Method Statement: Groundwater Framework

Consultation version

July 2020

Title	Method Statement: Groundwater Framework
Last updated	July 2020
Version	Consultation version July 2020
History of Changes made to this version	Minor Language and grammar updates Addressed comments from various reviewers. Added executive summary
Author	Simon Cook
Approved by	Meyrick Gough
WRSE Director Approval	Meyrick Gough

Email: contact@wrse.org.uk

Table of Contents

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 method statements setting out the processes and procedures we will follow when preparing all the technical elements for our regional resilience plan. We are consulting 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.

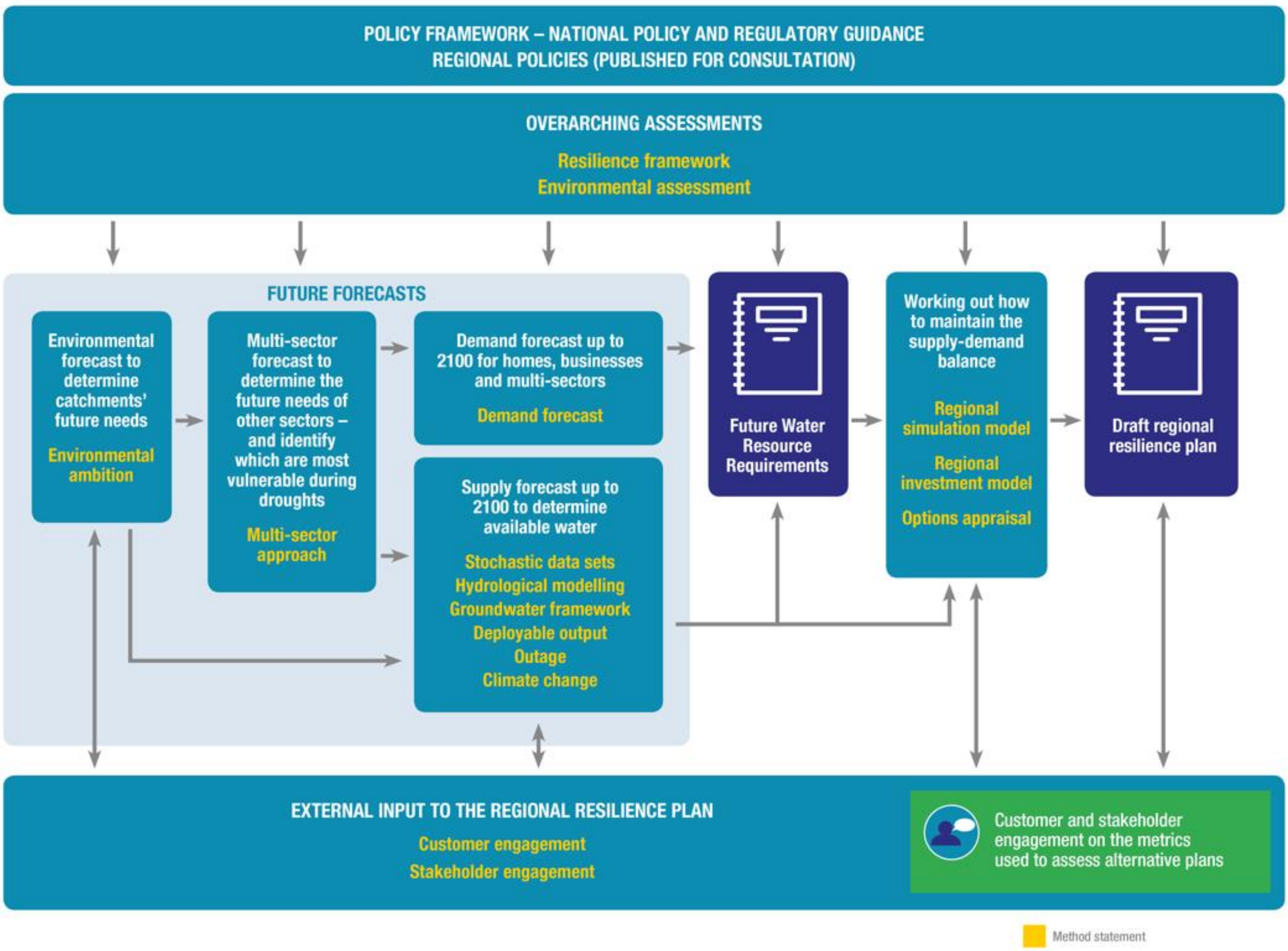
Figure ES1 illustrates how this groundwater framework method statement will contribute to the preparation process for the regional resilience plan.

Groundwater comprises around 70% of the water used for public supply in South East England. To date for WRSE companies the assessment of groundwater deployable output has largely been achieved outside of system simulator models following the guidance set out by UKWIR, 2017. The computational demands of these standard methods, particularly where regional groundwater models are used to determine flows or groundwater level responses, has so far limited the extent to which groundwater can be represented within system simulators.

There are multiple benefits to developing a more sophisticated representation of groundwater. The groundwater framework we have developed proposes a standard assessment approach to be applied across all water companies and water resource zones. Application of the framework assigned a weighted score across different source characteristics and suggests the deployable output (DO) modelling approach and system simulator representation that should be employed.

Generally, the higher scoring a source is under the framework the more suitable and the more benefit would be gained from dynamic representation within the system simulator model.

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



1 Introduction

1.1 Groundwater makes up around 70% of the water used for public supply in South East England. The assessment of deployable output for groundwater tends to be more complex than for run of river sources as it must consider aquifer properties, variation in groundwater levels, antecedent operation, interference effects and asset and licence constraints.

1.2 To date for WRSE companies the assessment of groundwater deployable output has largely been achieved outside of system simulator models following the guidance set out by UKWIR[1]. The computational demands of these standard methods, particularly where regional groundwater models are used to determine river and groundwater flows or groundwater level responses, has so far limited the extent to which groundwater can be represented within system simulators. The simplest and most common approach has been to develop groundwater deployable outputs outside of the system simulator mode, and represent them within the simulator either by a fixed value or represented by a simple time series derived from coherent climate data used to derive surface water flows.

1.3 There are multiple benefits to developing a more sophisticated representation of groundwater within the WRSE regional system simulator, these include, but are not limited to:

a. Where antecedent operation and utilisation of a groundwater source may affect future yield and hence drought DO through preserving or depleting groundwater storage, abstraction could be optimised to preserve that storage for supply
b. Optimising abstraction where groundwater has conjunctive use with surface water for example through aggregate licence volumes, hands off flows or works treatment capacity.
c. Differences in the timing of Drought responses between surface water and groundwater dominated resource zones would allow optimisation of transfers and use of supplies
d. Groundwater – surface water interactions are important at environmentally sensitive sites and by incorporating groundwater in a more dynamic way resource use could be optimised to reduce environmental impact.
e. Better inclusion of groundwater sources will aid consideration of resilience benefits and more realistic assessment of option utilisation and stress testing.

1.4 Development of more dynamic representation of groundwater will be challenging within the timescales available for this first Regional Resilience Plan. We have set out a framework for prioritisation within this "groundwater framework". The framework has been designed to focus development of dynamic groundwater approaches within the system simulator model for those aquifer blocks or sources where such representation will provide the most benefit in aiding decision making. When using "dynamic" in this sense we are considering groundwater sources where the yield and/or DO and any associated impacts are determined by the system simulator model rather than as an external boundary condition.

[1] UKWIR, 2014, Handbook of source yield methodologies, Report Ref. No. 14/WR/27/7, UK Water Industry Research Limited, London

1.5 The framework proposes a standard assessment approach to be applied across all water companies and water resource zones. Application of the framework assigned a weighted score across different source characteristics and suggests the DO modelling approach and system simulator representation that should be employed. Generally, the higher scoring a source the more suitable and the more benefit would be gained from dynamic representation within the system simulator model.

1.6 A key principal of the framework is that the application is standardised across all companies and water resource zones. It should include an auditable governance trail and be robust to scrutiny and challenge such that it may be used as supporting evidence within a public inquiry.

1.7 However, it should be recognised that the framework is semi quantitative and assessment must consider both uncertainties in numerical data and in hydrogeological understanding.

1.8 This is our first attempt at considering the regions groundwater resources in a more sophisticated manner within the WRSE regional system simulator model. The WRSE groundwater framework will be subject to an ongoing refinement/development through multiple planning periods as system simulators and groundwater models continue to become more sophisticated in step with advances in computational speed.

2 Development of the Framework

2.1 The Groundwater Framework was developed in the first half of 2020 over a series of workshops including both face to face meetings and teleconferences. It included participants from:

a. WRSE
b. Groundwater resource specialists and Water Resource Planners from WRSE Member Water Companies
c. Water Resource Specialist consultants working on behalf of WRSE and Water Companies.

2.2 We reviewed each water company's approach to assessing groundwater deployable outputs across their resource zones and the extent to which groundwater resources were presently included in company system simulation models.

2.3 We considered that there were in general three main approaches to developing groundwater deployable output:

a. Indicator borehole approaches using recharge or climate data to curve shift drought curves at sources to estimate deployable output during drought
b. Lumped parameter models which directly estimate groundwater levels from recharge and rainfall inputs
c. Distributed regional groundwater models which are used to either simulate groundwater levels at indicator boreholes or at groundwater sources themselves
d. We also recognised a hybrid approach developed for the Water Resources East (WRE) which were based on lumped parameter models developed from regional groundwater models.

2.4 Within these approaches there are sources that have fixed characteristics, for example those sources which are not drought sensitive and which are constrained by infrastructure or simple licence conditions (e.g. daily/annual). These sources would therefore not benefit from dynamic representation. The groundwater framework should therefore be capable of screening these sources from further assessment.

2.5 We also considered the key characteristics which should be used to prioritise groundwater sources for dynamic inclusion within the system simulator. These included:

a. The DO constraints with higher weighting applied to those sources where DO varied by drought severity or with complex licence conditions (e.g. seasonal licences, surface water flow constraints)
b. Potential groundwater and surface water conjunctive use benefits, including environmental benefits where sources may have adverse environmental impacts
c. Sensitivity to antecedent conditions and operation for sources where groundwater storage may have an impact on groundwater DO
d. Proportionality of any benefit, focusing on where useful DO gains or transfers might be achieved through better representation. This also recognised that even small volumes of available unutilised DO may have still have an overall regional resilience benefit
e. Stated levels of service

f. The level of uncertainty associated with current DO assessment to understand whether it is better to spend more time in investigating approaches to limit this uncertainty in source DO (e.g. by models) rather than to build into the simulator.

2.6 We tested several approaches in development and refinement of the groundwater framework to ensure we appropriately characterising the aquifer blocks and their sources. Ensuring consistency in approach and moderation across the different water companies was also a key theme of the development. A pilot exercise was iteratively refined by the steering group through feedback, discussion, and trial applications. The key enhancements achieved through this process were:

a. Improved wording and more automated scoring criteria for some questions to allow clearer and more consistent interpretation
b. Simpler and more standardised approaches for characterising the key hydrogeological characteristics of a source and aquifer water body
c. Improving consistency of how existing company DO's could be included, recognising that each company has different baseline planning DO and understanding of how DO varies across droughts of different severity. Adjusting the scoring and banding around DO variation at varying levels of drought sensitivity
d. Adjustments to proportionality scoring to remove consideration of adjacent water resource zones
e. Adjustments to overall ranking system to better screen out simple groundwater sources that would not benefit from dynamic inclusion in the system simulator
f. Adjustments to the weighting of conjunctive use benefits and sensitivity to antecedent conditions so scoring highly on either would increase the prioritisation of the source
a. Addition of an automated suggestion for the most appropriate representation of each source within the system simulator was added

2.7 Following these adjustments, the water companies undertook a further review of their characterisation and undertook a final review of score weighting and modelling method from four possible choices:

a. Development of lumped parameter model of the source or group of sources which would be included in the system simulator
b. Dynamic representation by other means for example computational algorithms within the system simulator where DO is not necessarily estimated by a physically based model such as a lumped parameter approach
c. Representation of DO by a coherent time series developed externally to the system simulator model derived using the standard UKWIR method for groundwater DO
d. Simple representation of a fixed DO or repeating annual profile (to account for peak, average and minimum conditions.

2.8 Each Water company reviewed and adjusted the suggested method based on their understanding of the source, existing model approached and what could be practically achieved in the time available for the regional resilience plan.

2.9 Although the DO of all groundwater sources will be represented in the system simulator in some way, only those where availability will depend on a parameter calculated by the simulator should need to modelled in a dynamic fashion. An example of where this may apply is where there is a strong interaction with surface water or other abstractions. All others can be calculated outside of the model and provided as an input; to save on computational time.

3 The Final Groundwater Framework

3.1 The following section sets out the arrangement and application of the groundwater framework we have developed. The key sections of the framework are outlined along with the scoring criteria.

3.2 The groundwater assessment consists of three phases:

a. Phase A: Background information. This includes the source name, type of source (e.g. single borehole, well and adit etc), the WFD Groundwater body from which it abstracts and if it is a confined or unconfined source. This information is not considered in prioritisation but provides some context when considering the modelling methodology and potential grouping of some sources.
b. Phase B: Prioritisation criteria. This considers the prioritisation of sources for dynamic modelling based on their importance and potential value of their representation within the simulator. Four key criteria are considered in the scoring:
    1. DO constraints
    2. Conjunctive use benefits
    3. Sensitivity to antecedent conditions
    4. Proportionality/threshold benefit
c. Phase C: Methodology. A review of current and available modelling methods, the suitability of the sources as well as the outcome of the assessment and the overall prioritisation. This balance the feasibility of implementation with the overall aim and method identified.

3.3 Phases B and C are the most critical in determining the prioritisation of a groundwater source and are described in more detail below.

a. Phase B Criterion 1 – DO constraints. This considers the potential change in DO with increasing drought severity. It also considers the sensitivity of the source to climate change and the nature of the constraints on deployable output. A source can be assigned a score of 1 to 5 (Table 1). A score is automatically assigned based on the gradient of the change in DO at different drought severity. If the DO under different drought return periods is not known, sensitivity of DO to climate change is used as a proxy. Assessment of DO from previous WRMPs should be used to complete this assessment. Highest scores are assigned to those sources which have large DO gradients and which are not asset or simple licence constrained.
b. Phase B Criterion 2 - Conjunctive benefits. This considers the conjunctive use benefits either with other downstream or downgradient sources or to the environment. It considers the extent to which groundwater source impacts on surface water and the designation of that affected surface water under the Water Framework Directive (Table 2). Sites score highly if there are downstream impacts on surface water or conjunctive use with surface water abstractions.
c. Phase B Criterion 3 - Sensitivity to antecedent conditions. This mostly considers the role of groundwater storage in providing a benefit to yields at a site. It is concerned with whether operation of a source may have a later impact on groundwater yield. For example, this may be where operation of a source at high rates during peak periods may reduce the yield of the source during minimum or average periods owing to depletion of groundwater levels or storage. The greater the sensitivity the higher the score assigned (Table 3).

d. Phase B Criterion 4 - Proportionality of benefit. This criterion is included in the framework and is automatically calculated by considering the DO of the site a proportion of the deficit in neighbouring resource zones expressed as a percentage. The intention was to represent the possible strategic importance of a site to resolve deficits. Whilst a score is assigned (Table 4) it was agreed that this criterion should not be used to determine if a source should be considered for dynamic modelling as it only provides an understanding of source size not of its other hydrogeological or environmental characteristics.

Table 1: Scoring for Criteria 1 DO constraints

Maximum gradient of DO drop off (%) >>	-0.5%	-2%	-5%	-10000%
Or climate change assessment if multiple DO's not available to generate gradient Maximum constraint	Not Sensitive	Low sensitivity	Medium Sensitivity	High sensitivity
Asset / Static	1	1	1	1
Other	2	3	4	5

Table 2: Scoring for Criteria 2: Conjunctive benefits

Question	Responses	Score>>
Potential DO benefit?	Yes	1
	Uncertain	1
	No	0
Is there a water resource WINEP driver?	Yes	1
	No	0
WFD GW body quantitative status	Poor	1
	Not assessed	0
	Good	0
WFD SW body status	Band 1	1
	Band 2	1
	Band 3	1
	Not assessed	0
	Compliant or surplus	0
Associated SW source	Yes	1
	No	0

Table 3: Scoring for Criteria 3: Sensitivity: to Antecedent Conditions

Question	Responses	Score>>
Vulnerability to antecedent conditions	Low	1
	Medium	3
	High	5

Table 4: Scoring for Criteria 4: Proportionality/Threshold of benefit

		DO as % of neighbouring WRZ deficit			
	0%	5%	20%	50%	>50%
	5%	1	1	1	1
	20%	2	2	2	2
	50%	3	3	3	3
DO as % of WRZ deficit	>50%	4	4	4	4

3.4 Following conclusion of the assessment a final ranking score is automatically calculated. Based on the final scores for Criteria 1, 2 and 3. If these scores exceeded a defined threshold for each criterion (Table 5) the site was prioritised for possible dynamic modelling by assigning a final ranking score of 5. If the site did not exceed the criteria it was assigned a score of 0 and it is not considered to be a priority for dynamic modelling within the system simulator as existing simplified approaches are appropriate.

Table 5: Overall ranking/thresholds for criteria determining prioritisation

	Criteria 1: DO constraint	Criteria 2: Conjunctive benefit - system	Criteria 3: Sensitivity to antecedent conditions	Criteria 4: Proportionality / threshold of benefit
Threshold value	3	4	5	Not used

3.5 The final stage of the framework is to automatically suggest a DO modelling approach within the system simulator for each source. This is based on the prioritisation criteria previously calculated.

a. If a source is screened out from dynamic assessment only an external profile of DO is required.
b. If a source is sensitive to antecedent operation (Criteria 3 score = 5) a lumped parameter model is most appropriate.
c. If there are conjunctive use considerations (Criteria 2 Score >=4) then dynamic assessment within the system simulator would be most appropriate
d. Similarly, If DO constraints are variable due to drought or climate change sensitivity (Criteria 1 score >=3) and there are other considerations such as conjunctive use or antecedent sensitivity a dynamic approach is also recommended.
e. If a site only has variable DO then it may still be possible and more computationally efficient to generate a coherent time series of DO using conventional methods outside of the system simulator.

3.6 At each stage of the framework assessment, including the suggested modelling approach, the suggested modelling methodology is intended to represent the ideal approach based on the outcome of the assessment and methods available. However, we recognised that this may not be practical to achieve in the required timescales or with the data available. The user can override the automated scoring, however, if this is done a justifying comment supporting the change must be provided and to provide a record of the manual adjustment to the framework outcome to ensure governance. The framework and modelling approaches are intended to be reviewed and updated for subsequent rounds of modelling which would allow for more advanced approaches to be developed in the future.

4 Next steps

4.1 We are consulting on this method statement from 1st August 2020 to 30th October 2020. Details of how you can make comments can be found here consultation website

4.2 We will take into account the comments we receive during this consultation process, in updating the Method Statement. Alongside this, the Environment Agency will shortly be publishing its Water Resource Planning Guidelines (WRPG) on the preparation of regional resilience plans. We may need to update parts of our method statements in response to the WRPG. We have included a checklist in Appendix 1 of this method statement which we will use to check that our proposed methods are in line with guidance where applicable.

4.3 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.

4.4 When we have finalised our Method Statement, we will ensure that we explain any changes we have made and publish an updated Method Statement on our website.

Appendix 1 Checklist of consistency with the Environment Agency WRMP24 Checklist

The Environment Agency published its WRPG on XXXXXX 2020, including the WRMP24 Checklist. The following table identifies the relevant parts of the checklist relating to this Method Statement, and provides WRSE's assessment of its consistency with the requirements in the Checklist.

No.	Action or approach	Method Statement ref:	WRSE assessment of consistency