Method Statement: Regional System Simulation Model

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Title	Method Statement: Regional System Simulation Model
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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 2075.

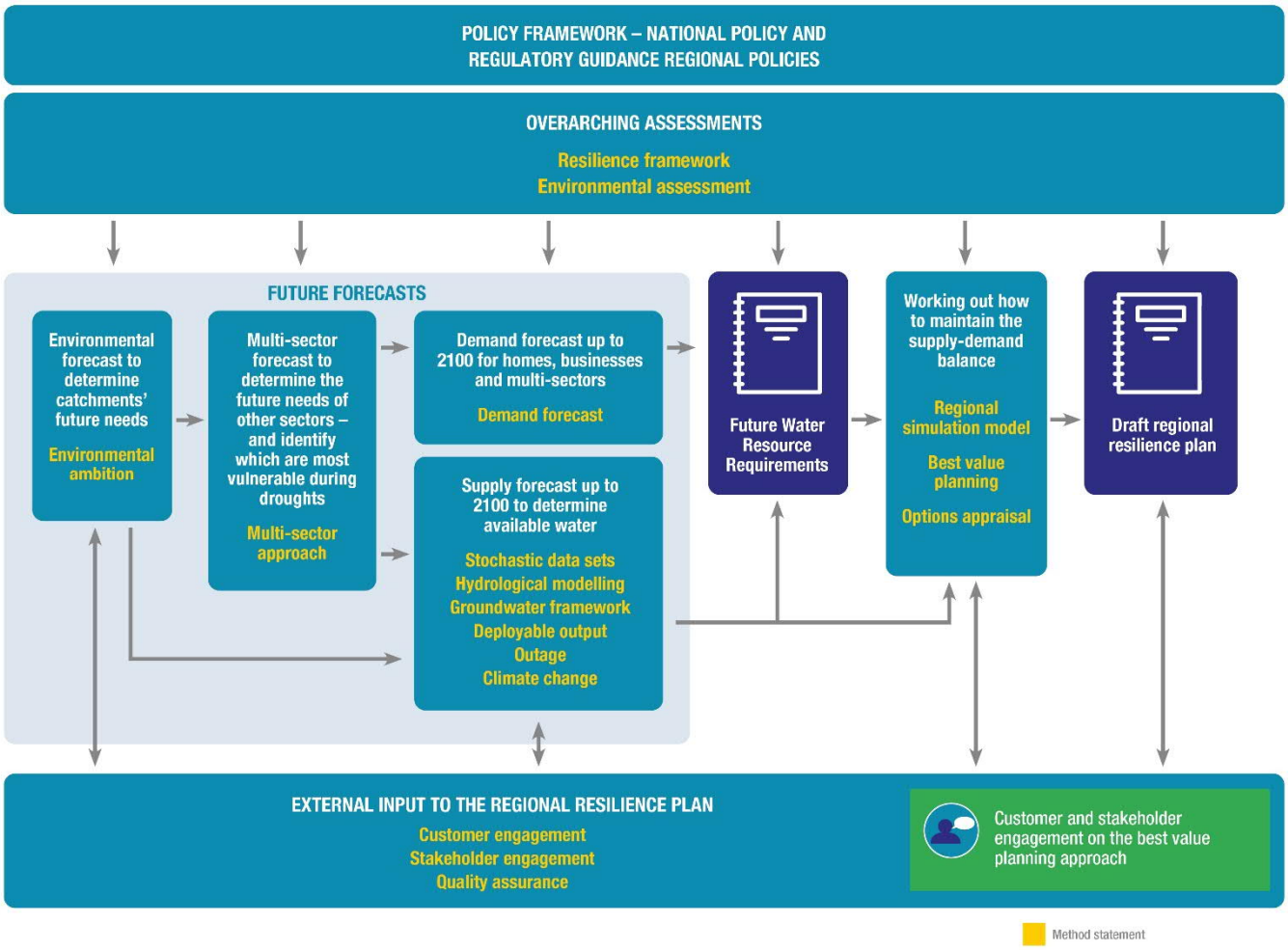
We have prepared Method Statements setting out the processes and procedures we will follow when preparing all the technical elements for our regional resilience plan. We consulted on these early in the plan preparation process to ensure that our methods are transparent and, as far as possible, reflect the views and requirements of customers and stakeholders.

Figure ES1 illustrates how this regional system simulator Method Statement will contribute to the preparation process for the regional resilience plan.

The regional simulation model will provide many of the outputs required for WRSE's supply forecast, including deployable output and climate change impacts, as well as the supply benefit that different options may bring. These outputs will feed into the WRSE investment model.

The regional simulation model will also later be used to test portfolios of options, in order to test whether options selected by the investment model (both on the demand side and the supply side) bring the outcomes that are anticipated when brought together.

Figure ES1: Overview of the Method Statements and their role in the development of the WRSE regional resilience plan



1 Introduction

1.1 Simulation models are used in water resources planning to assess the supply capability of water resource systems, to assess the implications of drought for customers and the environment, and to examine the impacts that future changes and interventions may have on water resources systems and the environment. These models provide many key outputs which drive investment through the Water Resource Management Plan (WRMP) process. Simulation models are also often applied in a more operational capacity, forecasting implications that dry weather could have on available water resources, and so guiding operational responses.

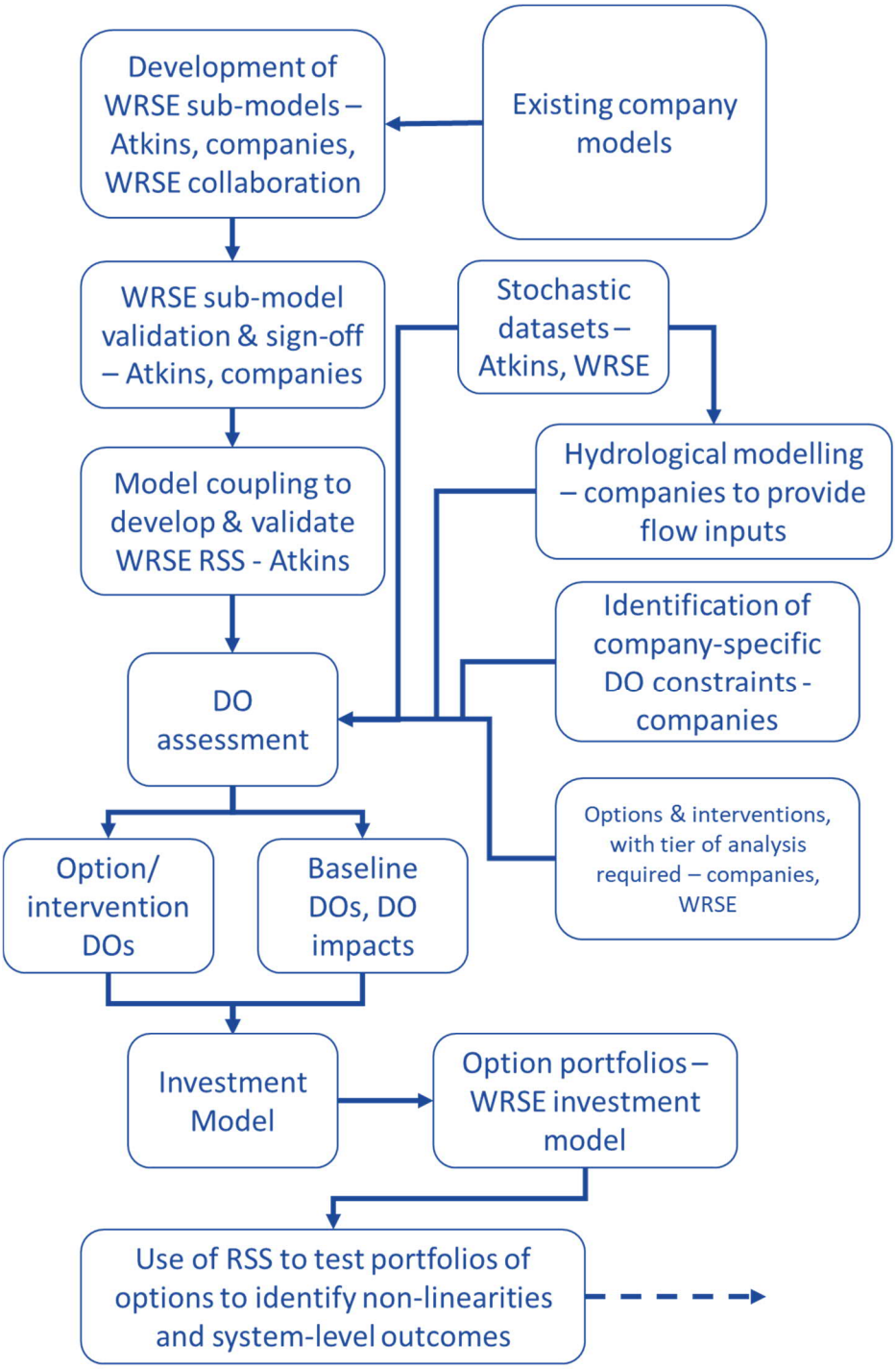
1.2 For the regional plan to be most easily translated into WRMPs for water companies, outputs should be compatible with the requirements of the Water Resources Planning Guideline and suitable as inputs to water resource planning tables. As such, WRSE supply forecasting methods will be developed to be compliant with guidance and analysis will be undertaken on a water resource zone (WRZ) level.

1.3 Figure 1 is a flow chart showing an RSS-centric view of WRSE modelling that is being undertaken. This flowchart should also be read in conjunction with the Method Statement 1318 WRSE Best Value Planning which also references the iterative nature of testing the outputs from the investment model back into the regional simulation model.

1.4 This Method Statement contains the following sections:

a. Uses for the RSS model
b. Development and validation of model(s)
c. Inputs & datasets used in the model.

Figure 1: A view of the WRSE modelling process, centred around the regional system simulator



2 Methods and approach

Uses for the Regional System Simulation Model

2.1 The Regional System Simulation (RSS) will have three primary stages of use. The model will initially be used to produce 'traditional' water resources outputs (Deployable Output (DO) assessments of existing sources, option/scheme DO benefits, and potential impacts on DO of uncertain future changes such as climate change and licence changes) which will be used as inputs for the investment model and which will be compatible with water resource plan table requirements. The second stage will use different scenarios to test the performance of WRSE's regional plan, to see whether portfolios of options deliver outcomes as expected. The third stage of the model will be to help explore the spatial stress points in the region in order to inform and test enhanced intra-regional transfers in the South East. These potential options will be passed through the options appraisal workstream

2.2 The first stage of model use involves using the model to produce values to feed into the WRSE Investment Model and water resource planning tables. Specifically, outputs to be produced by the RSS model are:

a. Baseline deployable output (Method Statement 1320 WRSE Deployable Output)

b. Impact of climate change on deployable output (Method Statement 1335 WRSE Climate Change Supply Side Methods)

c. Assessment of DO benefit/disbenefit of sustainability reductions, water resource options and transfers (Method Statement 1320 WRSE Deployable Output).

2.3 Each item listed has a specific Method Statement associated with it. These methodologies are not replicated here. These items will be combined with an assessment of outage allowances (Method Statement 1323 WRSE Outage) , raw water losses and treatment works losses (in some cases treatment losses may be considered implicitly within DO assessments) to form a forecast of Water Available for Use (WAFU).

2.4 The second stage of model use involves taking outputs from the 'Investment Model' and testing portfolios of interventions suggested by this model to determine overall impacts on system performance. This will test whether the additive assumptions which are implicit in investment modelling hold, and so whether the outcomes for customers match those expected.

Development and validation of model(s)

2.5 The RSS model is being built with high aspirations in mind. The aim for the model is that it is a sufficiently detailed representation of the South East such that it can be used independently (i.e. not be used in

conjunction with water company water resource models), but also that it is fast enough that 'stochastic' datasets (many thousands of years long) can be run through the model.

2.6 With these goals in mind, the RSS is being developed using a platform called 'Pywr' [1], a python-based water resources model which is open source, flexible and extendable, and which is faster than many other existing water resource modelling platforms. This platform was deemed to be the most suitable for this model after an extensive review (WRSE Regional Simulation Model Scoping Report).

2.7 The RSS is being developed by Atkins, but with significant guidance on model structure and system performance from water company specialists, recognising the model development skills that consultants have, and the system knowledge possessed by those working for water companies.

2.8 A full description of model development methods used can be found in the Regional Simulation Model Report, available on the WRSE website in the document library.

2.9 The RSS can be seen as a model composed of many coupled sub-models. Existing models that water companies have developed exist for the purpose of modelling individual company WRZs and sub-regions. A key requirement of the RSS is that methods and models used are, where reasonable, consistent with existing company assessments. As such, the initial sub-models are being built to represent company WRZs and sub-region models. These sub-models will be validated by comparing outputs from existing models (e.g. WRMP19 model outputs) with those from newly developed models. Models do not exist for some company areas. In these cases, 'expert judgement' will be required to ensure that behaviours exhibited in the new models are consistent with what would be expected. The fact that some companies are moving from having no model or very simple models to a more complex modelling approach may mean that some outcomes may differ from expectations. Differences from existing assessments are certainly acceptable but should be explainable.

2.10 WRSE is an alliance of water companies, rather than a regulator or entity in its own right. As such, WRSE itself has not set acceptability criteria regarding calibration/validation of sub-models. Instead, company specialists have engaged with the RSS development team and have 'signed off' models for use when they are happy with the representation of their system(s), via examining outputs such as river flows, reservoir storage, source utilisation, and deployable output.

2.11 While it is hoped that the WRSE RSS will be universally applicable across all companies' WRZs, it may be that some WRZ/sub-region sub-models produce results which differ materially from expectations, and companies will require further investigations to be carried out to understand the differences in expectation versus outputs, before committing to the outputs. Following the sign off process, companies will determine the purposes for which each model is suitable. Once the new models have been developed and validated against existing models, there may be opportunities for updates and enhancements to the new models, for example to represent revisions to system/operational constraints, or to improve the representation of interzonal and inter-company transfers.

[1] Tomlinson, J.E., Arnott, J.H. and Harou, J.J., 2020. A water resource simulator in Python. Environmental Modelling & Software. https://doi.org/10.1016/j.envsoft.2020.104635

2.12 The second stage of model development is to couple these sub-models together to form a model for the whole WRSE regional model. Pywr relies on solving linear algebra problems, with different sources of water being used subject to 'costs'. These costs are not financial and are instead costs which the model uses to solve a resource allocation problem during each time step – i.e. the costs inform the solver which sources should be preferred at any point in time. In coupling sub-models together, it may be that unexpected interactions occur, perhaps due to inconsistencies in costs defined in different parts of the model. Validation of the whole RSS will also be undertaken to ensure that sub-models continue to produce results consistent with what would be expected.

2.13 At the time of writing, the RSS broadly exists as a 'WRSE North' model (Thames and Affinity Central area) and a 'WRSE South' model (South East Water, Southern Water, Affinity South East, SES Water, Portsmouth Water), as there is currently relatively little interaction between these two areas. The flexible nature of the Pywr model means that the WRSE North and WRSE South models will be able to be connectable, although it will be necessary to check that the model still functions as expected when this happens.

Inputs and datasets used in the model

2.14 The regional simulator will draw together many inputs and datasets. This section summarises the key inputs and datasets used in the model.

Climate data

2.15 Flows, groundwater yields, and other variables within the model are driven by climate data, largely rainfall and potential evapotranspiration (PET). New 'stochastic' datasets have been generated for use in regional plans and WRMP24 which will be used extensively within the RSS model (Method Statement 1332 WRSE Stochastic Datasets).

2.16 When considering evaporation from reservoirs, factors will be applied to PET data to scale it from PET from grass to open water PET.

Flow data

2.17 Rainfall-runoff modelling will not be carried out within the RSS, due to the runtime penalty that would result from their inclusion. Instead, work on hydrological modelling has been carried out to support the RSS. Please see Method Statement 1330 WRSE Hydrological Modelling for details.

Groundwater yields

2.18 It has been recognised that groundwater has received a lack of attention in company water resources modelling efforts to date, in comparison with surface water. Groundwater yields have generally been based on assessments of average and peak source deployable output, reflective of conditions associated with 'design droughts', but not reflecting the potential variability in yields that may be seen under

extreme conditions. The groundwater framework (Method Statement 1322 WRSE Groundwater Framework) has applied a consistent methodology to identify those sources where the representation of time-variant yields is appropriate, either by including lumped parameter groundwater models within the RSS, or by having a time series of groundwater yields. Groundwater yields will be provided by companies; whilst differences in assessment methods may exist, the DO will still be consistent with standard groundwater DO guidance and methods. Underlying climate datasets and the consideration of time-variant yields from sources will be consistent across companies.

Information on existing sources and assets

2.19 Data exists in company models and assessments, defining licences, source constraints and assets. These data will be carried across to the RSS. Companies may need to review and update these constraints to account for changes since WRMP19.

Levels of service

2.20 Levels of service define the expected frequencies with which different levels of restriction on water use would be imposed by companies. Levels of service are defined as constraints within water resources modelling (for example, if a given company's level of service is that non-essential use bans would be implemented once every 50 years, but a modelling output implies they would be imposed once every 40 years, this model run would be considered a failure). Implied levels of service are, however, also an output from water resource models, as it can be the case that model outputs suggest restrictions would be necessary less often than stated in levels of service. It is expected that the driving 'level of service' constraint for companies that make up WRSE will be the 'Level 4' constraint, or the frequency at which emergency water restrictions and emergency drought orders would be imposed. This is because there has been a recent change in national policy, whereby all companies must show that they would only impose emergency restrictions not more than once every 500 years on average. Companies must achieve this level of resilience by 2039. Up to this point, companies may have a lower level of service regarding emergency restrictions.

2.21 WRSE consulted on the question of levels of service for the region in August 2020. The outcome of that consultation process will be taken into account in this aspect of the regional simulation model.

Emergency/dead storage

2.22 Emergency storage in raw surface water storage reservoirs is an allowance that companies make to ensure that water will still be available even if drought more severe than that which is planned for occurs. Emergency drought restrictions are often defined based on the point at which companies enter their emergency storage allowance. It is recognised that different companies within WRSE make different assumptions around dead storage and emergency storage requirements due to the nature of different reservoirs and reservoir systems and the way that they operate. As such, WRSE will not align assumptions regarding emergency storage requirements. Companies must, clearly define how and why their emergency storage volumes have been calculated.

2.23 WRSE is not proposing to associate a similar 'emergency storage' concept in groundwater dominated zones, although this means that South East will have less reserve storage than regions dominated by raw surface water reservoirs.

Drought management options

2.24 There are several interventions that water companies can make when responding to drought events. These include the imposition of demand restrictions. A recent change to water resource planning guidelines states that drought permits and orders, along with any demand saving measures, must not be included in 'baseline' deployable output runs. As such, all drought permits and orders and all demand savings measures are excluded from baseline DO. There is a facility to 'turn on' demand savings within the model, which has been used to calculate the DO benefit associated with demand savings measures, in order that these can be included as 'options'.

Planning scenarios

2.25 All water companies must undertake assessments of 'Dry Year Annual Average' (DYAA) deployable output. For many zones companies also consider 'Dry year critical period' (DYCP) and 'Minimum Deployable Output' (MDO) scenarios. The regional simulator may calculate DYAA, DYCP and MDO values directly from simulation results, or additional analyses may be necessary to supplement model runs.

2.26 Terminology around planning scenarios has been qualified in order to avoid confusion with demand-side terminology (generally in water resource planning, DYAA DO has been a 'worst historical' DO while DYAA DI is closer to a 1 in 10 value). Deployable output has been calculated for 'average' and 'peak' scenarios, and for different return periods of emergency drought order imposition. Scenarios used have been 2A, 100A, 100P, 200A, 200P, 500A, 500P, where for example 500A refers to the 1 in 500-year annual average supply capability.

Treatment works losses and operational use

2.27 Thames Water calculate the impact of treatment works losses and operational use using simulation modelling, while all other WRSE companies calculate treatment works losses and operational use external to simulation modelling.

2.28 In all cases, deployable output will be calculated excluding treatment works losses, and these losses will be accounted for in WAFU.

Transfers & bulk supplies

2.29 Bulk supplies and transfers should generally not be included in baseline deployable output modelling. Instead DO benefit and disbenefit for recipient and donor zones respectively should be calculated for bulk supplies and transfers, whether these are existing transfers or options. However, in some cases bulk supplies and transfers have very important system response implications (for example releasing 'locked-in' DO). In situations where there is sound reasoning for doing so, companies may include inter-zonal/inter-company transfer(s) in baseline deployable output modelling. In such cases, however, it must

be made explicitly clear that this is being done, explain why this is necessary, and both zones/companies involved must adopt the same approach. In addition, the impact of these transfers should be accounted for after DO modelling (i.e. within the baseline supply-demand balance) such that DO values used as investment modelling inputs include only DO which 'belongs' to a given zone, such that the investment model can optimise intra-regional transfers.

2.30 Existing and proposed inter-company transfers under drought conditions have previously, generally been assumed as constant requirements. The RSS allows for these to potentially be modelled more dynamically in response to spatially variable supply and demand. The rules required to model such transfers dynamically may be complex, relating to levels of service, bulk supply agreements and changing resource stresses through a drought.

2.31 For transfers and joint options, the RSS will not seek to maximise the DO-benefit brought by a given option by dynamically allocating water to participating companies/WRZs (options and transfers being a supply-demand issue, not a supply capability issue). Instead, rules regarding transfers and joint options must be pre-specified, though these rules could be based on the relative drought severity affecting different areas if it is possible to implement this in the model and if it would be possible to write the rules into a contractual agreement. This reflects the necessity of water resource modelling to represent what would happen during a drought situation.

Representation of non-public water supply abstractions

2.32 Regional planning guidelines require that non-public water supply (non-PWS) users are included in planning.

Potential feedback loops

2.33 There are potential feedback loops that may exist in the development of the regional simulation model. This section highlights where these may exist. In some cases, initial assessments may be used in early iterations of the regional plan (i.e. before we have 'gone around the loop' completely).

- Triggers for the implementation of demand savings - Companies may initially specify control curves for the implementation for demand saving measures. It may be that these control curves lead to outcomes which are unfeasibly different to stated levels of service, and control curves may be iteratively altered accordingly
- Assessment of groundwater source yields, particularly for peak source yields - Historically, groundwater peak source deployable outputs have been calculated considering a fixed peak period (fixed in both time during the year and duration). The introduction of the consideration of dynamic demand may imply that different peak periods exist, and this may lead to re-evaluation of how source yields are considered.
- Treatment works capacities and process losses - It may be that outcomes from initial model runs suggest that values calculated for process losses and treatment capability are not representative of scenarios driving planning. Where this occurs, these values may be changed.
- Representation of non-PWS abstractions - The detail with which non-PWS abstractions are considered will depend on the relative impact that they have. As such, more/less consideration may

be given to these abstractions, dependent on the outcome of initial assessments (see Method Statement 1334 WRSE Multi Sector Approach).

- Model uses - Companies may initially find that the WRSE RSS is not suitable for use in one or more circumstances. Further investigation and development may then be undertaken, and the RSS may later be applied.

Decision points and documentation

2.34 As described throughout this Method Statement, there are several decision points when producing and using models. Examples of decisions to be made are: determining which uses a given sub-model is suitable for; and, determining whether to use the RSS or company models/ assessments for calculating baseline deployable output for different scenarios.

2.35 Decisions to be made will become apparent as the project progresses. WRSE will identify key decision points and add them to this document when necessary.

2.36 For key decisions, keeping appropriate documentation is valuable for later justifying outcomes and decisions further down the modelling chain. In this section, key decision points are identified. Decision makers, those collating decisions across the region, and required documentation are described for identified decisions. There are of course many small decisions made during the course of building a water resources model and it is infeasible that all decisions would be recorded, although all decisions should be justifiable if questioned. This section only focusses on high-level decisions.

2.37 Assumptions underlying data that companies provide in the development of RSS sub-models should be documented by companies. Again, it is recognised that there are many assumptions made in the development of models, and that documenting all of them is infeasible. However, for key assumptions companies should document and/or be able to justify assumptions, such that they can be justified when questioned.

2.38 The decision to use Pywr as a modelling platform has been documented (WRSE Regional Simulation Model Scoping Report).

2.39 Identification of key assumptions to underly deployable output assessments which will not be aligned across WRSE - Water companies should document and justify key assumptions which will underly their deployable output; WRSE will collate assumptions from companies. Assumptions considered 'key' will vary between companies and WRZs and so companies should identify those assumptions that they see as key for given WRZs. Examples of key assumptions include levels of service, emergency/dead storage assumptions, control curves, the point at which Level 4 restrictions would be implemented, and inclusion/exclusion of the benefits of demand restrictions from baseline DO.

2.40 Inclusion of bulk supplies/transfers in baseline deployable output - If any inter-zonal or inter-company transfers are to be included in baseline deployable output, this should be justified and documented by the

relevant company. If it is an inter-company transfer, the company should inform the other company involved to ensure a consistent approach. WRSE should be informed of all cases where transfers are to be included in baseline deployable output.

2.41 Identification of suitability of model for different purposes. As part of the model build process, Atkins are undertaking a model validation process in collaboration with water company leads. Company model leads will 'sign off' models for use in different circumstances and scenarios based on the validation evidence presented to them. This will include a table stating the planning scenarios for which the model is suitable.

Confidence grades

2.42 It is recognised that a methodology will be required for assigning confidence grades to deployable output. However, this has not yet been determined.

3 Summary

3.1 This Method Statement has outlined the steps in development and validation of the WRSE regional simulation model. It has also outlined the uses that the model will have, as well as the input datasets that are required.

3.2 For key input datasets, points of alignment between WRSE companies and/or previous assessments have been highlighted. Equally, aspects where alignment will not be sought across WRSE have been highlighted and expectations of data from companies have been outlined.

4 Next steps

4.1 We consulted on this Method Statement from 1st August 2020 to 30th October 2020. This Method Statement has now been updated to take into account the comments we receive during this consultation process and has been published on our website.

4.2 WRSE, in conjunction with the companies developing Strategic Regional Options (SROs), will be continuing to use the RSS through Autumn 2021 and into 2022. This Method Statement may be amended and updated should the approach vary as a result of this further work.

4.3 We may need to update parts of our Method Statements in response to regulatory reviews, stakeholder comments or improvements identified during the implementation phase of the methodology.

4.4 If any other relevant guidance notes or policies are issued, then we will review the relevant Method Statement(s) and see if they need to be updated.