

A stylized map of the South East region of the United Kingdom, colored in shades of blue. The map shows the coastline and major landmasses of the region, including Kent, Surrey, Sussex, Hampshire, and West Sussex.

Water Resources in the South East

An Overview of the WRSE

An introduction to the Water Resources of the South East group, its purpose and objectives

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1 Introduction

For the foreseeable future, the pressure on water supplies in South East England is expected to increase due to climate change, population growth and the need to further protect the environment. If no action is taken, unconstrained demand for water will increase while the volume of water available for use is likely to reduce.

In response to these pressures, the Water Resources in the South East (WRSE) Group was set up in 1996 to determine a regional water resources strategy, comprising a range of strategic options, to find the best solutions for customers and the environment in the South East of England.

1.1 Period of existence

Since 1996 the WRSE Group has explored opportunities for existing and new water resources to be shared in the most efficient and effective way, to provide reliable, sustainable supplies at best value to customers while protecting the environment.

The WRSE has undertaken work to determine a regional water resources strategy and help inform decisions on the formulation of water companies' Water Resources Management Plans (WRMPs) and Business Plans for a long time. The work of the WRSE has assisted in companies' preparation for the Periodic Reviews of 1999, 2004, 2009, and 2014 (respectively PR99, PR04, PR09, and PR14).

The WRSE group is currently working towards the 2019 Periodic Review (PR19).

1.2 Aims and objectives

The aim of the WRSE is to undertake water resource options modelling at a regional scale to explore the potential opportunities for water companies to share water resources in the south east of England.

This aim is achieved by working together to try and overcome the constraints imposed on the distribution of water resources in the region.

The objectives of the WRSE work are to:

- Develop a strategy to share water resources within the study area;
- Satisfy Government aspirations; and
- Meet relevant parts of the national water resource planning guidelines.

The overall intent of the WRSE Group is to determine a regional water resources strategy that will inform but not replace the statutory duties of the water companies in the development of their own WRMPs and Business Plans.

When individual water companies prepare their draft WRMPs they will consider the options identified in the WRSE outputs, but will also need to consider issues that cannot be modelled in the regional approach. These include the need to create best value plans, which balance affordable supplies while protecting the environment; to consider customers and stakeholder views; and the need to incorporate pertinent technological, environmental, socio-economic and water quality issues.

1.3 History

The impetus to create a working group of water companies came following a recommendation in a Monopolies and Mergers Commission inquiry, in the mid-1990s, into the proposed takeover of Mid Kent Water by the then Veolia owned water companies: South East Water and Folkestone & Dover Water (now since renamed). The recommendation indicated the benefits of more formal regional co-operation between the water companies.

The WRSE group was subsequently formed in 1996, led by the Environment Agency, with Ofwat, and the then five water companies of Environment Agency Southern Region. The group's work for the Periodic Review 1999 identified four new bulk supply agreements for inclusion in the water company's 1999 WRMPs and Business Plans. These schemes were funded within Ofwat's determination of its 1999 Periodic Review (PR99) of water company Business Plans. The water companies agreed final terms and conditions, with engagement of Ofwat in some cases and the four schemes were implemented by 2004/5.

The WRSE group undertook a series of meetings during 2005 and 2006 to establish how to take the regional modelling work forward to help water companies prepare their statutory WRMPs, due in 2009. Principles and commitments were agreed through the WRSE Senior Management (Managing Directors) Group in November 2006. The Environment Agency and Ofwat also issued a joint position statement in March 2007 setting out their expectations.

The three Environment Agency Thames Region water companies were formally included in the WRSE group and the regional modelling work in 2006, particularly to expand on the modelling representation of opportunities to transfer resources between those water companies and the Environment Agency Southern Region water companies. Thames Water had participated as an observer prior to 2006.

The collaborative work continues to this day.

1.4 Area covered

The WRSE study area covers some 21,000 km² in South East England split into 34 water resource zones. Figure 1 shows the area covered by the WRSE and the WRZs.

The six water companies supply 19 million customers, with an average demand of about 5086 MI/d (million litres per day) in a dry year, rising to about 5825 MI/d for a peak week during the summer period, see Table 1.

Table 1 Summary details of each water company

Water company	Number of water resource zones	Population served (approx. million)	Current average demand in a dry year (MI/d)
Affinity Water	7	3.3	951
Portsmouth Water	1	0.65	188
South East Water	8	2	582
Southern Water	10	2.3	612
Sutton & East Surrey Water	2	0.65	175
Thames Water	6	9.85	2,578
Total	34	18.75	5,086

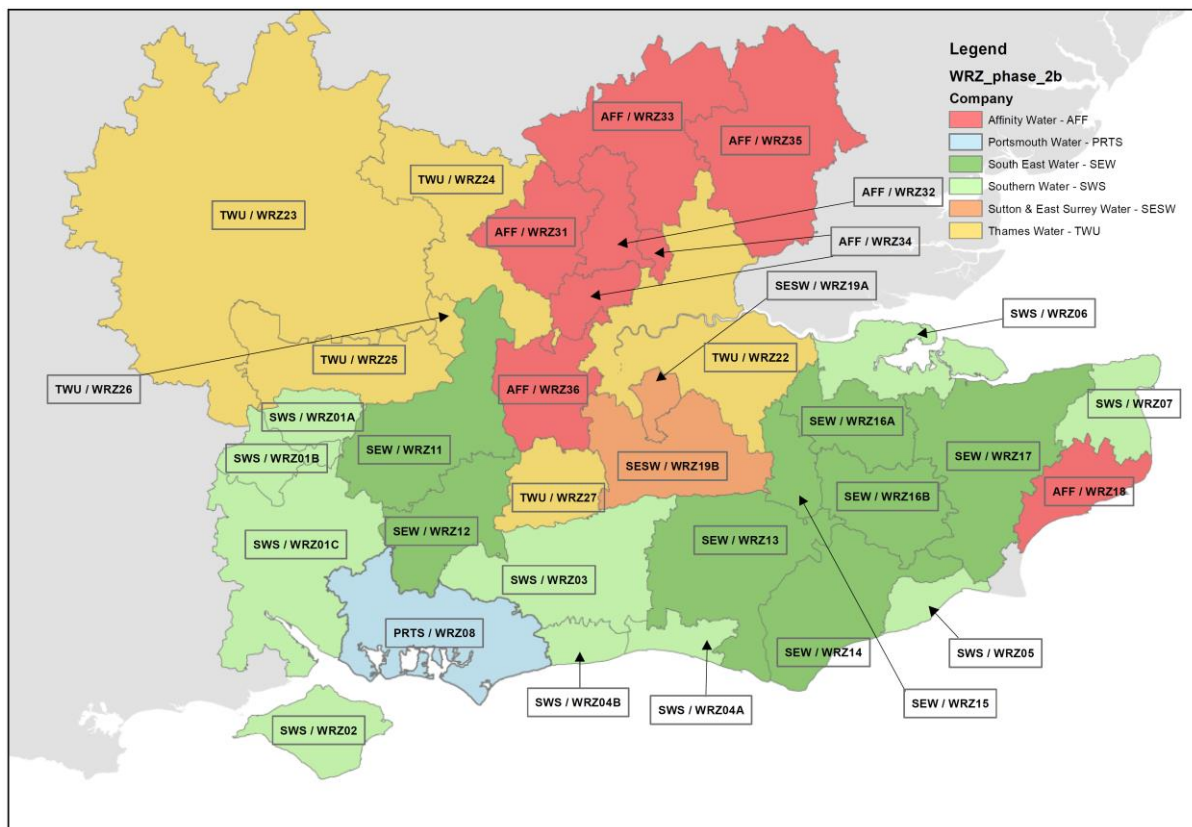


Figure 1 The area covered by the WRSE and the 34 Water Resource Zones (WRZs)

1.5 Governance and membership

The WRSE has established a comprehensive governance structure to ensure the technical delivery of the desired work programme and to provide appropriate high level direction and control. The governance structure comprises four main tiers, namely the

- Chief Executive Officer Level
- Senior Management Group;
- Programme Management Board; and
- Technical Sub-Groups.

The Chief Executive Officer Level, meet regularly to discuss and be appraised of the technical findings of the WRSE, and to discuss other region-wide issues approaches, both in terms of regulatory commitments and delivery.

The Senior Management Group consists of representatives from within stakeholder organizations plus senior members of the core organisations. The Group meet on a 3-6 monthly basis and is responsible for establishing the oversight of the project and employing resources at a strategic level. When first created, this group comprised the MDs of each water company; now the membership mostly reflects senior water resource directors within the companies.

The Programme Management Board communicate on a fortnightly basis and comprises representatives of the core members, the chairs of the Sub-Groups and the independent Project Manager. This Board is responsible for providing the day to day direction of project activity to ensure it is delivered in accordance with strategic objectives.

At an operational level, the Technical Sub-Groups examine the key areas of interest to the WRSE in the particular planning cycle. The Sub-Groups are responsible for overseeing and coordinating the activity need to achieve the required technical outputs.

Table 2 shows the membership of the WRSE group as per the governance structure.

Table 2 Membership of the WRSE as per the governance structure

Organisation	Member of the CEO Level	Member of the Senior Management Group	Member of the Programme Management Board	Member of Technical Sub-Groups
Affinity Water	Yes	Yes	Yes	Yes
Anglian Water		Yes		
Canal and River Trust		Yes		
Consumer Council for Water		Yes		Yes
Defra		Yes		
DWI		Yes		
Environment Agency	Yes	Yes	Yes	Yes
Greater London Authority		Yes		
Natural England		Yes		Yes
Northumberland Water		Yes		
Ofwat	Yes	Yes	Yes	
Portsmouth Water	Yes	Yes	Yes	Yes
SES Water	Yes	Yes	Yes	Yes
Severn Trent Water	Yes	Yes		
South East Water	Yes	Yes	Yes	Yes
Southern Water	Yes	Yes	Yes	Yes
Thames Water	Yes	Yes	Yes	Yes

2 The Benefits of a Regional Solution

A regional water strategy is needed for the South East to find the best solutions for customers and the environment in the region. The development of a regional strategy, to inform individual water company plans, can maximise the benefits of sharing of water resources, reduce the need for new water abstractions from the environment, and facilitate greater reduction of existing abstractions.

Many of the 34 water resource zones across the South East currently, or in the future, will experience shortfalls in water availability in periods of prolonged dry weather. However, there are also areas that have adequate water availability and can provide supplies for short or long periods to areas with a shortfall.

The WRSE group accepts the importance of inter-company co-operation in strategic planning, as well as the need for consistency in the interface between water companies and regulators. The group works towards the shared strategic development of water resources in South East England.

The benefits arising from the WRSE regional strategy, include the following:

- It permits the management of water resources on a regional, strategic and long term planning basis that would not happen otherwise;
- It avoids the potential for the selection of mutually incompatible or even mutually exclusive schemes to be selected by individual water companies;
- It can avoid unnecessary developments being promoted by individual water companies which could result in the creation of excessive headroom, greater environmental impact and higher customer bills than necessary;
- It creates the opportunity to make the optimum use of limited resources, and realise any potential for economies of scale with minimum impact/cost by providing a platform for joint investment; and
- Given intended equitable implementation of options identified within regional least-cost solutions, all customers involved in these schemes will benefit from a smaller bill increase.

The work of the WRSE sets out to determine if, by sharing existing and future resources between water companies, it may be possible to derive a different permutation of resource developments and transfers and so arrive at a cheaper solution for the region. There are four reasons why this could be possible:

- In some locations, existing resources exceed forecast demand and required headroom, and so these surpluses can be transferred to locations where current or future resources are inadequate;
- Water companies must submit plans whereby each zone remains in surplus for all years, with sufficient capacity to reach dry year critical peak demand while including target headroom, where new resources are required they are frequently not utilised to full capacity in the initial years and surplus could be transferred;
- Future resource development needs can be better optimised when water company boundaries are ignored and a regional view is taken; and
- The regional model considers more options for transferring existing or future resources between WRZs and between water companies than water companies consider within their individual options selection.

3 The Challenges facing the WRSE

Water companies must deal with several challenges to develop a cost-effective and environmentally sustainable plan for maintaining the security of water supplies to their customers. Whilst many of these challenges are not confined to the South East, many of them are particularly acute in this region.

The South East of England has a number of characteristics that make water resources planning more challenging than other parts of the country. These characteristics include a higher than the (national) average per capita consumption, relatively low rainfall and high population levels that are predicted to increase. A large part of South East England has been classified as being *seriously water stressed* by the Environment Agency in recognition of the growing pressure on the already highly intensive use of water resources in the region. There are also a number of challenges specific to the South East region due to the nature of the existing supply systems across the study area, with six water companies operating 34 discrete water resource zones.

Some of the challenges facing the WRSE area are briefly summarized below.

3.1 Water availability

The entire WRSE study area falls within a wider area that has been designated as an “*area of serious water stress*”.

Consequently, there are significant challenges to meet the water supply needs of society and the economy without over-exploiting the water environment. The provision of good levels of service, to ensure reliable water supplies to customers, need to be maintained whilst the number of customers is increasing. In addition, actions are required to reduce abstraction where damage to surface water ecology is occurring and respond to the expected impacts of climate change.

Water companies in areas of serious water stress are required to consider the cost-benefit of compulsory metering of unmeasured households as an option in their WRMP. Three areas are already metering their household customers. In other areas, existing metering policies continue and compulsory metering is considered in WRSE modelling work.

Water companies plan to maintain an unrestricted supply of water to their customers in most years. During droughts, water companies may have to restrict water use to conserve supplies. Water companies agree a Level of Service which sets out how frequently the water company expects to impose restrictions on the use of hose-pipes, sprinklers and other non-essential uses. The water company's drought plan also sets out how often a water company expects to apply for drought permits and drought orders seeking temporary increased abstraction of water from the environment.

The study area has experienced droughts in 1972-73, 1975-76, 1984, 1989-91, 1995-97, 2003, 2005-06 and most recently during 2011-2012. These droughts resulted in some water companies applying restrictions more frequently than implied by their intended Levels of Service. Such challenges may become more apparent in the future because of climate change.

It is noteworthy that none of these drought periods, on which company water resource assessments are based, lasted for more than two winter seasons. However, three-season and longer droughts are evident in the historical

record, albeit further back in time when the hydrological record is less reliable. Climate change projections do not give clear signals on the length of future droughts, but if longer multi-season droughts occur in the future, the resilience of companies' water resources systems would be severely tested, with significant repercussions for the economy and the environment. Therefore, the WRSE seeks to model the effects of several more extreme scenarios to explore the level of resilience and impact of stated Levels of Service.

3.2 Population and growth

The south-east area is one which has a trend of increasing growth, meaning that estimates for water consumption increase each year.

The Office for National Statistics (ONS, 2014¹) forecast that population in London is projected to grow by 13%, the East by 9% and the South East by 8% over the 10-year period to mid-2022, compared with the projected growth for England of 7% over the same time period.

3.3 Nature of the supply system

The water supply system within the WRSE area is the result of the historic development and integration of local systems over more than a century.

The structure of the system and pattern of WRZs is complex, due to the geographical areas of some water company supply systems, and inter-connections between many of the water companies in the region. This makes it difficult to easily share water across different WRZs.

3.4 Climate change

Key findings from the UKCIP and other studies suggest that all areas of the UK will get warmer, with a likely change in precipitation pattern to wetter winters and drier summers. The magnitude of this change is, however, uncertain.

Climate change will affect both the demand for water and the water available for water companies to use. It also needs to be considered when assessing which future supply-demand options will be most resilient to future hydrological extremes.

3.5 Environmental sustainability and the impacts of environmental legislation

The environmental sustainability of existing abstraction licences has been under review in recent years, due to European Union and national legislative requirements. The Environment Agency is responsible for interpreting European Union environmental legislation, including the Habitats Directive and the Water Framework Directive. The Environment Agency's Restoring Sustainable Abstraction programme considers whether reductions in existing abstraction licences might be needed for environmental reasons. Any required changes are known as "sustainability reductions" within water resources planning work, because they reduce the quantity of water that may be abstracted and hence reduce the deployable output of water sources.

Water companies and the Environment Agency, in liaison with Natural England, carry out investigations to understand the effects of water abstraction. In some cases, these have identified requirements for reduced abstraction under certain conditions to protect or enhance the water environment. The Environment Agency uses the results to consider the needs for changes to abstraction licences.

The Agency inform water companies of "confirmed" or "likely" required sustainability reductions in advance of water companies preparing their draft WRMP. Water companies are also required to evaluate in their WRMPs through sensitivity testing the effects of several potential "unknown" sustainability reductions. In addition to the "confirmed" and "likely" sustainability reductions, there may be other changes to abstraction licences that are required in the future but the needs are currently unknown. Further to this, water companies must ensure their activities do not cause deterioration to water bodies, under the Water Framework Directive.

1 Office for National Statistics (2014) Subnational Population Projections, 2012-based projections, available here: <http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/rel/snpp/sub-national-population-projections/2012-based-projections/index.html>

3.6 Resource development constraints in the South East

There are many constraints on new water resource development in the South East. The Environment Agency has, for many years, not allowed an increase in abstraction from groundwater for consumptive purposes. Furthermore, high population density, and the designation of large areas of the South East as Areas of Outstanding Natural Beauty, significantly reduces the options available for new abstraction, storage, treatment and supply infrastructure. There are also few sites with suitable topography and geology that might be acceptable for new reservoirs.

Many water companies believe that all the appropriate strategic sites for potential development of new resources during the planning period, and possibly beyond, should be recognised and given the appropriate level of land use planning protection, provided they are socially, economically and politically acceptable and environmentally sustainable.

3.7 Government aspirations

The Government has stated its commitment to reduce water use, especially in household demand, through decreased per capita consumption (pcc). In Defra's 2011 water strategy, 'Future Water'², the Government set an aspiration of reducing normal year average pcc to 130 litres per head per day (l/h/day) by 2030.

Further, in its Water White Paper "Water for Life" (2011³), the Government set out its objectives for providing secure, sustainable and affordable water supplies. It outlines the challenge that climate change and population growth present for future water supplies. The key policy priorities that Government expects all WRMPs to address can be summarised as follows:

- *Taking a long-term perspective:* Water companies are to assess the vulnerability of their resources to climate change and analyse how their supplies might be affected within their water resource zones;
- *Water scarcity and environmental damage:* Water companies are to ensure that the value of water reflects its scarcity and the environmental and social costs of abstraction;
- *Investigating options for sharing water to reduce costs and the need for new water supplies:* Each water company must demonstrate that it has considered interconnections between its own water resource zones; water trading through bulk supplies with other water companies; abstraction licence trading within catchments; and supply/demand options provided by other water companies or third parties; and
- *Reducing the demand for water:* All water companies are expected to state how they will promote water efficiency, and to consider all technically feasible demand-reduction options. Where a company is in an area designated as an area of serious water stress (all WRSE companies), it must consider the cost-benefit of compulsory metering as a potential solution.

4 The Regional Optimisation Model

4.1 Introduction

The delivery of the WRSE regional strategy required an optimisation model as a key tool to help find the best solutions for customers and the environment in the South East of England.

The development and use of such a regional water resources investment model has been central to the work of the WRSE group. The use of a model not only provides indications of potential least-cost regional water resource development strategy but also provides a focus for the discussion of supply demand investment options and water resources planning issues.

The model has been populated with demand reduction options, resource development options and transfer options established in a process of consultation and discussion with the water companies over several years.

4.2 Purpose of Modelling

Modelling is carried out to produce a regional water resources strategy, which will contain a range of strategic options to develop the best solutions for customers and the environment in the South East of England. The options that form

² Defra's 2011 "Future Water" paper can be found here: <https://www.gov.uk/government/publications/future-water-the-government-s-water-strategy-for-england>

³The 2011 "Water for Life" paper is available here: <https://www.gov.uk/government/publications/water-for-life>

the strategy can then be considered by individual water companies when developing their draft WRMPs. Modelling is undertaken in accordance with the national water resources planning guideline.

4.3 Model Development

The WRSE model was first developed and implemented by Halcrow Group Ltd and University College London. In 2003, the Environment Agency contracted Halcrow to establish and maintain a new regional water resource investment model. The model works to the principles and practice of the economics of balancing supply and demand (EBS) guidelines, choosing supply options that contribute to a least-cost solution over the planning period.

The WRSE model is a regional least-cost option selection model built using the GAMS⁴ software developed by Prof. Julien Harou's research group (then at UCL; now with the University of Manchester). Since inception it has been updated by CH2M in collaboration with Prof. Harou's researchers.

It follows the EBS methodology to consider the projected supply/demand settings for each of the 34 water resources zones (WRZs) of the WRSE Group and optimise a set of new supply, transfer and demand management options to satisfy future supply/demand deficit.

The model is complex, with over 1000 potential demand, resource and transfer options put forward by the six water companies to satisfy the supply and demand challenges in 34 water resource zones. The water companies provide a comprehensive set of data for inclusion in the model, including demand and deployable output forecasts, and cost, yield and timing data on the options.

The model works to "least cost" optimisation principles, using data provided by water companies concerning the forecast supply-demand balance, and options that could be chosen to maintain that balance.

The model identifies the minimum cost solution under four simultaneous water supply-demand balance conditions: dry year annual average (DYAA), dry year critical period (DYCP), normal year annual average (NYAA), and minimum deployable output (MDO). DYCP applies to summer peak week demand conditions and MDO applies in the autumn when water stocks are low after a dry summer. The model is constrained to ensure supply and demand are balanced for all four conditions. Cost is optimised using the capital and fixed operating costs and the average of the variable operating costs for each demand condition.

4.4 Results for PR14

The use of the EBS model for PR14 yielded results such that the following conclusion can be made, i.e.:

- the WRSE region would enter a dry year critical period and annual average supply-demand deficit in the late 2010s and early 2020s respectively;
- there would be an overall dry year critical period deficit of almost 800 Ml/d by 2039/40;
- deployable output (DO) is expected to reduce significantly over the planning period due to climate change and sustainability reductions; and
- an effective strategy in the late 2010s is to implement demand management; and
- from the 2020s onward, an increase in inter and intra company bulk supplies combined with the new sources is an effective strategy for the region.

4.5 Use for PR19

The EBS model is being used to generate a set of portfolio options to inform water company plans for the 2019 Periodic review. In reflection of other development in the industry, the current EBS model is being used in conjunction with the "Info Gap" advanced decision making approach.

5 The Regional Simulation Model

5.1 Introduction

For its work in PR19 and beyond the WRSE seeks to move beyond the limitations to least-cost optimisation modelling, and take advantage of advances in computer power and the development of advanced decision making approaches.

⁴ <https://www.gams.com/>

The specific *advanced decision making under uncertainty* method chosen is one of phased *Robust Decision Making* (RDM) utilising a regional simulator. The purpose of this method is to investigate which combinations of strategic options could perform robustly and efficiently for a range of plausible futures in the south east of England. It would also be set up to examine ways to schedule the implementation of new assets to help develop flexible strategies for the region.

One of the central elements of the proposed robust decision making approach is the use of a regional simulator of the water resource network which can evaluate the regional system against various metrics. Using a regional simulator in this way allows testing of the performance of a wide range of feasible portfolios of options against many future scenarios in the non-linear water resources system. The use of such a method aligns with the overall WRSE objectives to:

- Develop a flexible and robust strategy; and
- Explore future levels of resilience.

The proposed method is conceptually simple: to evaluate portfolios of strategic options against plausible futures. However, the behaviour of the water resource system is known to be complex, and evaluation of a portfolio and/or future is non-trivial. The process utilises a water resource simulator to enable this evaluation. This simulator component can be thought of as a function, the inputs to which are the future supply and demand conditions along with feasible strategic options, and the outputs are various measures of the performance of the system.

5.2 Development of a regional simulation model

A regional simulation model does not exist for the WRSE region. Therefore in 2016 the WRSE commissioned Atkins and the University of Manchester to construct a regional simulator model for the south east region.

The model will function as the tool by which portfolios of options are evaluated against future uncertainties represented via scenarios. That evaluation will be reported through a set of performance metrics each time the simulator is run using those scenarios.

The outcome of a modelling platform review was to recommend that the modelling platform, Pywr is utilised. This platform provides several advantages in developing the regional simulator in stages and allows for complex rules to be represented in a fast simulator without very complicated modification of the core allocation algorithms.

5.3 Delivery and use in PR19

The construction of any simulator or model is a trade-off between many factors such as detail, accuracy, run-time, usability, flexibility, etc. As there is no existing simulator, one must be built from scratch. Given the uncertainties involved, the WRSE adopted a precautionary approach to ensure that it still delivers information with which to inform company plans. It recognised that risks were involved regarding the design, build and calibrate a new model and then use it to inform company plans, especially given the relatively short time in which company plans were to be produced within the 2019 Period Review cycle, and the fact that Pywr is a relatively new platform. Therefore, the WRSE commissioned the creation of the river simulation module of the model as 'Plan B' for the PR19 process, retaining the use of the EBSD as 'Plan A' for the PR19 cycle.

However, the river simulation module of the model will be used and its outputs examined in the PR19 cycle, where possible.

The intention for the future however is to move completely away from EBSD modelling, and fully use the RDM and regional simulator for strategic regionally based water resources planning in the future.

6 The Future

The work of the WRSE will continue, to address the challenges facing the south east. These challenges are expected to increase and so concerted collaborative effort is needed to meet water demands and the work of the WRSE is recognised as being increasingly important as a mechanism to continue to deliver a regional strategy to balance the needs of water from people and the environment.