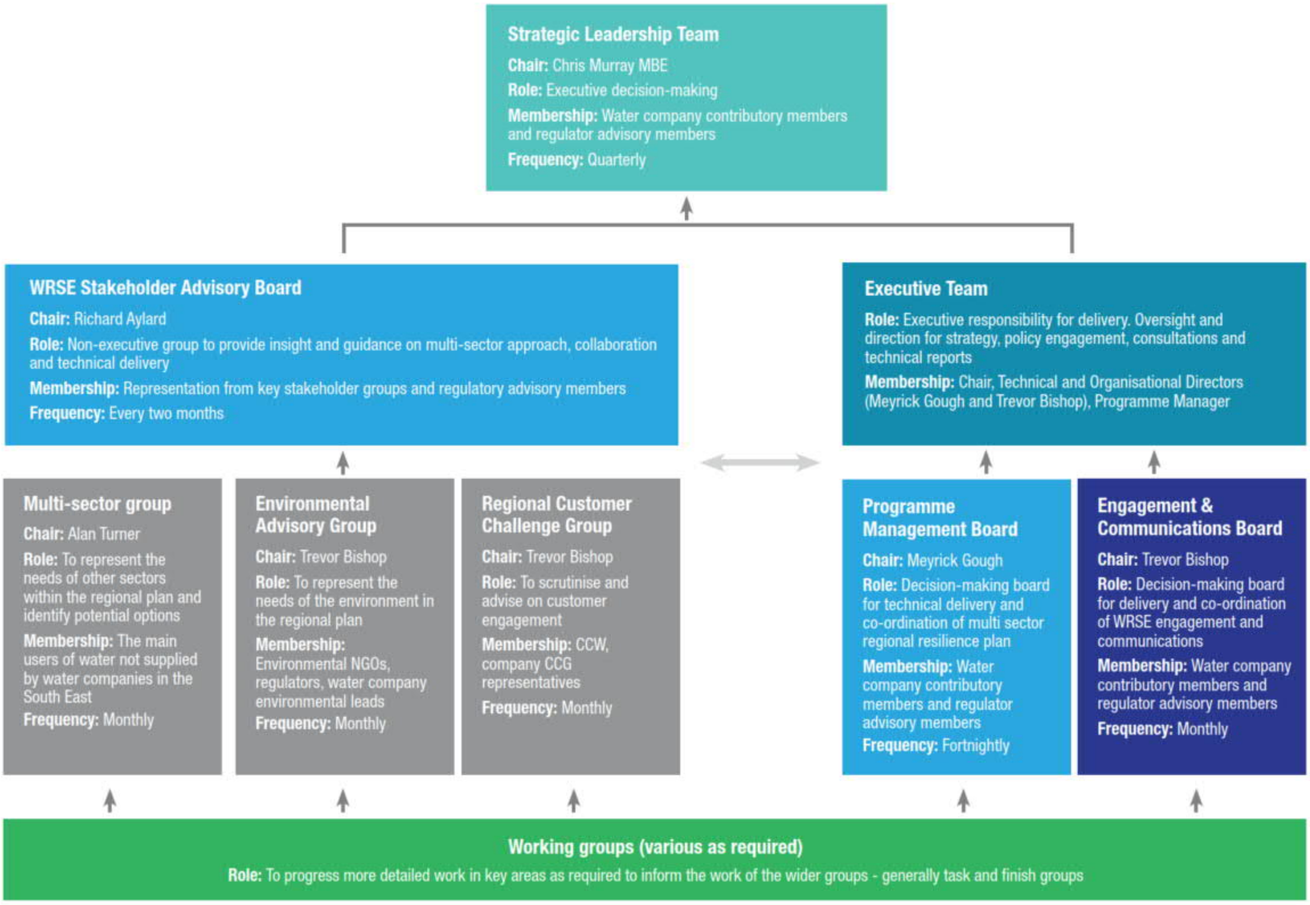
2.30 Decision makers need to ensure they have a clear and reasoned justification for the decisions taken, documenting the consideration of alternative approaches rejected.

2.31 Sensitivity analysis will be used to assess any areas of disagreement to understand the materiality of the decision.

Objectivity vs Subjectivity

2.32 Decision making at all levels is a balance of objectivity (things are objectively calculated) and subjectivity (expert judgement). It is not currently possible, or we would argue, desirable to programme a model (or models) to consider all the variables within water resources planning and have it make all the decisions for us. There is always a balance of evidence as provided by the decision support tools alongside subjective assessment and judgement, taking the views of stakeholders in the round.

Figure 4: WRSE Decision making groups



3 Stage 1: Data validation

Input data

3.1 The methods for producing the input data required are detailed in our other workstream-based method statements. All data input to the data landing platform (DLP) is signed-off by the input workstream and the version, authorisation and author automatically captured as part of the upload. This section lists the data required and expected provenance.

Planning scenarios and planning horizon

3.2 The Water Resources Planning Guideline (WRPG) states that a Water Resources Management Plan (WRMP) must consider the worst-case dry year combination of supply and demand forecasts for each water resource zone, together with the uncertainties incorporated in target headroom. Drought resilience must also be included, to provide resilience to 1:500-year extreme drought by 2039/40.

3.3 To enable investment modelling for dry year and drought across the region, baseline supply and demand forecasts and uncertainty profiles are imported for each of four deterministic planning scenarios:

1. Normal year (1:2yr) annual average (NYAA)
2. Dry year (1:100yr) annual average
3. Dry year (1:500yr) annual average (DYAA)
4. Dry year (1:500yr) critical period (DYCP)

3.4 Deterministic deployable outputs (DOs) are also provided for supply options for each of the planning scenarios, and demand reduction profiles for each of the demand reduction strategies.

3.5 Where possible drought interventions are not included in supply or demand baselines; media campaign impacts, temporary use bans, non-essential use bans, and drought permits or orders may be included as options that have a DO or demand reduction available during the dry year or drought planning scenarios.

3.6 As explained in the Initial Resource Position for WRSE, the planning horizon for WRMP24 will be April 2025/26 to April 2099/2100.

Baseline supply forecasts

3.7 Baseline supply forecasts for the Integrated Risk Model (IRM) and Investment Model (IVM) define water available for use (WAFU) from each water resource zone's (WRZ's) own sources, plus or minus any external or commercial transfers to/from the WRSE water companies, and inset appointments. These WAFU forecasts are generated by the Regional Simulation Model, based on regional weather and climate datasets, hydrological modelling, groundwater modelling and dynamic demand algorithms and methods. See Method Statement 1331 WRSE Regional System Simulator and WRSE regional simulation model scoping report for more details.

3.8 Existing inter-zonal transfer pipelines and existing inter-zonal bulk transfer agreements within the region are included as options, to enable existing transfer agreement inclusion as either fixed volumes representing inter-company agreements, or options for optimisation of conjunctive use of regional WAFU, as desired for different IVM runs.

3.9 As noted above, drought intervention DO reduction or enhancement is not included in the baselines, but as options available for dry or drought year planning scenarios.

Baseline demand forecasts

3.10 Baseline demand forecasts for the IRM and IVM are generated by the demand modellers for each company, based on the regional population and properties forecasts generated by Edge Analytics (Population and Property Forecasts – Methodology and Outcomes). The modellers provide deterministic distribution input (DI) forecasts with DI per WRZ per year, for each planning scenario.

3.11 As there are several relevant population and properties forecasts, the demand forecasters will select forecasts that are most applicable for regional adaptive planning, as detailed in Method Statement 1319 WRSE Demand Forecast. It is feasible to include alternative demand forecasts either:

- as fixed baselines, for separate optimisations of a range of supply demand balances where the range covers supply uncertainties only; or
- as demand forecast uncertainty profiles in the IRM, sampled to generate a range of supply demand balances for a single optimization.

3.12 Testing and evaluation of the IRM and IVM with full data will enable determination of the preferred method, or combination, going forward.

Situations and policies

3.13 Deterministic baseline forecasts require the forecaster (WRSE) to select appropriate forecasts from those that are feasible, using expert judgment and professional experience. Situations (i.e. circumstances beyond reasonable control of the water companies or regulators such as population growth, climate change, etc.) and policies (either internal or governmental/regulatory) are key factors that influence both system forecasts, and the uncertainty distributions around these influences are all captured as part of the supply and demand forecasting workstreams, to be input to the IRM via the DLP.

3.14 The WRPG states that situation and policy uncertainties affecting public water supply forecasting should be sampled to provide a deterministic target headroom forecast to be included in problem development and ensure that water resources management planning can meet the risk that the future deviates from the most likely forecasts. The IRM includes all the uncertainties used to create a target headroom buffer, but samples and solves for them separately and in combination to allow greater understanding of the relative impacts of key situations or policies on investment planning.

3.15 Situation and policy uncertainty profiles input to the IRM will include more than these key challenges to public water supply. Additional uncertainty profiles will also be input relating to environmental protection, non-public water supply, and wider South East systems, as defined in the WRSE Resilience Framework, so as to ensure that the problems to be solved are comprehensive enough to provide solutions resilient for all planning scenarios.

Investment options

3.16 Both working together as WRSE and in preparation for their own WRMPs, individual water companies have identified and provided data for all regional supply, demand and transfer options not included in the baselines, whether existing, under construction, or new. Options may be stand-alone or made up of:

- Option elements (resource, conveyance,)
- Option phases (modular increases in resource DO)
- Option stages (planning, development, construction and operation)

3.17 For example, existing transfers are input with two elements:

- DO of the bulk transfer agreement under different planning scenarios (resource element)
- capacity of the transfer pipeline (conveyance element)

3.18 This enables the investment model to both run simulations of the system with the bulk transfer agreements fixed, or to run with optimisation of existing transfer pipeline utilisation.

3.19 Drought interventions may be included as options to enable better understanding of the impact of temporary use bans, non-essential use bans, drought permits and drought orders, and to better evaluate the investment cost of resilience to different levels of service.

3.20 Demand and supply options due for completion before the 2025 start of the planning horizon will be included in the baseline forecasts. Any sustainability reductions planned before 2025 will also be included in the baseline forecasts.

3.21 Companies will have agreed with regulators any other options that are considered fixed in the plan, for instance those which planning, development or construction is due to start before 2025 but complete beyond that date.

3.22 Demand reduction strategies per WRZ are developed by companies from combinations of available demand options to meet different demand reduction targets. Three per zone are envisaged. As recirculation of WAFU through effluent discharge is a consequence of demand levels upstream, for each demand strategy in upstream zones, the associated effect on downstream WAFU is calculated by the simulation model for input via the DLP.

3.23 New supply options and transfers can include elements, phases and stages as listed above; the combination of the components by the investment model defines when or if an option is commissioned, the maximum DO available, and the combined operational expenditure, which the optimiser uses in comparison with the operational expenditure of all other options to minimise utilisation while satisfying demand across all planning scenarios.

3.24 Whether options result in a need for new treatment capacity in a zone depends on:

- baseline demand growth
- amount of demand reduction that frees up existing treatment capacity
- amount of DO reduction that frees up existing treatment capacity (e.g. sustainability reductions)

3.25 If additional treatment is required these are taken into account when deriving the overall investment programmes.

3.26 WRSE's Multi-sector group and Environmental Advisory Group (part of SAB) will also provide potential options which will be considered in the investment model. Customer input to options is considered through their preference of option type.

3.27 A more detailed description of options development, appraisal, and option component mapping for modelling is included in Method Statement 1328 WRSE Options Appraisal.

Data flow and quality control

3.28 Regional planning input data outlined in section 2.1 is being delivered by several workstreams listed above. The majority of these workstreams are being undertaken by different contractors, and each may include local data storage and visualisation elements to streamline and audit data. To control the data sharing, data management and quality assurance across the regional planning process a centralised Data Landing Platform (DLP) has been created (see Appendix 1).

3.29 A complementary assurance process of the methods and data being used within WRSE will be undertaken to ensure the correct methods are being deployed by the companies.

4 Stage 2: Defining the Decision-Making Framework

4.1 This Stage has the following elements:

- Problem characterisation and risk-based planning
- Defining objectives for the plan
- Developing a suitable set of criteria and metrics that demonstrate whether and how the objectives are met.

4.2 Each of these points were discussed in pre-consultation on our plan and information added to our website.

Problem characterisation

4.3 Water Resources Planning uses a risk-based planning approach. The tools you develop and methods you employ to identify an overall best value solution should be commensurate with the risks in your planning area. In order to establish the level of risk we have taken the base data gathered in Stage 1 and carried out an assessment known as problem characterisation.

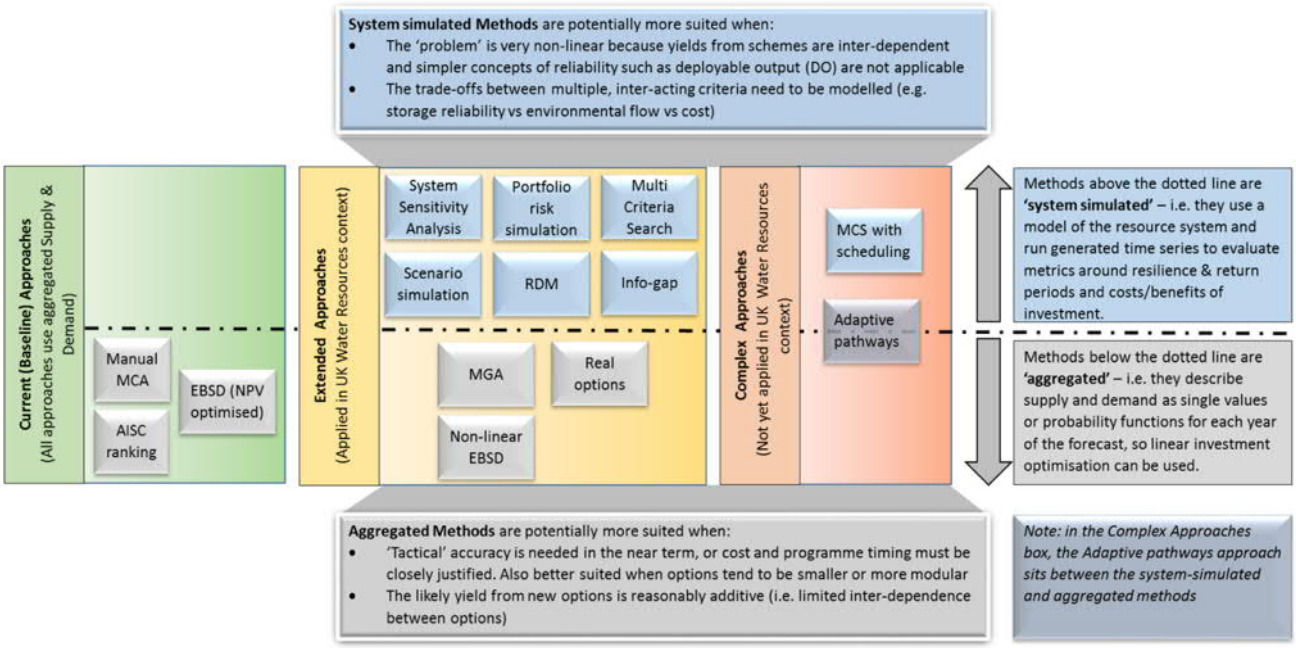
4.4 Problem characterisation enables us to examine the severity of any potential planning problems and the potential complexity of solution to those problems at WRZ-level. By combining these elements, we can establish an overall High, Medium, Low risk level for each zone, and go on to consider which tools are fit for purpose to meet those risks.

4.5 Our problem characterisation has been written up and will published on our website[5]. There are a range of risk levels identified at individual WRZ level. We consider that taken together at a regional scale, the overall risk for the South East of England to be High.

4.6 The UKWIR Decision Making Process guidance describes decision-making tools and supporting methods available from the simple to the complex, cost-based to full multi-metric, system simulated adaptive planning. Figure 4 is taken from the UKWIR guidance.

[5] www.wrse.org.uk/library

Figure 5: Decision making methods and tools for problems of different complexity



4.7 With WRSE assessing its level of risk as high, UKWIR Guidance recommends that we consider the use of extended or complex risk-based techniques to enable a thorough analysis of the planning problem. The decision support tools we have developed fit into the above matrix as set out in Table 3.

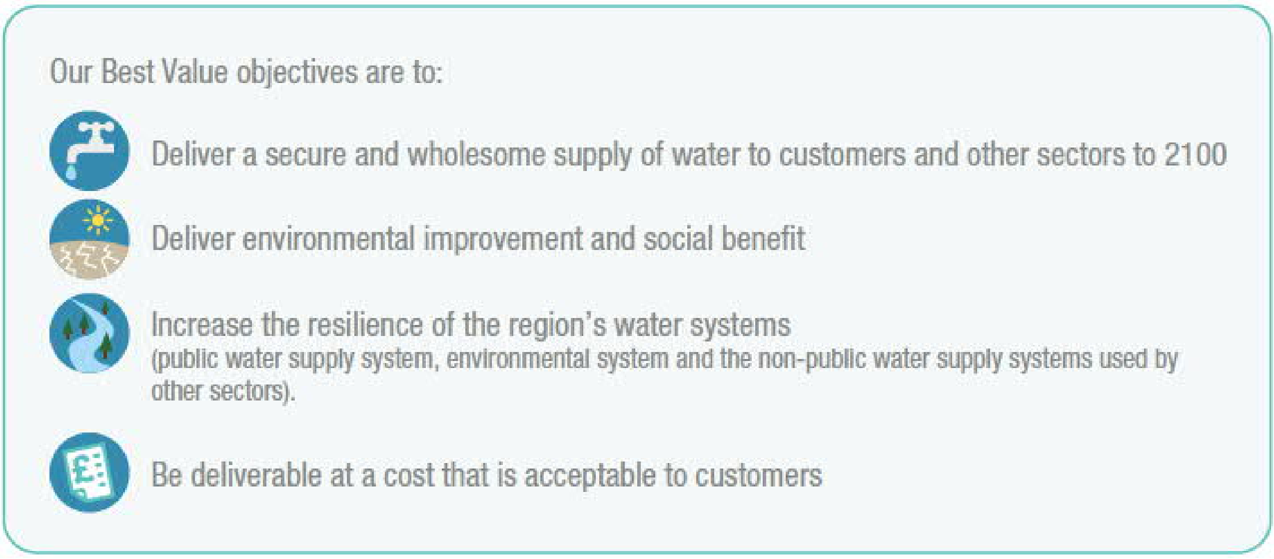
Table 3: Our Decision Support Tools and modelling approaches

Model	Method		Approach	Used for
Integrated Risk Model, Investment Model	Current	Aggregated	NPV optimised	Future situations and solutions - All WRZs
	Extended		Multi-metric optimisation	
	Complex		Adaptive Pathways	
Regional System Simulator	Extended	System-simulated	Scenario simulation	Supply calculation and Performance testing

Our objectives

4.8 In order to develop a Best Value plan, we first need to set its objectives – these are the high-level goals that our regional plan must aim to deliver relating to 'Best Value'. Using insight from water company customers across the South East to help us understand their priorities, our objectives are representative of what matters most to customers. We also shared our draft objectives with wider stakeholders to gather their views, which has resulted in the four objectives in Figure 5, below.

Figure 6: Our objectives



4.9 Water companies have a statutory duty to develop and maintain an efficient and economical system of water supply and to prepare, publish and maintain a Water Resources Management Plan (WRMP) which explains how this duty will be achieved.

4.10 The Water Resources Planning Guideline (WRPG) sets out the requirements for companies to follow in producing their plans and the Environment Agency's National Framework gives details of the indicative scale of challenge facing future water resource provision in England and requires water companies to work together in regional groups to meet the challenge and develop a cohesive set of water resource plans.

4.11 We developed our framework of objectives, criteria, and metrics with reference to the National Framework and the WRPG as primary reference sources to ensure our plan will meet legal, regulatory and policy expectations and is capable of incorporation/alignment with company WRMPs. Specifically, Section 9.2 of the WRPG sets out a suite of factors that need to be considered in the development of a best value plan including cost, affordability of your customers' bills and intergenerational equity; resilience to drought and non-drought events; environmental protection and improvement with specific reference to biodiversity, natural capital, net zero carbon; as well as customers' preferences.

4.12 We ensured that our proposed framework and overall approach covered all the factors identified in the WRPG. We also used insight from water company customers and stakeholders across the South East to help us understand their priorities and used this to shape the framework to reflect what matters most to them. We recognise that the four objectives are high level, but they are represented by criteria and metrics that give further detail and enable assessment of additional value.

Value criteria and metrics

4.13 As our objectives are high-level, we need to turn them into measurable indices on which we can assess best value.

4.14 Each objective is represented by a set of value criteria which, in turn, will each have an associated metric that will measure the additional value it delivers. We will use the criteria and metrics to assess the different water resource programmes that are produced through our investment modelling. We'll also use them to compare the shortlisted best value programmes and explain the differences between them and the additional value each delivers.

4.15 Each programme will comprise a series of options and will be a different version of what the plan could look like. Some of the value criteria identified are things that we 'must do', including the legal and regulatory requirements that our regional plan must meet to support companies' WRMPs. Others are topics or policy areas (things we "should-do") where there is a strong policy expectation that they will be achieved and/or the individual companies have already made commitments regarding their incorporation. These value criteria are described as constraints. For example, the secure and wholesome supply of drinking water to customers is an absolute requirement on companies; as is the demonstration of how all the water resource programmes we produce meet these requirements.

4.16 There are other criteria we will use to generate different programmes which deliver additional value. We will use these criteria and metrics to help us identify where value is added so we can differentiate between the programmes. These are described as optimised criteria and we will use them to shortlist the water resource programmes that offer 'Best Value' and help us to achieve our four objectives.

4.17 Once we have used these criteria to shortlist our 'Best Value' water resource programmes we will use the metrics, and potentially some additional metrics, to help compare the different programmes. This will facilitate the informed conversations we need to have with stakeholders and customers about their respective costs, benefits and outcomes, and will help us to identify any 'trade offs' in how different (optimised) value criteria are measured and weighted that need to be made before ultimately identifying the preferred water resource programme that will form the basis of our regional plan.

4.18 We will not be appraising and selecting individual options in isolation. We propose to appraise a series of programmes, each comprising options that we consider, by combination, meet our objectives, value criteria and deliver additional value.

4.19 There will be a number of potential best value programmes that could be adopted, each delivering alternative levels of value against different best value criteria. There is no single understanding of what is "best" but trade-offs will be made between different levels of value across the objectives.

4.20 Tables 4-7 below, set out the value criteria and the metrics that represent each objective.

Table 4: Value Criteria and metrics for the secure and wholesome supply objective

Deliver a secure and wholesome supply of water to customers and other sectors to 2100					
Value criteria	**Definition**	**How we'll measure it (metric)**	**Criteria type**	**Data source**	**Method statement / document**
Meet the supply demand balance	All the water resource programmes that we consider for the regional plan must meet the supply demand balance so there is no water shortfall in any of the water companies' supply areas over the planning period. This is a legal requirement.	Public Water Supply - supply demand balance profile (Ml/day)	Constraint	Final supply demand balance for public water supply	Regional planning tables
	The regional plan is also looking to address the future needs of other sectors. We've worked with representatives of sectors that rely heavily on water in our region to understand how much additional water they need the regional plan to deliver to meet their future needs.	Provides additional water needed by other sectors (Ml/day)	Constraint	Non-public water supply demand forecast	Multi-sector
Leakage	The South East water companies have committed to reducing leakage by 50% by 2050. All the water resource programmes that we consider for the regional plan will achieve this target.	50% reduction in leakage by each company by 2050 from 2017/18 baseline (%)	Constraint	SE water companies Annual Review 2017/18	Options appraisal
	There are options that would reduce leakage further over the planning period. We will develop programmes that include leakage reduction beyond 50% and use this criterion to assess and compare the performance of the shortlisted programmes.	% leakage reduction above 50%	Optimised	Option level assessment	Options appraisal
Water into supply	All the water resource programmes we consider will include options to reduce water use. At present there is no formal target for water consumption that we can include in our plan so we will develop programmes that include different levels of consumption reduction and use this criterion to assess and compare the performance of shortlisted programmes. Defra is considering a metric or target to encourage a reduction in the amount of water used. We'll revisit this if it is set to make it a constraint within the plan. In that event, anything beyond that target will be used to demonstrate performance of the shortlisted programmes.	Distribution input (DI)	Optimised	Option level assessment	Options appraisal
Customer preference	We have conducted research into customer priorities and preferences for different option types. This produces a score, and we will use this criterion to assess and compare the performance of shortlisted programmes. In addition to using this criterion to assess best value, we will engage with customers to help us consider the application of weightings to the different criteria and identify the preferred programme.	Customer preference for option type (score)	Optimised	Customer research	Customer engagement

Table 5: Value Criteria and metrics for environmental improvement and social benefit objective

Deliver environmental improvement and social benefit

Value criteria	Definition	How we'll measure it (metric)	Criteria type	Data source	Method statement / document
Strategic Environmental Assessment (SEA)*	Regional plans are non-statutory but we will apply the SEA criteria. The SEA informs the decision-making process through the identification and assessment of the effect a plan or programme will have on the environment. We will use the SEA to calculate the individual scheme scores. This does not replace the SEA process.	Programme benefit (score max) Programme disbenefit (score min)	Optimised	Option level assessment	Environmental assessment
Natural capital	Natural capital can be defined as the elements of nature that directly and indirectly produce value or benefits to people (now or in the future). There is no statutory target to increase natural capital, but it is an aspiration of the UK Government's 25-year Environment Plan. We will calculate the increase in natural capital that the different water resource programmes deliver and use this criterion to assess and compare the performance of different programmes.	Enhancement of Natural Capital Value (£m)	Optimised	Option level assessment	Environmental assessment
Abstraction reduction	Reducing abstraction from sensitive water sources is one element of how the regional plan will deliver environmental improvement. We will use our investment model and technical environmental work to optimise this, considering affordability, the expected benefits that will be derived and the timing of delivery.	Reduction in the volume of water abstracted at identified sites (Ml/day) and by when (date)	Constraint	Environment Agency scenarios and water company scenarios	Environmental ambition
Biodiversity	Improving biodiversity is required under a range of different legislation and policy and assessing the biodiversity net gain of our water resource programmes is a requirement of the Water Resources Planning Guideline. It is also an SEA objective. We will develop a net gain score** for each of our different water resource programmes and use this criterion to assess and compare the performance of different programmes.	Net gain score (%)	Optimised	Option level assessment	Environmental assessment
Carbon	The water industry has committed to achieving net zero operational carbon emissions by 2030. There is also an objective to reduce embodied and operational carbon emissions as part of the SEA. We will show how different water resource programmes seek to balance the additional carbon created through a combination of minimising emissions by considering alternative construction techniques and/or materials and by carbon offsetting schemes. The cost of this is included in the total programme cost but we will also use the cost of carbon offsetting to assess and compare the performance of different programmes.	Cost of carbon offsetting (£m)	Optimised	Option level assessment	Environmental assessment

*The Strategic Environmental Assessment (SEA) is a separate part of the programme appraisal process and includes a number of objectives and metrics. We consulted on the scope of our SEA and its objectives in August 2020. In addition to looking at the overall benefits and disbenefits we will also be undertaking further checks on the in-combination effects of different options working in conjunction with each other both from an environmental perspective and the ability to deliver the options within each programme.

**We will agree an appropriate method of calculating biodiversity net gain through discussions with regulators.

Table 6: Value Criteria and metrics for the resilience of the region's water systems objective

Increase the resilience of the region's water systems

Our multi-sector, regional resilience plan will plan for a wider range of shocks, stresses and events beyond drought and will assess the resilience of the region's main water systems:

- The public water supply system run by water companies
- The non-public water supply system that provides the water to other sectors
- The environmental water system.

We have developed a Resilience Framework*** so we can show how the resilience of each system is changed by the different water resource programmes. There are three components of our resilience assessment – reliability, adaptability and evolvability – which each have a set of associated metrics. We will produce a score based on the amalgamated metrics for each of these components and use this as a criterion to assess and compare the performance of different water resource programmes.

Value criteria	Definition	How we'll measure it (metric)	Criteria type	Data source	Method statement / document
Drought resilience	Water companies currently plan for a severe drought to occur once in every 200-years. The National Infrastructure Strategy[3] set a requirement for this to increase to once in every 500-years, increasing the level of resilience, this has been endorsed by HM Treasury. All the water resource programmes we produce will achieve this level of resilience. We will use the Best Value planning approach to identify the optimum time we can achieve this increased level of resilience.	Achieve 1 in 500-year drought resilience (date achieved)	Constraint	This is included as a requirement in the National Infrastructure Strategy	
Resilience assessment **Reliability**	Reliability is the ability to withstand short term shocks without actively changing the performance of the system.	Programme reliability score	Optimised	Resilience assessment	Resilience Framework
Resilience assessment **Adaptability**	Adaptability is the ability to make a short-term change in performance of the system to accommodate the impact of a shock and recover.	Programme adaptability score	Optimised	Resilience assessment	Resilience Framework
Resilience assessment **Evolvability**	Evolvability is the ability to modify the system function to cope with long term trends.	Programme evolvability score	Optimised	Resilience assessment	Resilience Framework

***We consulted on the Resilience Framework in June 2020. It sets out a method for assessing resilience across the three main water systems – public water supply, non-public water supply and the environment. We have responded to feedback and developed it further through engagement with stakeholders. You can view the final Resilience Framework Method Statement here.

[3]National Infrastructure Strategy, November 2020

Table 7: Value Criteria and metrics for the acceptable cost objective

Deliverable at a cost that is acceptable to customers					
Value criteria	**Definition**	**How we'll measure it (metric)**	**Criteria type**	**Data source**	**Method statement / document**
Programme cost	This represents the total cost of delivering all the options in the water resource programme. It uses the standard HM Treasury rate to calculate the total programme cost. We will use this criterion to assess and compare the performance of the different water resource programmes.	Net Present Value (£m) using the Social Time Preference Rate (STPR)	Optimised	Option level assessment	Option appraisal
Inter-generational equity	This criterion also looks at the total cost of the programme but calculates it using a lower HM Treasury rate that spreads the cost of the programme over the planning period delivering best value for both present and future generations. We will use this criterion to assess and compare the performance.	We are using the long Term Discount Rate (LTDR)	Optimised	Option level assessment	Option appraisal

How the metrics are calculated

4.21 Most of the optimised metrics used in best value appraisal are calculated using information that is evaluated at option-level. The IVM takes the option-level information and combines it to make programme-level assessments.

4.22 Combining option-level information to make a programme-level assessment can be as simple as adding option-level values together. In other cases, further calculations are made e.g. the cost metrics, where each of the schemes have to be scheduled over the planning period and costs discounted over time.

4.23 The key data source for each of the metrics, links to the relevant method statements where further information can be found, and a summary of the programme-level calculation is in Table 8.

Table 8: BVP Metrics: Links to other method statements

Metric	Data Source	Option-Level Method Statement	Programme-Level Calculation
Least cost & Intergenerational equity	Option level assessments	Options appraisal	Schemes scheduled into a programme. Costs of programme elements scheduled and discounted.
Leakage (optimised post-2050)			Baseline demand minus savings of chosen DM programme
Water Consumption			
Environmental benefit		Environmental Assessment	Sum of individual scheme scores
Environmental dis-benefit			
Biodiversity net gain			Sum of impact score
Natural capital			£/yr per selected option, summed up over the planning period (expressed as £m)
Carbon			Sum of total Carbon emissions, monetised
Reliability		Resilience	Sum of scheme values
Adaptability			
Evolvability			
Customer preference for option type	Customer research	Stakeholder	Sum of scheme values

Double counting

4.24 We recognise there is a risk of double counting or double consideration of the benefits and dis-benefits of some of the metrics, in particular between each of the environmental metrics and between the resilience metrics. Additionally, the carbon metric is a sub-set of the cost metric. We will carry out a sensitivity analysis to provide confidence that the plans are robust and to understand the impact of different scenarios. This will allow us to explain in the regional plan whether any double counting risk has been identified and how it has been accounted for in our decision making.

5 Stage 3a: Integrated risk modelling

5.1 Stage 3 represents the core modelling stages of the BVP process and is split into two parts:

- Stage 3a – Integrated Risk Modelling which produces the water resources planning problems over the planning period from the wide range of potential futures/situations.
- Stage 3b – Investment Modelling in which the problems provided by the IRM are solved to produce investment programmes for comparison and shortlisting.

Overview

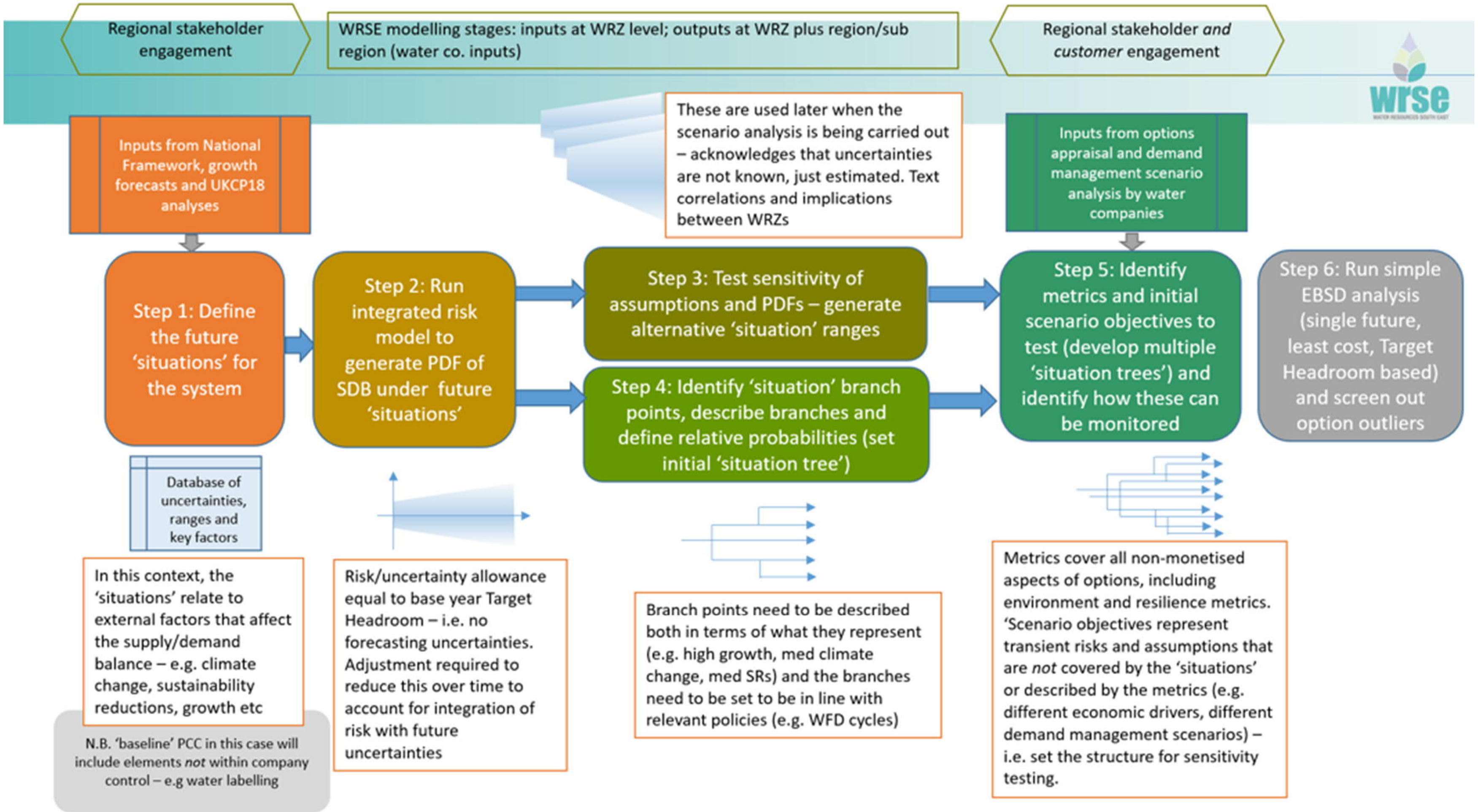
5.2 The Integrated Risk Model (IRM) derives the water resource planning problems to be investigated by the investment model. The process is split into five steps as described in the Resilience Framework (Figure 6).

5.3 Technical details of the IRM model are provided in Appendix 2.

5.4 Using the IRM through Steps 1-5 we will identify a large number of single future situations and combined situation trees (explained below) to be passed to the Investment Model (IVM). From this number, we will establish three important planning baselines that will be used to describe the development of the plan:

- The *core* baseline situation – Following the requirements of the WRPG (see Step 1)
- A *most likely* baseline situation – This the core baseline with an allowance for environmental destination (see Step 3).
- A *baseline situation tree* – This is a branched pathway through the planning period used for adaptive planning (see Steps 4-5). It is likely that the core and the most likely single baseline situations will form two of the branches of the baseline situation tree.

Figure 7: Integrated Risk Modelling as part of development of a plan



Process Steps

Step 1: Defining futures

Key uncertainties

5.5 We consider that key future uncertainties in the supply demand balance relate to:

- Growth – Population and property growth in the South East
- Climate change – The impact of climate change, particularly on supply availability
- Environmental ambition– The amount of abstraction reduction that we need to plan for environmental and social reasons

5.6 These are by no means the only challenges or drivers for change, (other uncertainties include efficacy of demand management, leakage reduction and behavioural change by way of example) but they represent the areas that are most likely to cause significant medium to long-term uncertainty and potentially large step changes to the supply demand balance for water in the future.

5.7 Further details on the range of scenarios produced for each of the key uncertainties are available in the population and properties, climate change and environmental method statements respectively. However, we summarise in the following sections.

The core baseline position

5.8 For previous regional plans by WRSE (that supported the preparation of previous Company WRMPs) a single baseline situation was defined, and alternative futures used to describe the risk around that situation (as headroom), following the WRPG.

5.9 Our approach for this regional plan, the first under the National Framework, is to bring the analysis of futures earlier in the planning process, because of the levels of complexity and uncertainty we face. We will have a range of baselines with alternative futures available for the investment model to select from and solve individually or at once.

5.10 Nevertheless, we are still currently required to illustrate a single, core baseline situation, as companies are still required to produce one for their WRMPs. This will help the integration of the regional plan with individual companies WRMPs. We have defined our core baseline scenario (Table 9) based on company information and guidance from the regulators.

Table 9: Assumptions in the core baseline scenario

Area	Scenario	Description
Growth	Housing Plan	Growth taken from Local Authority housing plans, then ONS-18 when plans cease Usage reductions assumed as per company plans to 2025 then only baseline water efficiency and optant metering as per the WRPG.
Climate Change	Median	A number of climate change scenarios have been developed using UKCP_18 spatially coherent climate datasets. The core baseline scenario includes the median position.
Environmental ambition	Central	Sustainability reductions scheduled to take effect by 2025 are included, together with the company "central" forecast of further reductions.
Drought resilience	1:500 by 2039/40	As required by the WRPG.
Non-PWS demand	Included	The regional plan is to include non-PWS demand.

5.11 We have chosen this core baseline scenario because:

- it aligns with regulatory expectations to use a Local Authority-based growth projection, to show the plan is not limiting planned growth;
- it uses a median climate change scenario which we consider a reasonable basis for uncertainty, without under or over representation; and
- Environmental destination is a policy choice to be analysed during programme appraisal.

Alternative baseline situations

5.12 There are a large number of potential alternative future situations, based on differing assumptions for growth, climate change and environmental destination.

5.13 We have identified a range of alternative assumptions for each key future uncertainty, the bases for which are discussed further in each of the supporting method statements. Combining these leads to over 5,000 potential alternative situations.

5.14 The IRM is then used (in Step 2) to generate supply-demand balances (SDBs), and thus the range of potential deficits, for all the above potential situations.

5.15 Before running the IRM to describe the range of situation uncertainties, the supply and demand forecasts input via the DLP are first combined into the following scenarios:

- Normal Year Annual Average (NYAA),
- Dry Year Annual Average (DYAA),
- Dry Year Critical Peak (DYCP), and
- A combined drought planning scenario (EMDO).

5.16 The reason for a combined drought planning scenario is to take account of changing levels of drought resilience within the planning period. The draft revised guidance states that 1:500 resilience should be attained in the 2030s; and as such the EMDO baselines will represent 1:200 DO and DI until 2030, and 1:500 DO and DI from 2040, but the exact date of change from one level to the other may be varied in different SDB scenarios for optimisation in the investment model, or sensitivity testing of preferred regional plans.

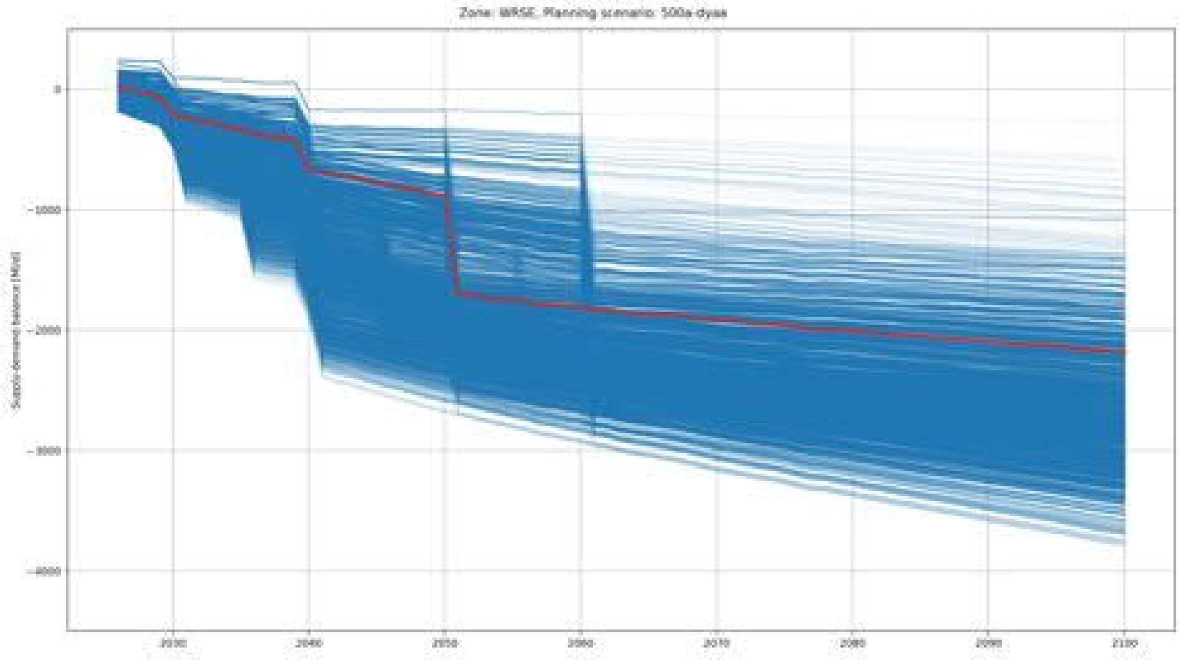
5.17 For the multi-sector non-public water supply demand we will use the NYAA, DYAA and DYCP forecasts but there might not be significant differences between their values given the nature and maturity of the available data. We will work with the multi-sector stakeholder group to better understand their typical seasonal demand pattern use.

Step 2: Generating futures

5.18 The IRM takes the information for all the potential futures and combines them to develop an overall spread of potential future baseline supply demand situations over the planning period, an example of which is shown in Figure 7.

5.19 Using our decision support tools it is possible to interrogate which combination of growth, climate change and environmental destination scenarios are used to generate each line on the graph. For example, the red line on the graph represents the core baseline, plus an environmental destination scenario for 2050 provided by the Environment Agency.

Figure 8: Future baseline supply-demand balance situations (example)



5.20 It’s not necessary (and impractical) to pass every possible baseline situation into the IVM to derive potential solutions.

5.21 We will choose a range of single situations (Step 3) and also develop situation trees, i.e. a combination of situations forming a branched pathway (Steps 4 and 5), to explore the range of potential futures.

Step 3: Choosing single situations

5.22 Single pathway analysis is the simplest and quickest method to initially test what mix of solutions will be generated by the IVM. We will select a representative range of single baseline situations (including the core baseline situation) and pass them to the IVM to produce a single, least cost solution for each selected baseline situation.

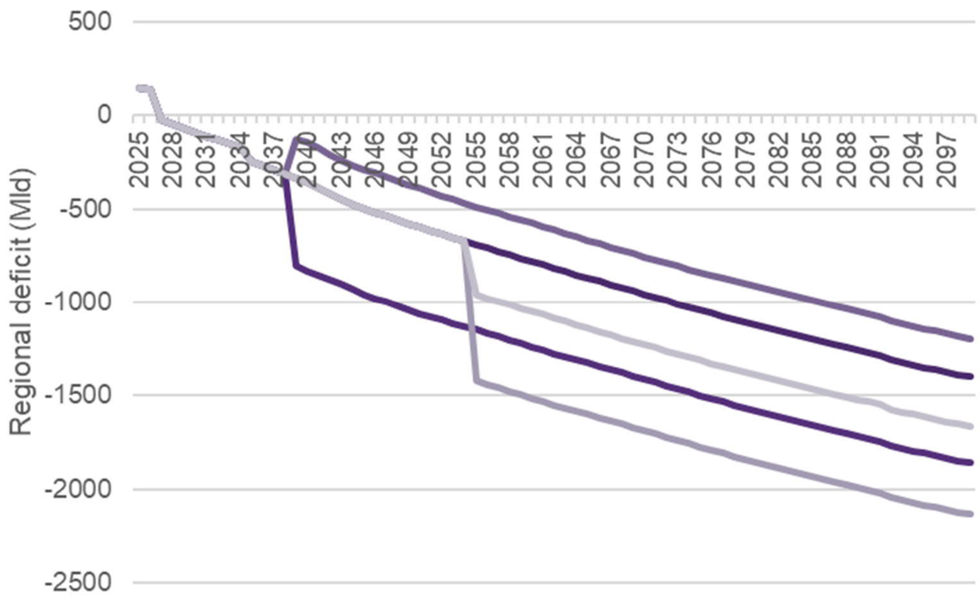
5.23 The number of situations sent to the IVM will be influenced by a number of factors. These could include discussion around the impact of specific policies where early provision of outline model outputs would inform the debate e.g. the potential impact of different Environmental Destinations, as well as to sample the general range.

5.24 The library of other situations not selected will still help us during the performance testing of shortlisted programmes in Stage 5 of the BVP process.

Steps 4 and 5: Choosing branched pathways – 'situation trees'

5.25 The IVM modelling is able to optimise solutions across a number of different baseline situations at once. As such the IRM is used to generate situation trees, like the one shown in Figure 8, below.

Figure 9: Example situation tree of one planning scenario



5.26 The idea is to produce a situation tree which reasonably spans the potential range of future situations. Branching points emerge for a number of reasons. These can be chosen based on regular time intervals with branches wide enough to cover the spread, or they can be related to policy deadlines set within the objectives or analysis of the options database. For example, where we can anticipate decisions may be required between strategic development options.

5.27 We can use two alternative approaches to define the situation trees (and branching points) within the IRM:

- Probabilistic – Use a Monte Carlo approach to turn the range of situations into a probability density function and then select specific percentiles across the spread to create SDB deficits; or
- Deterministic – Combine pathways from Step 2 (e.g. follow a particular growth and climate change pathway before branching at a point in time depending on the choice of environmental destination scenario)

5.28 We intend to follow the deterministic approach in the first instance as we consider that being able to explain each branch of the tree in terms of a specific set of forecasting assumptions will be more understandable for stakeholders. It will also give a clear line of sight to the datasets on which the scenario was derived.

5.29 We will test how the probabilistic method performs as part of sensitivity and performance testing.

5.30 Review, assurance and sign-off of the single pathway and situation trees will be undertaken throughout the programme appraisal process with PMB (Stage 3b).

IRM Visualisation

Problem visualisation: baseline forecasts & existing transfers

5.31 The proposed visualisation tool (VT) enables viewing of supply demand balance scenarios on a map and chart, and exploration of the change in them through time. The WRSE VT will be used to show how existing transfers are utilised through time to meet the demands in the receiving water resource zone (see Figures 9 and 10 for examples).

Figure 10: Example visualisation of baseline forecasts

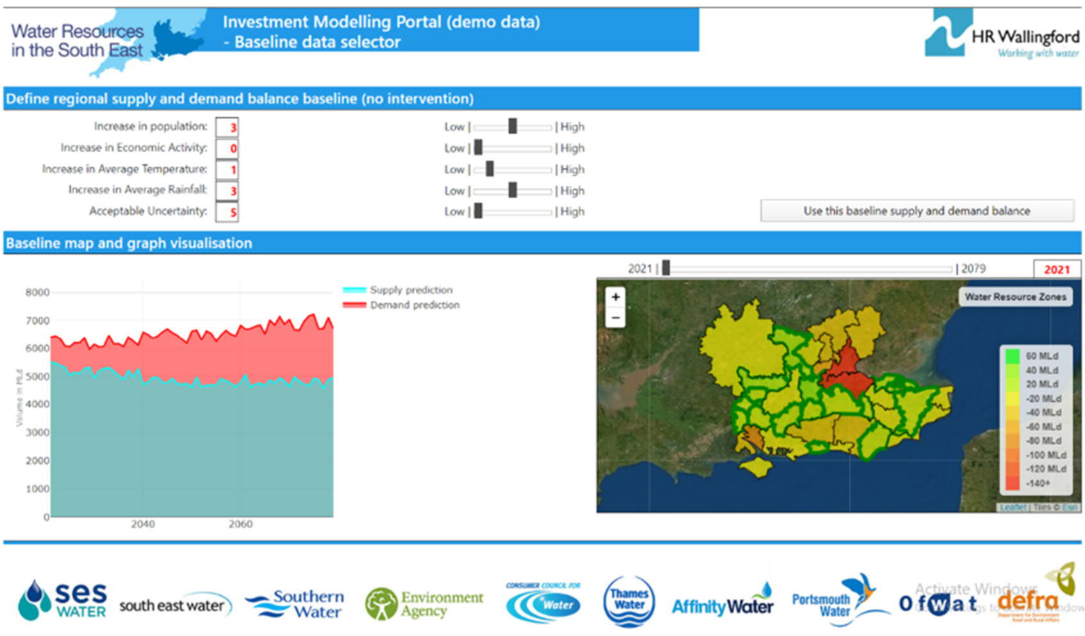
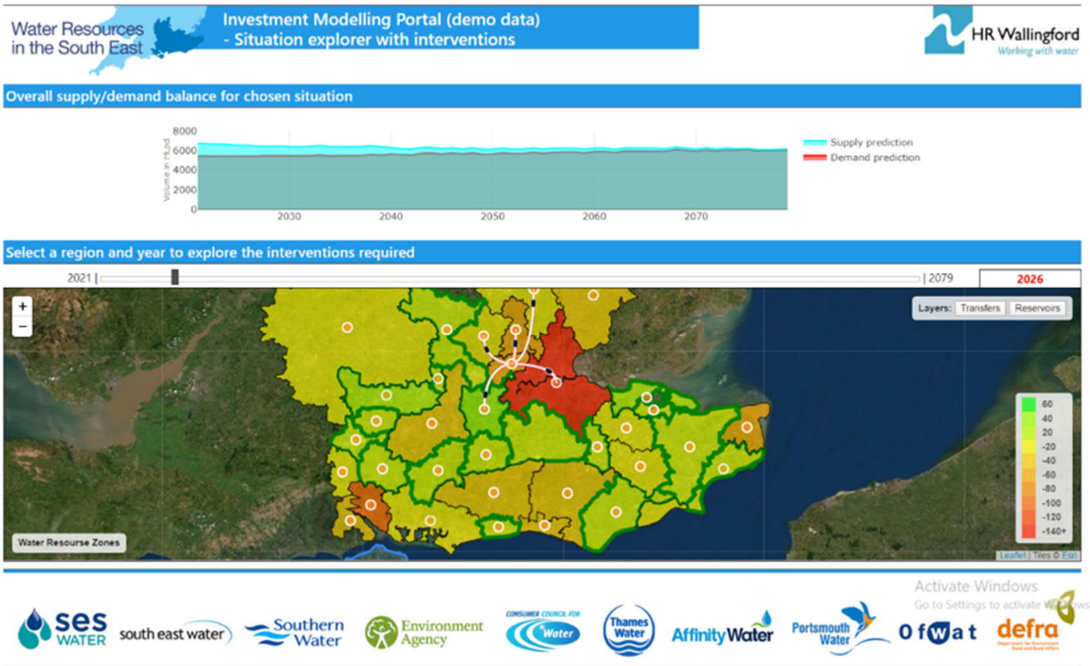


Figure 11: Example visualisation of transfers



5.32 The purpose of the VT and the various map layers within the tool is to gain a better understanding of what is driving the requirements for water, where the requirements are, and how the existing infrastructure can cope (or not) with these requirements.

5.33 It is intended that similar visualisation tools are used to view the final preferred plan and its alternative plans.

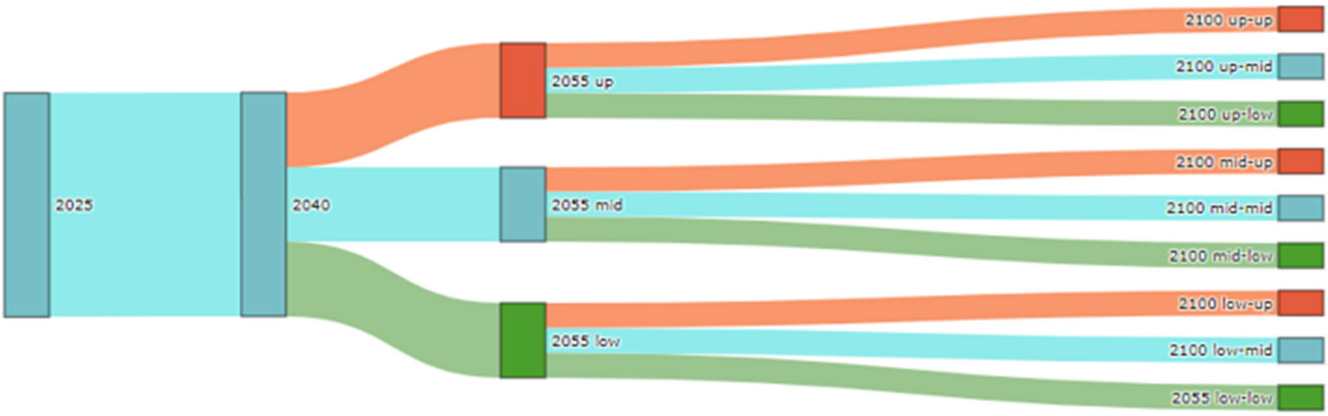
Problem visualisation: Situation trees

5.34 The amount of water required through the planning period will change according to some key external influences such as climate change, population growth, policies and the requirements of the environment in the future. We will use animated 'Sankey' plots (see Figure 11 for example) to visualise the situation trees through time, for both problem and solution understanding.

5.35 For each of the branches we will explain the factors that influence the anticipated levels for the supply demand balances. This will provide regulators, stakeholders and customers with a better understanding of the characterisation of these branches.

5.36 In many cases, the anticipated supply demand deficits could be achieved by several different combinations of external factors. Although at the more extreme ends of the supply demand balances tend to be driven by a more limited number of factors (e.g. more extreme climate change or environmental destination scenarios).

Figure 12: Example sankey plot to visualise the situation trees



6 Stage 3b: Investment modelling

Overview

6.1 Technical details of the Investment Model (IVM) are provided in Appendix 3.

6.2 The primary purpose of the IVM is to identify and schedule programmes of options to meet the supply demand challenges passed to it by the IRM. It is able to:

- Conjunctively optimise for all planning scenarios and all WRZs at the same time.
- Ensure the supply demand balance remains in surplus each year of the planning period, for all planning scenarios, in all WRZs, while minimising or maximising the value of a single objective function (e.g. cost), or multiple objective functions (e.g. a cost and an environmental or resilience function).
- Optimise against a single future situation or for a situation tree as defined by the IRM.

Model operation

Modes of operation

6.3 The IVM operates in three different modes: EBSD, Adaptive and Pareto (see Table 10, below).

Table 10: IVM Modes of operation

IVM Mode	Future Situations	Objective Function	Used for
EBSD	Single	Cost	Investigating different future situations and performance testing.
Adaptive	Tree	Cost	Investigating adaptive plans across multiple future situations. Identifying the least cost programme.
Pareto	Tree	All	Producing programmes optimised against alternative single and multiple objective functions.

6.4 The EBSD mode can only consider a single future situation produced by the IRM at a time. We use a series of EBSD mode runs for initial investigation of the potential range of futures (Step 6) and to carry out "what-if" type analysis, where we are interested in identifying a broad indication of changes between programmes (Stage 5). As this is an investigative mode, we optimise on least cost considerations only at this point, consistent with guidance.

6.5 The Adaptive mode optimises across all the branches of a situation tree produced by the IRM, rather than a single branch. We use this mode to investigate adaptive planning decisions, optimising on cost only. It is used to identify the least cost adaptive programme.

6.6 The Pareto mode, like the adaptive mode optimises across all branches of a situation tree. We use this mode to produce programmes using objective functions other than just cost. This is a key function required for best value planning.

Objective functions for programme development

6.7 In all runs of the IVM the primary objective is to ensure the supply demand balance is not in deficit in each year of the planning period, in all planning scenarios and in all WRZs. This is to ensure that statutory supply duties of the individual water companies can be met, and is a statutory function of the WRMP.

6.8 There are then optimisable objective functions (as defined in Stage 2) that can be used to focus how the model achieves the primary objective. As such, we can seek to develop investment programmes which may perform better in terms of cost, resilience, environmental impact or social value. The optimisable functions are shown in Table 11, below.

Table 11: Optimisable objective functions

Optimisable function	Unit	Code	Function
Least cost	£m NPV	COST	Minimise total NPV using the Social Time Preference Rate (STPR) discount rate
Intergenerational equity	£m NPV	IGEQ	Minimise total NPV using The Health Discount Rate (THDR) discount rate
Environmental benefit	Score	ENV+	Maximise, for all operation years, for all WRZs, the sum of the ENV+ scores for all new options
Environmental dis-benefit	Score	ENV-	Maximise, for all construction and operation years, for all WRZs, the sum of the inverted ENV-scores for all new options (to ensure poorly performing programmes can be identified)

Optimisable function	Unit	Code	Function
Biodiversity net gain	%	BING	Maximise, for all years, for all WRZs, the biodiversity net gain values for all new options
Natural capital	£m	NATC	Maximise, for all years, for all WRZs, the natural capital values for all new options
Carbon	£m	CARB	Minimise, for all years, for all WRZs, the total cost to offset carbon emissions.
Reliability	Score	RELI	Maximise, for all years, for all WRZs, the reliability score for all new options
Adaptability	Score	ADPT	Maximise, for all years, for all WRZs, the adaptability score for all new options
Evolvability	Score	EVOL	Maximise, for all years, for all WRZs, the evolvability score for all new options
Leakage	Reduction above 50%	LEAK	Maximise for all years, for all WRZs, the reduction in leakage
Water Consumption	Litres/person	CONS	Maximise for all years, for all WRZs, the reduction in distribution input per person
Customer preference for option type	Value	CUPR	Maximise, for all years, for all WRZs, for all planning scenarios, the value based on customer preference for option types proportional to the volume supplied by each type

6.9 The IVM can optimise against:

- a single objective function (COST or NATC or CUPR)
- or dual objective functions, (i.e. COST and NATC – the model will seek to find the solution that optimises the values of both functions together).

6.10 The resulting programmes of options are sent to the visualisation tool for appraisal (Stage 4).

Single function optimisation runs

6.11 Single function optimisation runs are performed in the IVM for all 13 of the optimisable functions. In each case the run will seek to either maximise, or minimise the metric value or score, as per the table above.

6.12 The WRPG requires that the plan must include a least cost programme. The least cost run is the output of a single function optimisation as described below.

Least cost

6.13 Least cost runs are produced by optimising against the COST function. Runs will be produced with the IVM in EBSD mode (only considering a single future situation, Step 6) and with the IVM in adaptive mode (considering a range of future situations, Step 7).

6.14 A least cost run (in either mode) minimises the cost for all selected options for all zones, following existing HM Treasury rules for discounting (using the STPR[6]) of:

- NPV Capital costs (annuitised)
- NPV Fixed operating costs
- NPV Variable operating costs (frequency weighted average of NYAA, DYAA, DYCP & EMDO)
- NPV Embedded carbon costs
- NPV Fixed operational carbon costs
- NPV Variable operational carbon costs

6.15 A large number of least cost runs will be produced, one for each single situation and situation tree given to the model.

[6] HM Treasury Green Book *Social Time Preference Rate*.

Dual function optimisation runs

6.16 Dual function optimisations are run with the IVM model in pareto mode.

6.17 In this mode the model seeks to optimise the values of two functions at the same time. This is useful as it forces the optimiser to find a balance between otherwise competing metrics. Any two functions can be chosen, but most commonly it will include one of the cost functions.

6.18 If desired, boundaries can be set to the primary objective function limiting the search range for the secondary, for example:

- maximise environmental net gain within a 20% cost increase from the least cost programme, or
- minimise cost within a greater than 20% increase in environmental net gain from the least cost programme.

Process Steps

6.19 The IVM phase can be broken down into several steps, as shown in Figure 12 overleaf. Each of the steps are described in the remainder of this section.

6.20 In summary, the single future situations and situation trees developed in Steps 3-5 are passed to the IVM and are optimised against COST in EBSD mode (Step 6, single futures) and Adaptive mode (Step 7, situation trees). The outputs are presented via the visualisation tool (Steps 8 and 9).

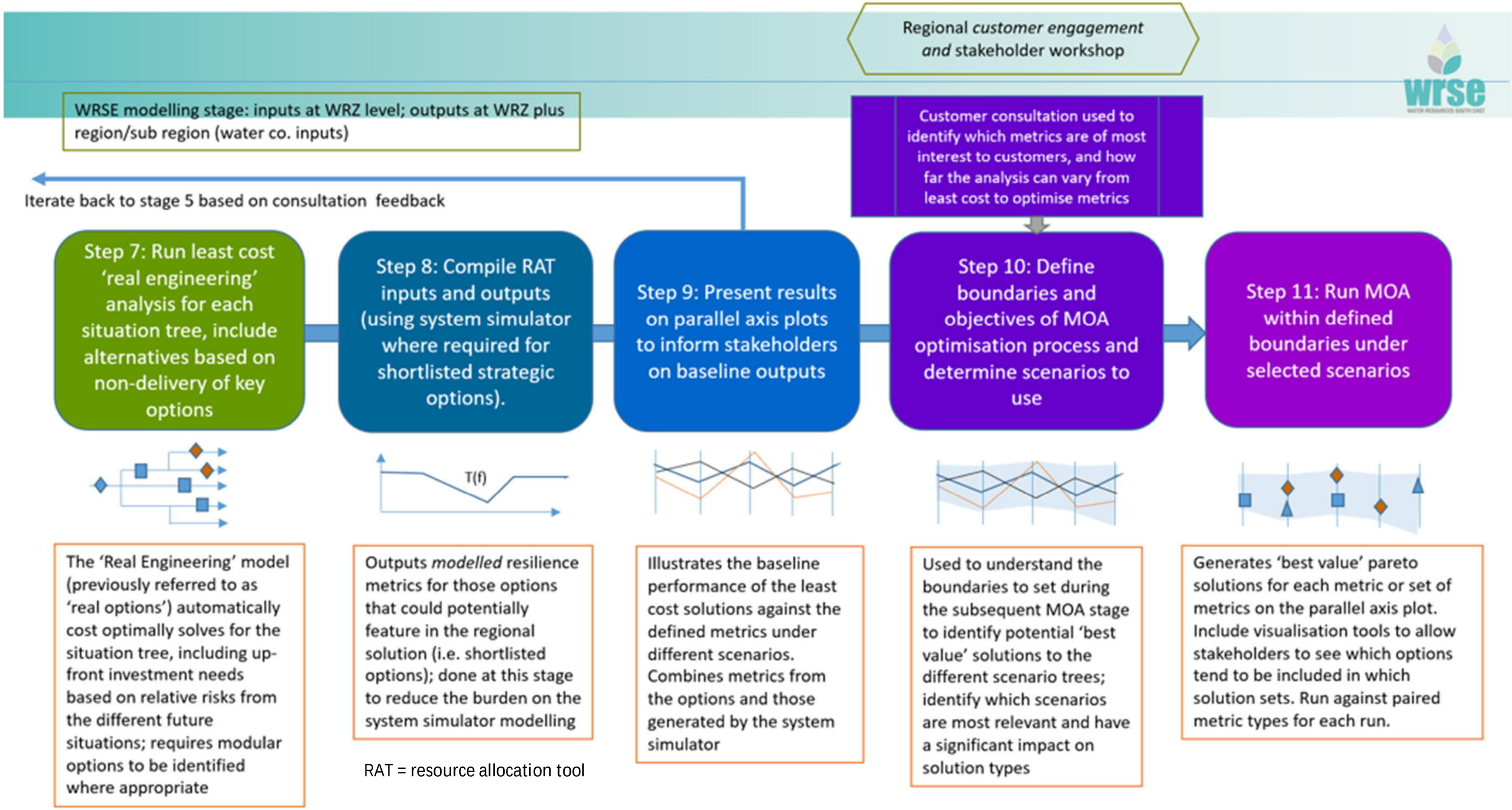
6.21 The outputs will help us form an initial view of the sort of solutions produced by the IVM and identify trends and issues. The situations run will also generate information to inform policy discussions, such as the consideration of environmental destination or the impact of non-PWS demand. The outputs will inform the ongoing stakeholder consultation process and help establish which options are selected more frequently and initial tipping points.

6.22 Taking all of this information into consideration, we will be able to identify our preferred least cost solutions to the baseline planning problem.

6.23 Alternative programmes of investment will then be developed using metrics other than COST and both single and multi-objective optimisations (Steps 10 and 11, with the IVM in Pareto mode).

6.24 The outputs of these runs are also viewed in the visualisation tool and passed to Stage 4 of the BVP process for the shortlisting.

Figure 13: Investment Modelling as part of development of a plan



Step 6: Least cost assessment (single situation)

6.25 This is a model running step where the single future situations from Step 3, covering a range of growth, climate change and environmental destination scenarios and including the core and most likely baseline situations, are passed forward to the IVM,

6.26 These are input to the IVM and initial least-cost runs completed in EBSD mode, optimising only on the COST metric.

6.27 The programmes produced by the optimisation are for information only (as we are seeking an adaptive plan, not one robust to a single future) and used to identify broad patterns and trends in the options selected and contribute to policy debates (see Step 9).

Step 7: Least cost assessment (situation tree)

6.28 This is a model running step where the situation trees from Steps 4 and 5, including the baseline situation tree, are passed forward to the IVM.

6.29 With the IVM now run in Adaptive mode, and optimising only on the COST metric, the IVM expands the optimisation to find the best solution that could meet the SDBs in all branches of the situation tree across the planning period. It will demonstrate solutions that can adapt to future change.

6.30 The outputs will be compared and assessed in Step 9.

Step 8: Preparation of performance testing tools

6.31 Step 8 is an internal advisory step where we inform the resilience and environment teams of the early outputs of Steps 6 and 7 so they can prepare their tools and be aware of the option types and ranges being produced by the optimisations. This facilitates the subsequent performance testing undertaken in Stage 5 of the BVP process.

Step 9: Comparison of least cost runs

6.32 In Step 9, all the least cost runs from Steps 6 and 7 are compared using the visualisation tool.

6.33 We focus particularly on the parallel plot visualisation, which charts the overall performance of each optimised run against each of the value criteria and their metrics, and also option scheduling tables that give us the types of options selected, where they are selected, when they are selected and how they are utilised across the planning period.

6.34 Further information on these plots can found in Section 8: Shortlisting.

6.35 The plots will also help identify zones or areas where additional options, alternative option yields, or additional or alternative transfers could be beneficial, and identify options which are never selected in any scenario.

6.36 We can also look at conjunctive use across the region, where existing formal bulk transfer agreements between WRSE zones are waived and the model optimises the transfer of water based on capacity of existing and potential transfer pipelines only, to identify the least cost sharing of resources and identify the minimum required resource development.

6.37 The EBSD mode outputs from Step 6 will identify the least cost solution to the single future baseline (from Step 1).

6.38 The Adaptive mode outputs from Step 7 will be analysed in the same way, but additionally we will be looking to:

- Identify a sub-set of situation trees that will be taken forward for full multi-metric modelling in Step 10 and further comparative analysis in Stage 4.
- Identify the Least Cost solution to the agreed baseline situation tree.

Steps 10 and 11: Optimisations with full suite of alternative metrics

6.39 With the IVM now run in Pareto mode, we will complete single and dual optimisation runs of the full suite of metrics across the sub-set of situation trees identified in Step 9. As before, the model will find solutions that can meet the SDBs in all branches of each situation tree across the planning period.

6.40 In Step 10 we confirm which single and dual optimisations will be run. In Step 11 we carry out the Pareto modelling on the situation trees identified in Step 9 and return the outputs to the DLP for visualisation. The outputs will be compared and assessed in Stage 4.

IVM visualisation

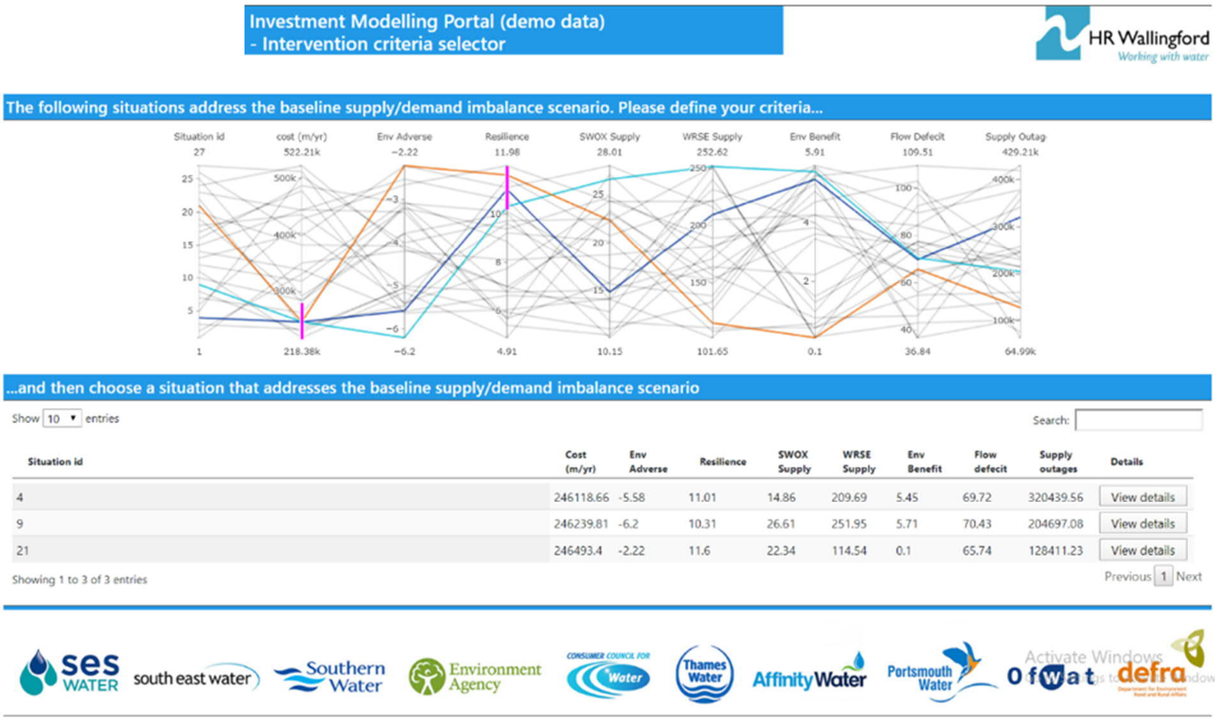
Parallel plots

6.41 Parallel axis plots are an established way of visualising programme performance across a range of best value metrics. An example parallel axis plot is shown in Figure 13.

6.42 Each (vertical) parallel axis will represent a best value metric. By plotting the performance of each metric for each individual programme we can understand which programmes perform better than others and investigate links and trade-offs between the metrics.

6.43 From this we are able to filter outputs based on performance for each best value metric to 'zoom-in' on a programme of interest (filters shown in pink in the figure below). We can also select individual runs and link them to an options schedule, check utilisation profiles at WRZ-level etc…

Figure 14: Example of programme metrics on a parallel axis plot



Options schedule

6.44 Through the VT, we will be able to show temporally and spatially which options types and specific individual options are selected in each run. This will allow stakeholders, customers and regulators to review which schemes have been selected at both a regional level and WRZ-level.

6.45 In addition, scheme utilisation information identifies if an individual scheme is used to its fullest capacity, ramps up or down or used intermittently.

6.46 These example tools and graphical displays demonstrate how WRSE will be able to provide programme information to regulators, stakeholders and customers, as outlined in Figures 14 and 15.

Figure 14: Example mapping of programme options

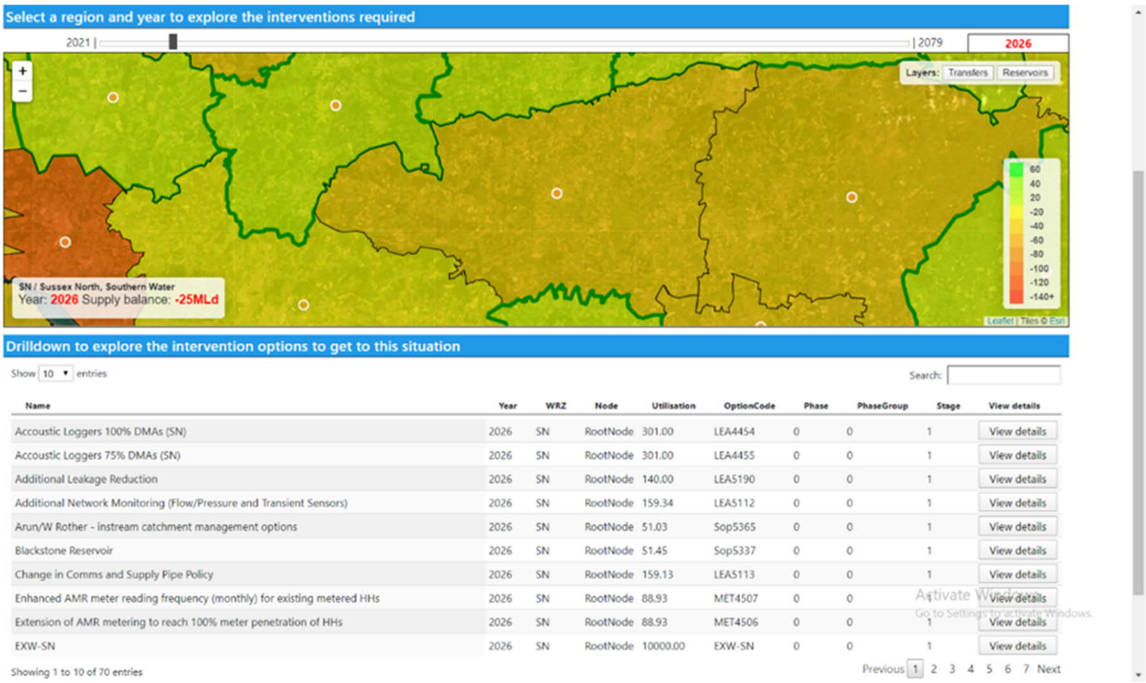
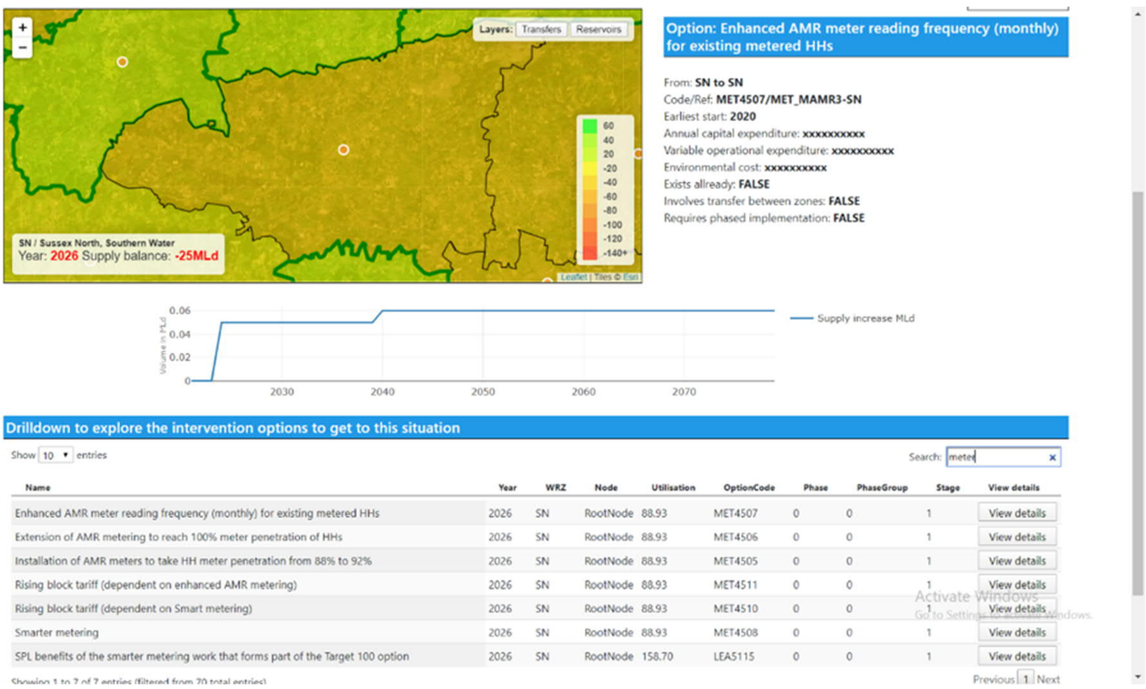


Figure 15: Example viewing individual options



7 Stage 4: Shortlisting

Overview

7.1 The IVM will output a large portfolio of optimisation runs in Stage 3b.

7.2 In Stage 4 we aim to focus in on a set of potential programmes that meet the planning problems whilst providing a range of additional value.

7.3 Shortlisted runs need not only perform well (in general) against the planning metrics but also provide variety in the types of options that are being selected. Each can then be taken forward for further performance testing (Stage 5).

7.4 Each optimisation run output contains information that will help decision makers and stakeholders in completing their review, particularly:

- The performance of the optimised programme against the best value metrics (which at this stage are evenly weighted) and
- The schedule in which options are selected along each path of the situation tree and how much they are used.

7.5 We are configuring specific functionality within the visualisation tool to be able to view and interrogate these outputs, as explained above. These forms of plots and visualisations are key to the development and understanding of the overall investment programmes and our discussion with customers and stakeholders to gain opinion on the various investment portfolios.

Programme shortlisting

7.6 The following two optimisation runs are automatically shortlisted as required by the WRPG:

- Least cost programme - this will be the programme that delivers the least cost solution to the chosen baseline situation tree (from Step 9).
- Best environmental and society programme – this programme is not optimised on cost, but will be the programme that we consider delivers best overall environment and society value outcomes. We will identify this by taking into account overall performance across the SEA, Natural Capital and Biodiversity Net Gain metrics, and through engagement with stakeholders.

7.7 We will also shortlist a range of alternative best value programmes for further assessment, taking all of the programmes that were optimised in Step 11, together with the chosen least cost solution and best environment and society programme.

7.8 We will plot all of these programmes, to enable our Programme Management Board (PMB) to make an initial selection of the best value programmes. This may not necessarily be the programmes which deliver the highest performance against each of the individual metrics, according to the model, as customer and stakeholder feedback, together with professional judgement will also be considered.

7.9 The justification for their initial selection will be documented, before being passed to Stakeholder Advisory Boards (SAB) and the Senoir Leadsership Team (SLT) as part of our decision making and governance processes.

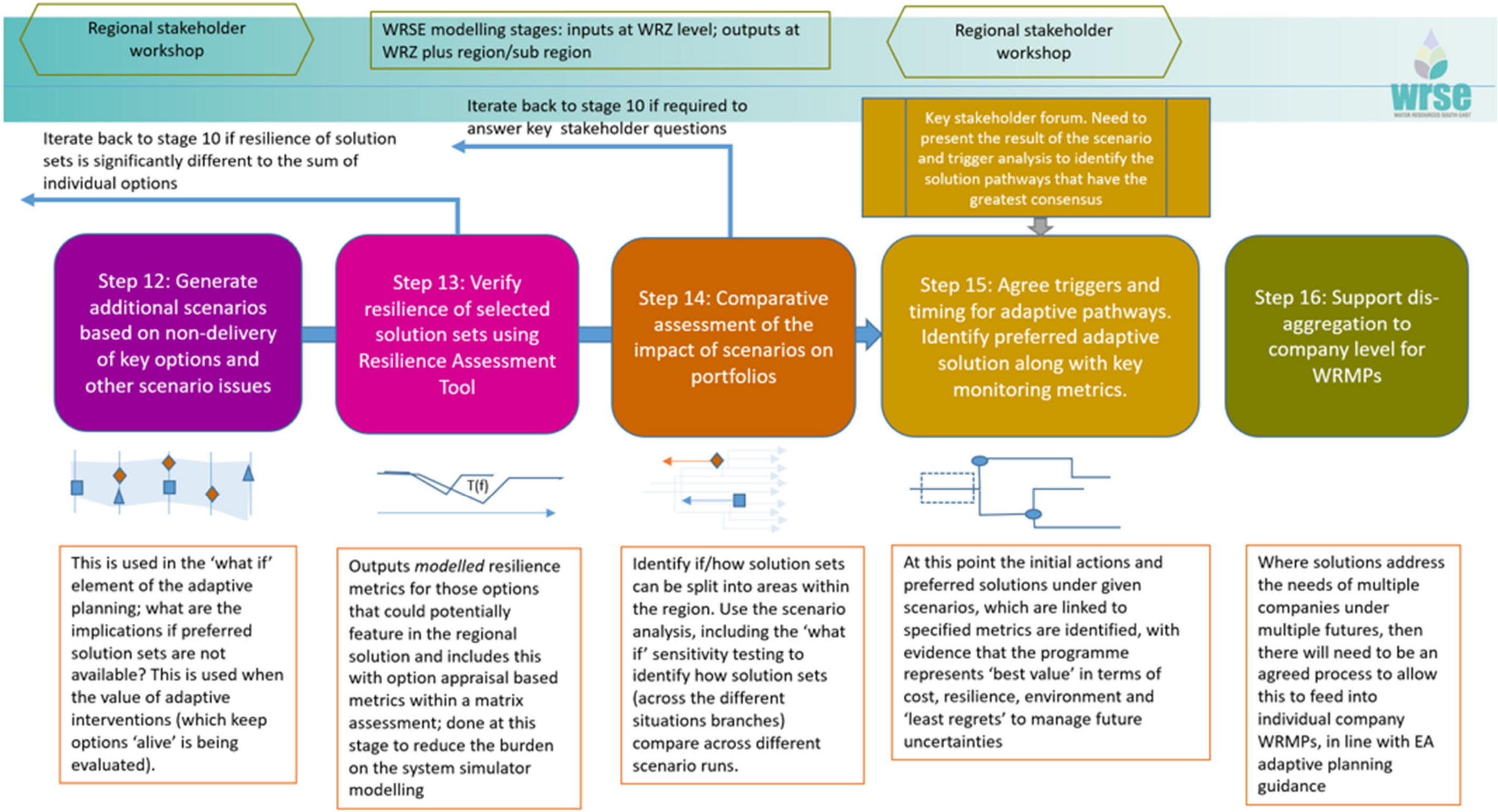
8 Stage 5: Performance testing

8.1 In Stage 5, Steps 12-14, we take each of the shortlisted programmes from Stage 4 and subject them to further investigation and performance testing as illustrated in Figure 16.

8.2 The following investigations will be undertaken:

- System simulation review (using the Regional System Simulator, RSS)
- Stress testing (using the IRM and IVM)
- Environmental review
- Resilience review

Figure 16: Steps 12-16 – Performance testing and preferred programme selection



System simulation

8.3 The IRM and IVM are aggregated models that look at changes in the supply demand balance on an annual timestep. Performance testing using system simulation gives us a better insight into how the combinations of options would work together in a more realistic temporal and spatial environment.

8.4 The Regional System Simulator (RSS) will be configured including the key strategic options chosen in the preferred programmes and tested to ensure levels of service can be met, conjunctive use is understood and that there are no distributional issues. Observations on performance will be reported back with recommendations on potential improvements, if necessary.

Stress testing

8.5 The simulation model will evaluate the robustness of a potential investment programme to the majority of climate and weather challenges. At this point we will also stress test the programmes using the investment model to find key dependencies and risks that impact on selection, e.g. “what-if” testing of specific alternative growth rates, environmental destination, dates for achieving policy goals and failure to gain planning permission for solutions.

8.6 The nature of the programmes themselves will help to identify the appropriate stress tests relating to them, as explained in Table 12 below.

Table 12: Potential stress tests

Area	Comments
Drought resilience (Timing)	Could we achieve the 1:500 level of resilience earlier in all or in certain water resource zones? The results from this might suggest consideration of whether achieving this resilience standard at different times across the region could be appropriate.
Growth forecast	We could test a scenario reflecting COVID demand impacts, or include growth associated with the Oxford-Cambridge growth arc.
Leakage reduction	Each company has put forward 3 different options/policies for leakage reduction. We could test each or have a different mixture of leakage reductions across the region.
Option availability	We could remove or pre-select certain option types or specific options and re-run to examine the impact on the solutions, should one or more not be deliverable or be delayed.
Tree sensitivity	We could make incremental adjustments to the shortlisted situation trees (timing and spread) to see how sensitive the model outputs are to these changes.

8.7 Further challenges such as uncertainties around option cost and deployable output (DO), asset failure, alternative demand forecasts together with regional conjunctive use assessments, can also be stress tested to better understand the adaptability and robustness of each shortlisted programme.

8.8 Outputs of the stress tests will be available in the visualisation tool. Observations on performance, including potential impacts on the selection of a preferred plan will be documented and subsequently considered by PMB.

Resilience assessment

8.9 Our approach to the resilience assessment of the regional plan is detailed in the WRSE Resilience Framework.

8.10 The regional system simulation model helps us to evaluate the effect of different stresses and hazards on a proposed investment programme in terms of impact on both the public water supply and non-public water supply. We do this through identification of a series of resilience sub-metrics as provided in Table 13, which enable a comparative assessment of the resilience of different programmes.

8.11 Observations on performance against the resilience sub-metrics will be documented and subsequently considered by PMB during programme appraisal.

Table 13: Resilience sub-metrics used to help differentiate shortlisted programmes

Criteria	Reliability	Adaptability	Evolvability
System characteristic	Uncertainty of performance	Timing and warning of events	Flexibility and diversity of options
Metric	R1 (PWS) Uncertainty of supply/demand benefit	A1 (PWS) Expected time to failure	E1 (PWS/non-PWS) Scalability and modularity of interventions
Metric	R2 (non-PWS) Breach of flow and level proxy indicators	A2 (PWS/non-PWS) Duration of enhanced drought restrictions	
System characteristic	Ability to persist with planned functions	Ability to respond to and recover from unexpected failures	Deliverability of planned changes
Metric	R3 (PWS) Risk of supply failure due to physical hazards	A3 (PWS) Operational complexity and flexibility	E2 (PWS/non-PWS) Intervention lead times
Metric	R4 (PWS) Availability of additional headroom	A4 (non-PWS/Env) Inter-catchment connectivity	E3 (PWS) Reliance on external bodies to deliver change
Metric		A7 (PWS) Customer relations enhance engagement with drought demand management	
System characteristic	Resilience of supporting services	System connectivity and ease of system recovery	Monitoring and management of change
Metric	R5 (Env) Catchment/raw water quality risks	A5 (PWS) PWS system connectivity	E4 (PWS) Flexibility of planning pathways
Metric	R6 (Env/All) Capacity of catchment services	A6 (non-PWS) Mean time to failure (MTTF) of enhanced drought restrictions	E5 (All) Collaborative landscape management
Metric	R7 (PWS) Risk of failure of supporting service due to exceptional events		
Metric	R8 (Env/All) Soil health		

PWS = Public Water Supply
Non-PWS = Non Public Water Supply
Env = Environmental

Environmental assessment

8.12 An environmental review will be carried out on each of the shortlisted programmes. This will ensure that we have an understanding of the environmental and social benefits and dis-benefits of the portfolios of options.

8.13 This environmental review is separate from the environmental assessment of the regional plan (although it will use common data and information). The environmental assessments process is outlined in more detail in Method Statement 1329 WRSE Environmental Assessments.

8.14 The environmental review will include:

- An examination of the environmental sub-metrics (Table 14), to identify any potential areas of concern or highlight particular benefits.
- A programme level assessment of the potential cumulative and in-combination effects of the options in the preferred programme.

Table 14: Environmental sub-metrics used to help differentiate shortlisted programmes

No.	Environmental Sub-metric
1	Protect and enhance biodiversity, priority species, vulnerable habitats and habitat connectivity (no loss and improve connectivity where possible)
2	Protect and enhance the functionality, quantity and quality of soils
3	Increase resilience and reduce flood risk
4	Protect and enhance the quality of the water environment and water resources
5	Deliver reliable and resilient water supplies
6	Reduce and minimise air emissions
7	Reduce embodied and operational carbon emissions
8	Reduce vulnerability to climate change risks and hazards
9	Conserve, protect and enhance landscape, townscape and seascape character and visual amenity
10	Conserve, protect and enhance the historic environment, including archaeology
11	Maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing
12	Maintain and enhance tourism and recreation
13	Minimise resource use and waste production
14	Avoid negative effects on built assets and infrastructure.

8.15 By looking closely at the environmental sub-metrics we will be able to consider the environmental and social issues raised by the individual options selected in each shortlisted programme and compare them. We will also be able to examine opportunities to mitigate or minimise any concerns identified.

8.16 The assessment of cumulative and in-combination effects will look at the options selected and consider their combined potential impacts on the environment in the region or in any particular WRZ.

8.17 Observations on performance against the environmental sub-metrics will be documented and subsequently considered by PMB.

Outcomes from performance testing

8.18 The outcomes from the stress-testing, resilience and environmental performance testing will be considered by PMB, SAB and SLT in accordance with our decision making and governance processes.

8.19 It may be that one or more of the original shortlisted programmes are considered to be no longer viable. For example, a set of schemes could have undesirable cumulative or in-combination effects, or the programme may not perform as well under system simulation as hoped.

8.20 If this happens, we will decide whether to:

- rule out that programme as a whole and continue with fewer programmes,
- alter the programme, re-assess it and retain it, or
- go back to the shortlisted programmes and pick another.

9 Stage 6: Selection of preferred plan

9.1 In Stage 6, Steps 15-16, the results of the specialised assessments (Stage 5) for each programme will be fed back into the visualisation tool for further comparative appraisal and ultimately the selection of a preferred adaptive regional plan.

9.2 During this stage, PMB will work to identify a provisional preferred shortlisted programme and adaptive overall plan, (i.e. a preferred pathway and alternatives branching from key delivery decision points).

9.3 PMB will also undertake a WRZ-level review and minor amendments, reviewing the adaptive pathways (showing alternatives) and from this select the preferred best value regional plan. In line with our decision making and governance processes, PMB's decision and justification will be considered by SAB and SLT.

A provisional preferred shortlisted programme

9.4 Having revised, if necessary, the shortlisted programmes as a result of the performance testing, we will examine again the parallel plots and weigh up their performance against the best value metrics.

9.5 A provisional preferred programme will be recommended to PMB that draws on all of the completed assessment work and robustly justifies the selection of a preferred plan. It will make clear if any decisions are marginal.

9.6 Summary Information on all the shortlisted programmes will be included in the reporting so customers and stakeholders can consider for themselves whether they would have chosen an alternative provisional plan.

WRZ-level review and minor amendments

9.7 The provisional preferred programme will then pass to companies to enable them to assess the proposed spatial breakdown of the provisional plan to WRZ-level and to allow proposals for minor amendments to be brought forward. At this point we would expect any to be limited to minor changes driven by WRZ specific factors or the practicalities of delivering the plan in a timely fashion.

9.8 Any proposed alterations will be considered by PMB in the first instance and may require additional or updated information to be included within the various environmental or other assessments underpinning the plan.

Adaptive Pathways

9.9 The PMB will then re-examine the adaptive pathways and ensure that key decision dates for delivery of the plan over the planning period are clear, practical and achievable within the current water industry planning frameworks.

9.10 It will consider how progress will be monitored and how, if a trigger is met and a change in pathway is required, it will inform customers and stakeholders.

9.11 Finally the costs and solution differences between the adaptive pathways will be clear including how customers and the environment will benefit.

Selection of a preferred plan

9.12 At this point the PMB will have identified a preferred best value adaptive plan. PMB's decision making will be informed by the technical modelling undertaken by WRSE, performance testing, and engagement feedback, along with expert judgment. PMB will provide selection justification for subsequent consideration by SAB and SLT.

9.13 This plan will be brought to the SAB, who may challenge the rationale for the choices made from the perspectives of their stakeholders.

9.14 The plan (including the SEA, HRA and other assessments) will then be passed to SLT who will consider the plan in full alongside any report, challenge or other recommendations from SAB. The SLT may ask the PMB to review any points raised by the SAB to help inform its decision making.

9.15 SLT will consider all of the information presented to it, and will accept or direct final changes to the plan and provide a reasoned justification for its decision. This justification will be provided alongside the draft plan and communicated to the water companies and the other regions, for regional and national reconciliation.

10 Stage 7: Consultation on the draft preferred plan

10.1 Assuming that SLT has not directed changes to the preferred plan, then it is anticipated that the preferred plan, including adaptive pathways would be put forward for public consultation in a draft regional plan in January 2022.

10.2 The consultation will run for eight weeks.

10.3 A series of supporting documents and assessments, including necessary SEA, WFD and other environmental assessments will be published alongside the draft regional plan.

10.4 A Non-Technical Summary of the regional plan will also be published.

10.5 The preferred, adaptive plan will also be entered into the WRPG WRP Tables for use by individual companies. We intend for this to be done automatically as a download from the DLP.

Actions following consultation

10.6 We will consider and respond to the public consultation submissions and adjust the plan, if required. A summary of representations and our response will follow in May 2022, confirming or otherwise any changes that will be made to the draft preferred programme before publication of the final plan.

10.7 The revised draft regional plan would then be used to inform the WRMP's of the water companies, the multi-sector plans, national reconciliation of regional plans, and the catchment-based solutions to be delivered through the appropriate parties.

10.8 We then expect the final draft plan will be published in August 2022 at the same time as the water companies in the South East publish their draft WRMP24s.

Appendix 1: The Data Landing Platform (DLP)

The DLP is a data warehouse/integration tool developed in Microsoft Azure with a visualisation function built in Moata.

It was developed in two parts, to deal with input data and output data:

- Part 1 of the DLP enables all data storage, transfer and transformation to and from the integrated risk model (IRM), investment model (IVM) and visualisation tool (VT).
- Part 2 of the DLP enables reporting the final problem, options and selection in the Water Resources Planning (WRP) tables for each zone in the region.

The table and figures below summarise the input data to the DLP and the data flows

Table 15: Integrated Risk and Investment Model Input Data

IRM/ IVM Input Data	Provided by	ID[7]
Baseline supply forecasts	Simulation model (RSS)	M
Baseline demand forecasts	Demand forecasting models via simulation model	H→M
Forecast uncertainties	Simulation & demand forecasting models	F&J
Existing transfers	Options appraisal	N
New supply options and transfers	Options appraisal	N
Demand reduction strategies	Demand strategies via Options appraisal	C→N

[7] Data IDs relate to the Data Landing Platform flow chart

Figure 17: Flow of information through DLP

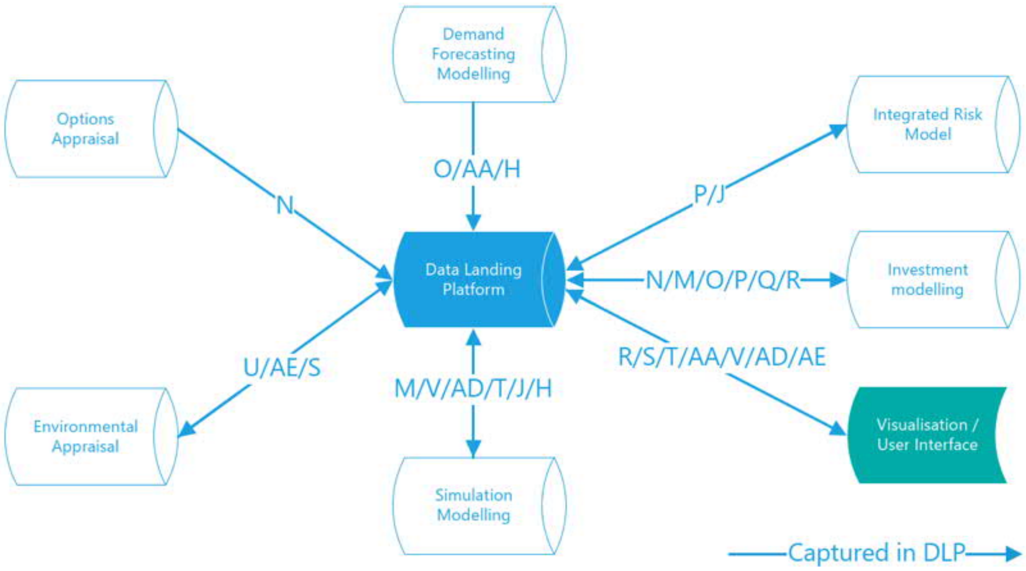
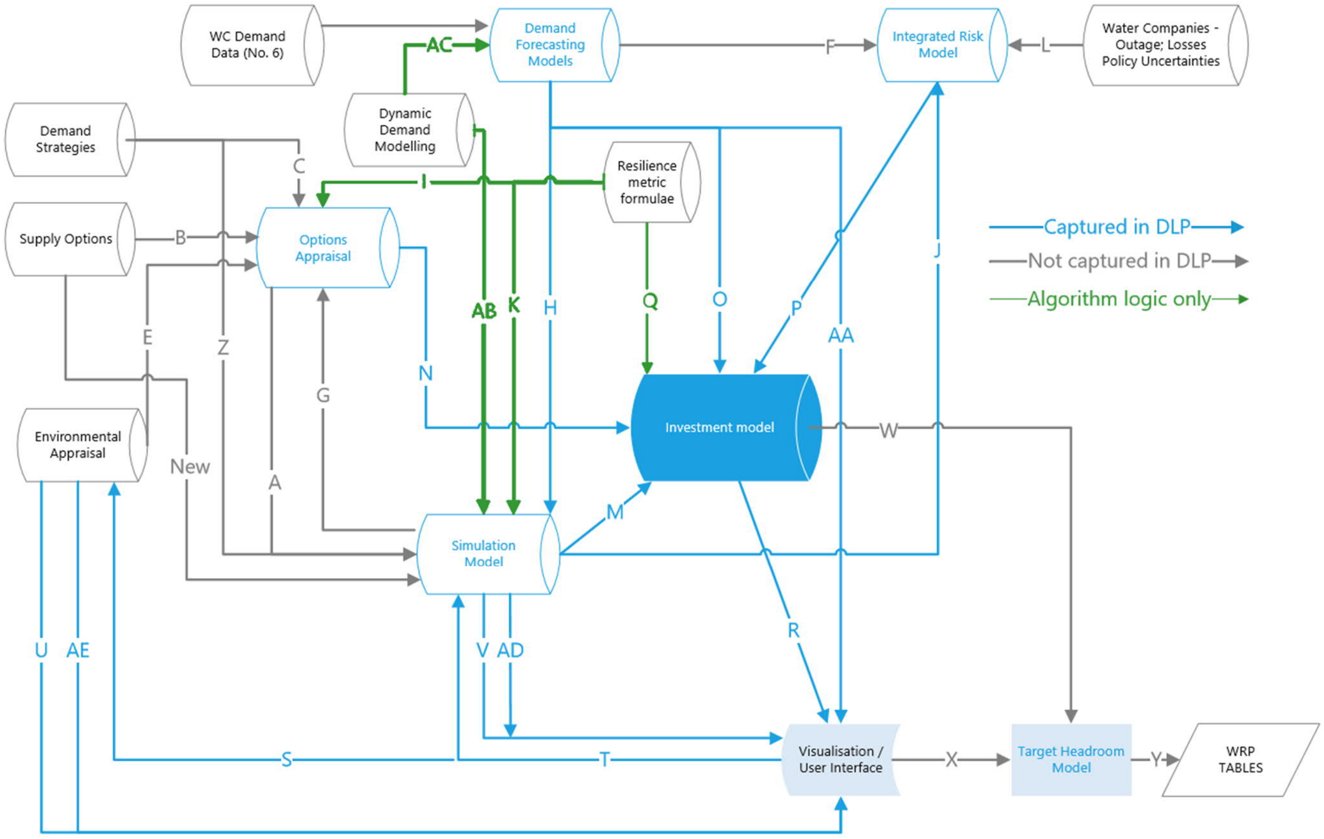


Figure 18: Data flows through data landing platform



The DLP will support the quality assurance process, through either visual or automated verification or likely both. Metadata will be set up to ensure governance of inputs in terms of version control and input personnel, and to track any transformations carried out in the DLP.

The QA logic will be defined by WRSE and will include identifying gaps in data, outliers, values outside of set tolerances, and incorrect value types, using a combination of manual and automated verification to balance out the pros and cons of each.

- Manual quality assurance. Dashboards are developed with the defined logic, with WRSE visually reviewing the data for any anomalies.
- Automated verification and checking of datasets. All defined logic will be automated and applied on data upload, with alerts sent to users if anomalies are detected.

Table 16: Manual and automated QA comparison

QA method	Pros	Cons
Manual	Can pick up anomalies that are difficult to automate Can deliver contextual experience	Labour cost Time intensive Sometimes difficult to spot anomalies
Automated	Supports automated process and consistence Can reduce human error	Development cost Development time Can be relied on too heavily

Appendix 2: The Integrated Risk Model (IRM)

The Inetgrated Risk Model (IRM) is a Monte Carlo model written in Python.

It takes information from the Data Landing Platform (DLP) and returns data to the DLP for use in the IVM and VT.

Its primary function is to produce plausible future supply demand balance situations based on ranges of key uncertainties. It can produce single future situations, or multiple linked futures, known as situation trees.

The model does this in two ways:

- It can accept several probability distributions regarding uncertainty of the supply-demand balance, perform a Monte Carlo simulation and then return sampled values from the output distribution.
- It can calculate the impact on the baseline SDB of alternative forecasts and combine them to produce a spread of potential futures.

It supports basic sampling of a single percentile and producing a "tree" of future situations by providing branching points (years) and several percentiles.

The integrated risk model generates multiple situations to represent different possible supply-demand balances (SDBs), known as future situations.

Appendix 3: The Investment Model (IVM)

The WRSE Investment Model (IVM) is a decision support tool used to identify and optimise ways of putting options together to meet the region's water resource planning problems (ie. maintaining the supply demand balance).

The IVM is built using Python[8] v.3.7. Python is a programming language that lets you work quickly and integrate systems more effectively.

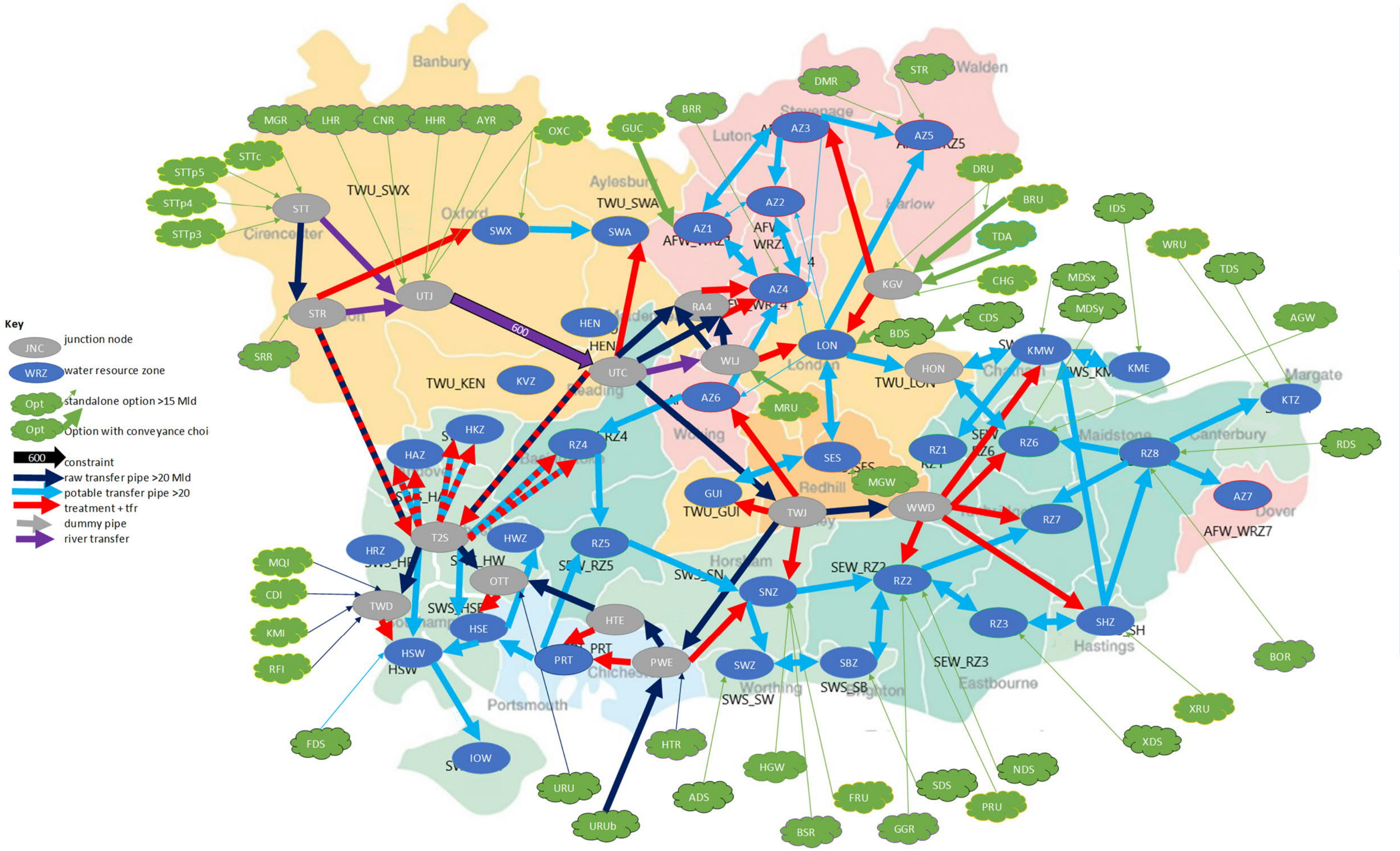
The model uses a Gurobi[9] optimiser. This is a commercial optimisation solver for linear and quadratic programming. In the IVM, both linear programming (LP) and mixed integer linear programming (MILP) are used.

The model interfaces with the IRM and the DLP and is visualised via the VT. The model schematic is set out in the figure below. The model contains:

- Nodes, representing the water resource zones in the WRSE region and their SDBs, or junctions in the system
- Options, the options available to each node to help balance supply and demand
- Links, the existing and potential future transfers between the zones.

[8] www.python.org
[9] www.gurobi.com

Figure 19:IVM Model schematic



The model has three main modes:

- Causative (EBSD) – Whereby the IVM solves a single future situation, based on optimising the COST metric
- Adaptive – Whereby the IVM works in tandem with the IRM to optimise across a range of future situations (a situation tree), using the COST metric.
- Pareto – As the adaptive mode but for optimisations are run using metrics other than COST. They can be single optimisations (maximising or minimising the value of a single alternative metric) or dual optimisations (optimising two metrics at the same time).

The IVM conducts a conjunctive optimisation of the planning scenarios.

For a single SDB, the IVM seeks an optimal investment programme to ensure that the SDBs for each of the four planning scenarios is satisfied for each year in the planning horizon, in each zone, while minimising or maximising a single objective function, or multiple objective functions.

The IVM both ensures enough capacity is available in each year and prioritises utilisation of the assets selected to meet the objective function. For example, when minimising cost, new assets are selected by minimising fixed costs while prioritising utilisation of selected assets in ascending order of variable costs; the utilisation priority order will change as new assets with lower variable operating costs are commissioned throughout the planning horizon.

Proportionality weightings related to the likelihood of occurrence are applied to the planning scenarios to allow combination of utilisation from the different planning scenarios for objective function optimisation. Default values are in the table below, although these can be adjusted per WRZ by the user.

Table 17: Weightings for planning scenario utilisation

Scenario	Calculation	Weighting
NYAA	40/52	0.7692
DYAA	8/52	0.1538
DYCP	1-(40/52+8/52+(15/200+60/500)/75)	0.0743
EMDO	(15/200+60/500)/75	0.0026

Appendix 4: The Visualisation Tool (VT)

The visualisation tool will be the primary decision support tool to allow quality assurance, appraisal, shortlisting, selection, communication and refinement of integrated risk SDB scenarios and trees and investment programme outputs and metrics throughout Steps 4 and 5, 8 and 9, and 13 to 15 of the development of a preferred plan.

As such the visualisation tool has to perform two key functions:

- To summarise and simplify, considering the complexity of problem and option combinations that may be output from the IRM and IVM.
- Support decision making in a way that is accessible to all audiences.

The WRSE visualisation tool is currently under development.