

Water Resources Management Plan 2014

Appendix 3 : Supply Forecast

Executive Summary

1. This Appendix describes our existing supply (our existing groundwater, surface water and bulk supplies).
2. Our supply forecast consists of five elements:
 - Deployable output assessments
 - Process Loss assessments
 - Outage assessments
 - Climate change assessments
 - Sustainability Reduction
3. This Appendix describes how all elements have been developed to derive our baseline supply forecasts. In the future we will build new schemes to meet increasing demand, and these new schemes are described in Sections 7 and 9 of the WRMP.

Deployable Output Assessments

4. The Deployable Output (DO) assessments have been updated for all sources following the droughts of 2010 to 2012. Rainfall during this period was exceptionally low, and resulted in some of the lowest groundwater levels we have ever seen in our area. River flows were also low and this impacted on the storage in our reservoirs. This drought allowed us the opportunity to understand how our sources operate in drought conditions, and record hydrological data which we subsequently used in our analysis. Our approach follows UKWIR Guidance. Our assessments are described in separate reports in Appendix 3A.
5. It is important to note that we are proposing some additional changes to the deployable output of the River Medway Scheme (RMS) as a result of on-going discussions with Southern Water. Southern Water has reviewed the yield from Bewl Reservoir (which is jointly owned by ourselves and Southern Water) and believes that the yield of the reservoir is lower than we have previously published. The two companies have agreed to adopt the analysis undertaken by Southern Water in 2020 to 2025, so it can be seen later that between 2020 and 2025 we reduce the deployable output of the River Medway scheme in line with Southern Water's assessment.

Process Loss Assessment

6. For WRMP09 we had undertaken only limited analysis of the amount of water we cannot put into supply as a result of process losses. For WRMP14 we have undertaken a thorough review and identified those sites where process losses occur, and the magnitude of those losses. The results are described in a separate report in Appendix 3B.

Outage Assessments

7. Our outage assessments determine the frequency and impact of planned and unplanned outages. Outages occur for all sorts of reasons, including power failures, pumps breaking down or raw water quality problems. For WRMP09 the approaches used to collect data varied from area to area, so for WRMP14 we have placed much more emphasis on collecting data regarding outage events. The results and approach are summarised in Appendix 3C.

Climate Change Assessment

8. We have commissioned specialists at HR Wallingford to undertake an assessment of the impacts of climate change on the yields of our existing sources. Initially HR Wallingford were asked to see if we, as a company, are vulnerable to potential future changes in the climate, and HR Wallingford confirmed that we were. Secondly HR Wallingford assessed the potential long-term impacts of climate change on our supply so we could see the long-term trends and include them in our plan. Their work is included in Appendix 3D.

Sustainability Reductions

9. The Environment Agency and Natural England have an on-going programme of work to assess the impacts of our abstractions (and all other water companies) on the environment. As part of this programme of work we have been working with them to understand the impacts of our groundwater abstractions on Greywell Fen in Hampshire and the Little Stour in Kent. These studies have indicated that some of our abstractions are not sustainable. We have agreed that we will stop our abstraction at Greywell and are working with other water companies in Kent to agree a solution for the Little Stour. Whilst that solution has not been finalised with the other water companies, we have agreed that we will stop our abstractions during the period 2020 to 2025.

Overview of Available Water

10. We have started with the analysis from WRMP09 and refined it using our recent operational experience, and this gives us confidence that the output figures are resilient in a 1 in 50 year drought. This matches our planned level of service.
11. We have included the yields from schemes to build additional capacity we have carried out, or intend to complete, before 2014/15 which will provide us with further improvements, and also the outcomes of our discussions with neighbouring companies to confirm our bulk supply arrangements.
12. Finally, we have included losses from our treatment works and also have analysed occasions when sites have not been available due to outages.
13. Planned reductions forecast between 2015 and 2040, due to climate change impacts, sustainability reductions and reductions to the River Medway Scheme, means that Water Available for Use (WAFU) reduces from 639.3 Ml/d to 614.4 Ml/d (3.9%) for the dry year average, and from 735.5 Ml/d to 714.2 Ml/d (2.9%) for the summer peak.
14. Overall, therefore, although the level of WAFU we are declaring is lower than the previous plan, we believe this figure is much more robust and resilient when compared with WRMP09. We are more confident that it will be available under periods of stress to meet our customers' expectations and levels of service.
15. We have used best climate change figures available for estimating the impacts over the 25 years of the plan, and we believe this further enhances the resilience of the final WAFU forecast.

Summary of Baseline Supply Forecast

16. The starting point for our supply forecast is WRMP09; however we have undertaken a substantial amount of work to improve our estimates of WAFU since WRMP09. These improvements, in particular around process losses and outage, mean we can be much more confident in our supply forecast. This is important as this additional resilience underpins our future investment programme.
17. The Table 1 summarises the supply forecast for two of the supply demand balance scenarios we consider in our plan. The first is the Dry Year Annual Average and the second is the Summer Peak Period.
18. The table shows the baseline supply for groundwater, surface water, and bulk supplies at 2015. For the Dry Year Annual Average Condition these total 676.8 MI/d. The sustainability reductions are shown totalling 10.3MI/d and the changes to the yield of the River Medway Scheme (RMS) are shown as 5.3MI/d. Climate change effects by 2040 are also shown totalling 12.7MI/d by 2040.
19. Given these changes we expect the total deployable output at 2040 to be 648.5 MI/d for the Dry Year Annual Average condition and 758.4 MI/d for the Summer Peak Condition.
20. Process losses are shown in the table (12.3MI/d) however we do not expect these to change over the planning period. Outage is shown also being consistent over the planning period at 27.4MI/d for the Dry Year Annual Average and 36.7MI/d for the Summer Peak.
21. The bottom line in the table shows the overall baseline Water Available for Use (WAFU) calculation.

Table 1: Supply Forecast

	Dry Year Annual Average (MI/d)					Summer Peak Period (MI/d)				
	Base Year 2015	Sustainability Reductions 2020 to 2025	RMS 2020 to 2025	Climate Change 2040	Total at 2040	Base Year 2015	Sustainability Reductions 2020 to 2025	RMS 2020 to 2025	Climate Change 2040	Total at 2040
Deployable Output										
Ground water	496.1	-6.8	0.0	-6.0	483.3	571.5	-6.8	0.0	-2.5	562.2
Surface Water	126.6	0.0	-5.5	-6.7	114.4	155.7	0.0	-6.0	-6.0	143.7
Bulk Imports	56.4	0.0	0.0	0.0	56.4	57.3	0.0	0.0	0.0	57.3
Bulk Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	679.0	-6.8	-5.5	-12.7	654.1	784.5	-6.8	-6.0	-8.5	763.2
Process Losses	-12.3	0.0	0.0	0.0	-12.3	-12.3	0.0	0.0	0.0	-12.3
Outage	-27.4	0.0	0.0	0.0	-27.4	-36.7	0.0	0.0	0.0	-36.7
Total (WAFU)	639.3	-6.8	-5.5	-12.7	614.4	735.5	-6.8	-6.0	-8.5	714.2

Table 2 below shows the changes in WAFU across the planning horizon for each WRZ.

Table 2: Changes in Baseline WAFU at the Resource Zone level across the planning period

Ml/d	2015		2020		2025		2030		2035		2040	
	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak
RZ1	40.1	48.7	40.1	48.6	40.1	48.6	40.1	48.6	40.1	48.6	40.1	48.6
RZ2	70.4	95.0	68.9	93.6	67.4	92.3	65.9	90.9	64.3	89.5	64.3	89.5
RZ3	68.2	77.3	67.7	76.9	67.3	76.6	66.9	76.3	66.5	76.0	66.5	76.0
RZ4	216.0	224.9	209.1	218.0	209.1	218.0	209.1	218.0	209.1	218.0	209.1	218.0
RZ5	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6
RZ6	76.2	89.0	75.7	88.9	72.0	84.2	71.6	84.0	71.1	83.9	71.1	83.9
RZ7	15.5	21.6	15.5	21.6	13.2	20.1	13.2	20.1	13.2	20.1	13.2	20.1
RZ8	99.6	117.5	98.9	117.2	98.2	117.0	97.5	116.7	96.7	116.5	96.7	116.5
TOTAL	639.3	735.5	629.3	726.6	620.7	718.4	617.5	716.3	614.4	714.19	614.4	714.2

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- Appendix 3B: Review of Process Losses
- Appendix 3C: Outage Assessment
- Appendix 3D: Climate Change Assessment by HR Wallingford
- Appendix 3E: Level of Service

Deployable Output Assessment

22. The deployable outputs assessments (also referred to as yields) are the starting point for our supply forecasts. They are our assessments of how much water our sources will provide during dry conditions. In general our deployable outputs are limited by the licences we have which are issued by the Environment Agency, but in some cases (for various reasons described below) we may not be able to abstract up to the full licence.
23. We calculate the deployable outputs during the summer peak, when demand is highest and for the average over the whole year dry year annual average so that we can compare our supply and demand forecasts on a consistent basis.

Groundwater Assessment

Approach

24. We have assessed the deployable outputs of each of our sources using industry standard methodologies developed by UKWIR. These approaches require us to use historic data from drought periods so we understand the yields of our sources during low groundwater level or flow conditions. The basis for WRMP14 is the same as previous plans, however UKWIR has developed some new approaches in a recent study, (WR27 – water resources planning tools, UKWIR 2012) and we have used this latest research to derive relationships between deployable outputs and levels of service. In addition to the new methodology, the latest UKWIR project has been used to define confidence ratings for the deployable outputs for each of our sources.
25. The full details of the deployable output calculations for each source are not included in this report, however these can be found in Appendix 3A.
26. We have chosen to set the deployable outputs to a drought severity of 1 in 50 years rather than a 1 in 100 year drought event. The work undertaken by HR Wallingford in 2009 (*Review of South East Water's Deployable Outputs, Testing the Resilience of surface and groundwater sources to severe drought, Technical Note MAR4183/06*) which was undertaken to address the Environment Agency's comment on the Company's source deployable output assessments in WRMP09, was revised and updated. This included an assessment of 1 in 100 year drought events using Hindcasting. The Environment Agency suggested at that time that the plan '*did not provide adequate security of supplies for customers or protection to the environment*' (*Environment Agency 2008*). The HR Wallingford report, 2009, found that the 1 in 50 year Deployable Outputs used were broadly resilient to drought and therefore provided a secure supply for our customers.
27. The HR Wallingford was updated using the recently revised deployable outputs. The original HR Wallingford report only focused on Resource Zones 1-5; however the same approach was extended to Resource Zones 6-8 as well during this update. There have been no significant droughts of a 1 in 100 year type event between 2009 and 2012 and therefore the revised values were not substantively different to the figures produced in the original HR Wallingford Report, 2009. The impact of 1 in 100 year drought compared to a 1 in 50 year drought is in the order of 1 per cent loss of yield for these zones; with the exception of Resource Zone 7 where further work is required due to the limitations of the existing dataset for this region (Table 3). The 1% loss of yield is much less than the impacts of climate

changes in the 2020's and as a result, we have continued to use 1 in 50 year deployable outputs as they are robust, reliant and provide a secure supply for our customers.

Table 3: Comparison of 1 in 50 and 1 in 100 year deployable outputs per resource zone (groundwater and surface water only).

	PR09 (MI/d)				PR14 (MI/d)			
	PDO		ADO		PDO		ADO	
	1 in 50	1 in 100	1 in 50	1 in 100	1 in 50	1 in 100	1 in 50	1 in 100
RZ1	41.4	41.0	36.4	36.0	49.8	49.4	42.5	42.0
RZ2	100.9	100.7	75.0	74.5	98.5	98.3	72.6	72.1
RZ3	79.9	79.1	67.5	67.2	79.8	79.1	67.1	66.9
RZ4	204.7	202.9	196.3	195.1	205.1	204.6	193.4	192.9
RZ5	66.6	66.6	54.5	54.5	68.4	68.4	56.4	56.4
RZ6	75.4	74.6	59.5	58.8	75.0	74.2	60.8	60.1
RZ7	25.7	19.8	17.5	13.1	22.3	17.8	16.4	12.0
RZ8	129.3	128.4	114.4	113.8	128.3	127.4	113.4	112.7
Total	723.9	713.1	621.1	613.0	727.2	719.1	622.7	615.3
Difference		-10.8		-8.1		-8.0		-7.4

Deployable Output Constraints

28. The output of our sources is restricted by many factors. Most importantly we have abstraction licences, issued by the Environment Agency, which limit the amount of water we can take. In addition there are other constraints such as the hydrology and hydrogeology of an area, the capacity of our pumps and treatment works and network of water mains.
29. Since WRMP09 we have undertaken considerable work to improve and update the deployable output constraints. This includes investigations into pump constraints, treatment constraints and examination of operational data such as water levels during the recent 2011/12 drought. Network constraints have also been a focus in the deployable output Assessments, and we have developed an updated MISER model to identify 'pinch points' in the network.

Licence Constraints

30. The licence for a source provides a rigid constraint on the maximum daily and annual abstraction. For cases where the licence only provides a daily maximum, the annual quantity is assumed to be the same as the daily quantity. For group or joint licences, the aggregate annual licensed quantity is normally apportioned between the sources according to historic average abstraction. Daily licensed quantities were used to constrain the Peak deployable output (PDO), and annual licensed quantities were used to constrain the Average deployable output (ADO).

Water Level Constraints/ Aquifer or Borehole Constraints

31. We keep records of time series data for our production and observation wells and boreholes, including water level data and abstraction readings from our abstraction meters. We took further measurements during the drought from autumn 2010 to April 2012 to ensure that the most recent data was reliable for the deployable output assessments for

WRMP14. For example, where telemetry data was not available, we undertook additional manual recording of water levels.

32. There have been a series of droughts for which we have records, and none of them are the same. This means that different droughts have different effects on the yields of our sources, so it is important that whilst the drought data from 2010 to 2012 was used in our analysis, we also used data from other drought periods including 1989, 1992, 1995, 1996, 2005 and 2006.
33. In addition to this measured data we have updated models we developed for WRMP09 so we can determine water levels and flows during earlier droughts which we do not have good records for. By hindcasting monthly rainfall sequences (back to the early 1900s) we can see if groundwater levels in earlier droughts were more severe than those we have recently experienced and have better data for.
34. The Deepest Advisable Pumping Water Level (DAPWL) in the deployable output assessments is defined by either the critical flow horizons in a well or borehole, or the level of an adit or from operational experience. In cases where there was insufficient data, the DAPWL was defined using the criteria provided in the UKWIR methodology 1. For non-uniform aquifers or aquifers which are highly fissured such as the Chalk, the DAPWL was estimated to be equivalent to 50% of saturated aquifer dewatering. For inter-granular and uniform aquifers, such as the Lower Greensand and Ashdown aquifers, the DAPWL was estimated to be equivalent to 70% of saturated aquifer dewatering. The DAPWL has generally been set to 0.5 m above the base of the adit (where applicable), except where operational data suggest that the adit is routinely dewatered. The Potential Yield of a groundwater source was calculated by the intercept between the 1 in 50 year drought curve and the DAPWL on the deployable output assessment graphs.

Environmental Constraints

35. For some sources environmental constraints may be necessary, for example a groundwater source which may be constrained by a minimal residual flow (MRF). In many cases the environmental constraint will have been established with the licence conditions and there will be no additional constraint.

Source works Constraints

36. Source works constraints include pump capacities, pump cut-outs, treatment work capacities and transfer/output main capacities. In our assessments the pump cut-outs are considered to be 3m above the pump depth. Source works constraints, particularly pump capacities and depths, are held within our asset records database (known as Maximo). These figures were also checked with our operational staff who know the sources. Where applicable, the source works constraint has been illustrated on the deployable output assessment graphs as yield constraints.

Water Quality Constraints

37. Water quality constraints have been illustrated on the deployable output assessment graphs as yield constraints, where applicable. Water Quality constraints were derived from operational and water quality data for generally the worst drought year, key examples are salinity and turbidity.

Drought Curve Construction

38. A 1 in 50 year drought curve was defined for both average and peak deployable output conditions, using source output and water levels. Historical non-pumping water levels (rest water levels) and drought operational data are plotted on the deployable output assessment graphs. For sources with multiple boreholes or wells the drought curve was determined using the source with the worst drought year operational data. The peak and average deployable output was taken as the minimum constrained output on the deployable output assessment graphs.
39. In the WRMP14 assessment the drought curves have typically been lowered paralleling the WRMP09 drought curve according to new data or constraints.

Deployable Output Grading

40. The assessments of deployable outputs are graded based upon the accuracy, source type and data availability according to the UKWIR Methodology. The majority of sources were graded and assessed using Option C, the operational approach. The accuracy of the analytical approach, Option D, was limited due to the complexity of multiple borehole sources and the use of non-drought step test data (which has a tendency to overestimate water levels).
41. Additional to the above approach the UKWIR project 'WR27 – water resource planning' has been consulted to define confidence ratings to the deployable outputs. The confidence levels range from A1 through to C3 depending upon confidence and quality of the datasets. Confidence grade A1 is for high confidence, through to C3 which is low confidence in the dataset. Confidence grades for deployable outputs are not given within this report; however they are given within the assessment reports for each water resource zone (WRZ) and subsequently deployable output Assessment Reports for each groundwater and surface water source.

Uncertainties in Deployable Outputs

42. It is noted that there will always be a level of uncertainty surrounding deployable outputs, but we have applied a best endeavours approach to sourcing of constraint data, data interpretation and delineation of drought curves. The constraints have been checked and updated where new information has been available, including data held within our own database (Maximo), Operational and Maintenance files, manual dips etc.
43. The uncertainties and assumptions with deriving of the deployable outputs are given below:
 - Where operational data suggests that borehole yields may have declined due to low water table and water level data is sparse, due to constraints with dipping or where telemetry data may have been flat-lining the drought curves have been lowered on the basis of comparison with local or regional observation borehole water levels and information provided by production on the operation of the source during the drought.
 - Outputs from Maximo have been checked with operational staff and operational data, to ensure data is correct.

- Deployable output assessment graphs were redrawn for sources in Water Resource Zones 6-8 as they were not our standard approach applied by HSI/Scott Wilson in WRMP09. Where possible the deployable output assessment graphs were re-drawn to reflect individual borehole constraints, as well as overall site constraints to give a more comprehensive and robust deployable output and better understanding of constraints.
- We have several newly drilled boreholes which had insufficient data beyond pump tests to represent the worst drought year condition. There are uncertainties and lack of confidence in deployable outputs for new sources until future drought data and analysis is available.
- New data during a peak demand period during a drought year was limited as there has not been a severe drought condition during the peak period since the WRMP09 PDO values were determined. Recharge prior to the peak weeks in 2012 reduced the impacts of the preceding two dry winters, groundwater levels increased and demands were exceptionally low due to the wet weather. Drought curves for the peak condition have only been reviewed whereby there was sufficient and relevant data available to do so.
- Where there is an existing planned funded scheme to be delivered before 2015, the deployable output has been estimated based upon delivery of that scheme and included. There are uncertainties surrounding the actual deployable output of some of these schemes.

WRMP14 Changes to Deployable outputs

44. Table 4 summarises changes in assumed groundwater source yields since WRMP09. Companywide, the overall average deployable output has decreased by 0.75MI/d and the peak deployable output has decreased by 2.31MI/d. Table 5 summarises the Company groundwater Deployable output values.

Table 4: Summary of changes in groundwater source yields since WRMP09

Resource Zone	Category	Source/WTW	2014-15 Yield change (MI/d)	
			Average	Peak
RZ1	Increased and Reduced	Kemsing	0.50	-0.70
	Reduced	Oak Lane	-0.20	-0.25
	Increased	Hartlake	0.00	1.50
	Increased & New	Pembury	1.59	2.79
	Increased & New	Saints Hill	1.48	1.30
	Increased & New	Tonbridge (Gravel)	2.40	2.40
	Increased & New	Tonbridge (Ashdown)	0.30	0.30
RZ2	Reduced	Clayton	0.00	-0.15
	Reduced	Cow Wish Bh1	0.00	-0.34
	Increased	Eridge Bh1	0.50	0.50
	Reduced	Poverty Bottom Bh4 & 6	-2.25	-1.25
	Reduced	Rathfinny Bh1 & 2	-0.66	-1.50
RZ3	Reduced	Crowhurst Bridge	-0.29	-0.29
	Increased	Deep Dean	0.30	0.60
	Abandoned	Filching	-0.25	-0.45
	Increased	Sweet Willow Wood	0.00	1.06
	Reduced	Water Works Road	-0.80	-0.80
	Increased	Cornish	0.69	0.3
RZ4	Increased & New	Beenhams Heath	1.80	0.00

Resource Zone	Category	Source/WTW	2014-15 Yield change (Ml/d)	
			Average	Peak
	Abandoned	Cliddesden	-0.18	-0.22
	Reduced & Increased	Hurley	-2.00	4.00
	Increased	Tongham	0.43	0.00
	Increased	Westham Park – Source	0.00	0.10
	Increased	Bray Gravels	9.1	9.0
	Reduced	Greywell	-0.02	0.00
	Reduced	Woodgarston	-3.00	-3.40
RZ5	Increased	Hindhead London Road	0.04	0.04
	Increased & New	Oakhanger – Source	-0.92	-0.93
	Reduced	The Bourne	0.00	-0.06
	Reduced	Tilford Meads	-0.06	-0.06
	Reduced	Tilford WR	-1.50	-1.48
	Increased	Halling Chalk	0.03	0.00
RZ6	Increased	Halling GS	0.04	0.00
	Increased	Forstal	1.20	0.00
	Reduced	Cossington GS	0.00	-0.10
	Increased	Boxley GS and Boarley	0.56	0.30
	Decreased	Boxley Chalk	-0.26	0.00
	Increased	Trosley (Group)	2.1	0.00
	Reduced	Hartley Chalk	-0.35	-0.60
RZ7	Reduced	Goudhurst	-0.60	-0.60
	Abandoned	Maytham Farm	-1.50	-1.80
	Reduced	Bewl Bridge	0.00	-3.00
RZ8	Reduced	Charing	-0.80	-0.74
	Increased	Hoplands Farm	0.00	0.02
	Increased	Wichling	0.00	0.90
	Increased	Wineycock Shaw	0.37	0.57
	Increased	Boughton	-0.03	0.00
	Reduced	Stockbury	-0.60	-1.70

Table 5: Company groundwater Deployable Outputs - Comparison of WRMP09 and WRMP14

	2014-15 GW Deployable output (Ml/d)	
	Average	Peak
WRMP09	488.95	566.49
WRMP14	496.1	571.75
Difference	7.15	5.26

Surface Water Deployable Output Assessment

45. Our surface water abstractions are taken from six different rivers and their respective tributaries. The rivers are the Medway, Ouse, Thames, Cuckmere, Wallers Haven and Rother. Each of these has been modelled separately to assess the deployable outputs and discussions are given below:

Ouse Cuckmere System (Resource Zone 2 and 3)

46. The rainfall – runoff modelling of the Ouse Cuckmere catchments using HYSIM modelling has historically been undertaken for the Ouse-Cuckmere System. Consultants, Jacobs, have updated these models for the deployable outputs for the WRMP and following the 2011/12 drought.
47. Abstractions at Shellbrook and Barcombe WTW are from the Ouse system within Resource Zone 2. In winter, water is stored within Ardingly Reservoir and released for augmentation into the River Ouse when river flows recede and peak demand increases during the summer months. Augmented water is then abstracted downstream at the Barcombe WTW. Shellbrook WTW abstracts water directly from Ardingly Reservoir.
48. Abstraction from the Cuckmere exists for storage at Arlington Reservoir in WRZ 3. There is a bi-direction transfer link between Barcombe and Arlington connecting the Ouse and Cuckmere river systems.
49. A considerable amount of deployable output modelling has been undertaken, particularly the Ouse system during the 2011/12 drought. The recent updated modelling for both the Ouse and Cuckmere systems confirmed that the deployable output from WRMP09 remained relevant and robust. The table 6 below compares the Ouse-Cuckmere deployable outputs from WRMP09 with WRMP14 from which it can be seen that the deployable outputs adopted are unchanged from the previous plan.

Table 6: Comparison of WRMP Deployable Outputs for the Ouse-Cuckmere System

	R Ouse at Shellbrook		R Ouse at Barcombe		Arlington	
	WRMP09	WRMP14	WRMP09	WRMP14	WRMP09	WRMP14
ADO (Ml/d)	4.5	4.5	38.1	38.1	14	14
PDO (Ml/d)	4.5	4.5	59	59	17.4	17.4

Wallers Haven (Resource Zone 3)

50. The Wallers Haven is a river in East Sussex, approximately 10km long and fed from a number of small tributaries. During periods of low flows and peak demand, water can be abstracted from boreholes upstream for augmentation. The Wallers Haven groundwater augmentation scheme is active if the surface water flows in the Wallers Haven drop below 3.41 Ml/d. Water from Wallers Haven is abstracted at our Hazards Green WTW for treatment.
51. HYSIM modelling has been undertaken for the Wallers Haven system under low flow conditions and long dry spells. The models have been updated and revised following the 2011/12 drought. The minimum average flow over seven days was determined to be 4.2 Ml/d and hence with the augmentation scheme the deployable output would be 6.8Ml/d (i.e. $4.2 - 3.41 + 60.3 = 6.82\text{Ml/d}$), unchanged from WRMP09.

Rother (Resource Zone 3)

52. There is a river abstraction on the River Rother at Crowhurst Bridge. If the flow in the Eastern Rother drops below 89.1 Ml/d the augmentation source at Witherenden is operated. This augmentation source can supply up to 3 Ml/d, but only two thirds is licenced to be abstracted downstream at Crowhurst Bridge WTW, equivalent to 2 Ml/d.

Thames (Resource Zone 4)

53. Our only site which abstracts water from the River Thames is Bray WTW. There are complex licensing issues for the River Thames. Abstraction at Bray WTW is limited to 45 MI/d if the flow in the River Thames falls below 1100 MI/d. The average and peak deployable output at Bray WTW is constrained to 45 MI/d by treatment capacity for the dWRMP14 although this has been further reviewed later in the report.

River Medway Scheme: Bewl Water (Resource Zone 7) and Burham (Resource Zone 6)

54. The River Medway scheme is shared between Southern Water and ourselves. Under the terms of the original Act of Parliament following the construction of Bewl Water, we have the right to 25% of the available output from the scheme. Output of this scheme is abstracted at Bewl Water Treatment Works, which we operate, and from Southern Water's Burham Water Treatment Works, which is supplied to us as a bulk supply arrangement.
55. Historical modelling of the deployable output from Bewl Water Treatment Works has been based upon the 1920s drought events, which is consistent with our 1 in 50 year drought year standard resource assessment. The output from this modelling defines the deployable output for the Bewl source in the WRMP14, however Southern Water have reviewed the deployable outputs from Bewl and believe that the yield is much lower than previously published. They have based their deployable output modelling for Bewl based upon an earlier 1900-1903 drought event which was more prolonged than the 1920s drought event.
56. Whilst both companies can and do successfully operate to the different deployable outputs published in their respective plan, both recognise the importance in the longer term of agreement, and as it stands the existing published deployable outputs will remain until 2020 to 2025. Post 2020 we will plan to start aligning with Southern Water's reduced deployable outputs for the River Medway Scheme. The Table 7 shows the reductions and percentages for the River Medway Scheme incorporated into the baseline outputs for this scheme:

Table 7: Reductions in the River Medway Scheme

	Published ADO WRMP14 (MI/d)	2020+ ADO (MI/d)	% Reduction in ADO	Published PDO WRMP14 (MI/d)	2020+ PDO (MI/d)	% Reduction in PDO
Bewl	8.0	5.7	29%	12.0	10.5	13%
Burham	8.2	5.0	39%	9.0	4.5	50%
RMS Total	16.2	10.7	34%	21.0	15.0	29%

Conjunctive Use Options

57. The analysis of conjunctive use options in the deployable output assessment has been limited and therefore a full discussion was not provided within this WRMP. The Company will commit to further assessing in detail the conjunctive use options before the next draft WRMP.

Levels of Service

58. With the exception of the Ardingly/Ouse and Arlington sites, all groundwater and surface water deployable outputs have been calculated using unrestricted demand only. The

Company will commit to further assess the effects of levels of service on deployable output calculations prior to the next WRMP.

Process Loss Assessment

59. Process losses within treatment works will reduce the quantity of water delivered to the distribution system. Typically, the method of accounting for process losses depends on whether a source constraint is upstream or downstream of the treatment works. In the past, process losses have not generally been quantified explicitly in our previous assessments. The detailed process loss assessment report is provided in Appendix 3B.
60. The process loss assessment was conducted in three stages. For the first stage of this assessment process losses were estimated for sites based upon reviewing the treatment processes onsite and associating a generalised process loss percentage for each treatment type. The losses have been quoted as a percentage of treatment works throughput. The calculated percentages for each process have subsequently been applied to those treatment works with similar processes but which were not individually reviewed as part of this study.
61. South East Water process losses were estimated for all surface water sites (with the exception of Barcombe, which was completed as a separate site audit earlier in 2012) and for selected groundwater sites for the following treatment processes:
 - Clarification
 - Rapid gravity filtration
 - GAC Adsorption
 - Water quality monitoring
62. The process loss values derived in stage one were then securitised by operational and production staff and process scientists on an individual basis based upon their regional areas covered within the Company. The process loss values were also reviewed using telemetry data from our SCOPEX system. Initial estimates of process losses for all sources in each water resource zone shows an overall company process loss of 13.48 MI/d for design throughput and a process loss of 11.61 MI/d for typical throughput. Appendix 3b summaries stage one and two of the process loss assessment.
63. It should be noted that later revisions to the assessments (stage three) result in some modifications to some of the process loss assessments.

Table 8 summarises the final process losses (post stage three of the assessment) which have been applied to the yields our groundwater and surface water sources only. The overall process loss is 12.3 MI/d as detailed in the table below. The process losses are reported as being the same for average and peak use conditions because they relate to continuous plant operation losses, and not throughput.
64. South East Water will commit to improve the process loss assessment at all of its sites, including those study sites in preparation of the next draft WRMP. A more accurate estimate of site process losses will be obtained through site visits and discussing the design and operation in more detail. This would inform a better understanding of process losses and would inevitably help to put in place measures to reduce those losses.

Table 8: Final Process Losses

Resource Zone	Process loss at design throughput (MI/d)
RZ1	-0.16
RZ2	-2.70
RZ3	-1.27
RZ4	-6.23
RZ5	-0.42
RZ6	-0.49
RZ7	-0.36
RZ8	-0.70
Total	-12.33

Outage Assessment

65. As part of the outage assessment process, a review of the outage models created for WRMP09 has been undertaken and the models updated with current data and new assumptions. Outages are of two types – Planned Outage and Unplanned Outage. Unplanned Outage is further categorised into pollution of source, power failure, system failure, turbidity, nitrate or algal issues.

66. Since WRMP09, we have developed a common control room log database system for all eight WRZs. For the WRMP14 outage models, actual data logged in this database from 2011 to 2012 has been analysed to obtain outage durations. Some assumptions adopted for calculating Planned and Unplanned Outages for WRMP09 have been retained for the WRMP14 outage calculations. These are:

- Pollution of Source Methodology: For confined sources, a most credible probability of (3 months) / (50 years) = 0.005 has been used with a minimum and maximum probability of 1 month in 100 years and 3 months in 40 years. In the case of unconfined sources, a most credible probability of (3 months) / (40 years) = 0.006 has been used with a minimum and maximum probability of 1 month in 50 years and 3 months in 30 years.
- Unplanned outage methodology (excluding pollution of source): For turbidity failures, nitrate pollution, algal pollution, power failures and system failures, the methodology is as was adopted by former Mid Kent Water in WRMP09 and the calculation of outage durations was undertaken from data recorded from 2011 to 2012.
- There is no seasonal trend in outage; the risk of a source being out due to power failure is assumed to be the same in all months.
- No planned outage occurs within the critical planning period, as maintenance of a source works occurs outside of peak demand periods.

67. Specific Assumptions:

The following new assumptions have been incorporated in the WRMP14 outage calculations:

- Planned outage methodology: From 2012 onwards, we are implementing planned maintenance at various sites so we move away from reactive maintenance. Planned outages have been worked out based on analysis of our planned maintenance framework. A review of the planned maintenance schedules revealed that all sites

would experience outages from 2 to 4 days per year. This has been used to develop a new probability distribution with a minimum probability of 2 days in 1 year i.e. $2/365 = 0.005$, most credible probability of 3 days in 1 year i.e. $3/365 = 0.008$ and maximum probability of 4 days in 1 year i.e. $4/365 = 0.011$.

- Following analysis of control room logs, it was noted that in many cases the logs failed to capture any outages due to power failure and turbidity. It was therefore recognised that there are likely to be outages which do not get logged in the control room logs. To take account of this, empty outage categories were populated with normalised outage duration from one of the other categories.

68. The WRMP09 model has been compared with the WRMP14 model on a like-for-like basis and the results of this like-for-like analysis are presented in Table 9. It should be noted that there are considerable changes in the datasets used between WRMP09 and WRMP14 for WRZ 1 to 5 which has improved the robustness of the analysis.

Table 9: Outage Review 2012: Comparison of outage values for WRMP09 to WRMP14

Resource Zone	WRMP09 : 2005 to 2007 data		PR14 : 2011 to 2012 data	
	ADO Outage	PDO Outage	ADO Outage	PDO Outage
WRZ 1	1.31	1.4	2.24	1.01
WRZ 2	2.49	3.0	4.91	6.21
WRZ 3	2.05	2.2	5.73	9.28
WRZ 4	6.64	6.57	7.28	10.02
WRZ 5	1.71	1.84	2.65	6.34
WRZ 6	2.12	2.48	1.58	1.35
WRZ 7	0.39	0.53	0.57	0.35
WRZ 8	2.29	2.43	2.54	2.13
Total	19.00	20.45	27.50	36.68

Climate Change

Vulnerability Assessment

69. HR Wallingford undertook a basic vulnerability assessment for our Resource Zones. This assessment describes a phased approach to climate change, with vulnerability assessments to classify resource zones as 'high', 'medium' or 'low' vulnerability, which then determine the level of climate change impact assessment on the supply-demand balance required. The full vulnerability and climate change assessment are given in appendix 3D.

70. A vulnerability assessment includes:

- 1) A summary of information available to determine vulnerability
- 2) A table summarizing the available evidence from a number of sources
- 3) A magnitude verse sensitivity plot of deployable output changes due to future climate change predictions. This is based upon a mid-range climate change scenario.

71. The deployable output vulnerability plots were based up the following calculations:

- 1) Deployable output losses due to climate change were taken from WRMP 2010-2035 and the CC deployable output assessment V3 (based upon the UKWIR06 'wet', 'mid' and 'dry' scenarios,
- 2) An additional assessment was completed using the 2012 revised deployable outputs, based upon the dWRMP14. However reductions made remained the same as the previous assessment.
- 3) The resulting deployable output including climate change was calculated as a percentage of the original baseline for undertaking the basis vulnerability assessment.

72. The vulnerability results based upon the WRMP14 ADO (baseline MI/d) figures are given in Table 10 below:

Table 10: Summary of Climate Change Vulnerability Assessment

Uncertainty Range (wet-dry percentage change)	Mid scenario (DO % change)		
	<5%	>-5%	>-10%
<5%	Low (WRZ6, WRZ8)	Medium	High
6-10%	Medium	Medium (WRZ7)	High
11-15%	High (WRZ4)	High	High
>15%	High (WRZ1, WRZ3, WRZ5)	High (WRZ2)	High

73. The outcome of this assessment highlighted that Resource Zones 1, 2, 3, 4, 5 were 'high vulnerability' to climate change, therefore indicating a need for further detailed analysis using UKCP09 data and future flows.
74. Water Resource Zone 7 showed a 'medium vulnerability' to climate change and would benefit from a further detailed analysis using UKCP09 data and future flows.
75. Water Resource Zones 6 and 8 were shown to be 'low vulnerability to climate change and therefore any require a simpler impact assessment using a smaller number of UKCP09 climate change factors.

Climate Change Impacts

76. HR Wallingford has provided estimates of the most likely impacts of climate change and also range of more extreme possible changes for the Company's sources. The analysis on groundwater and surface water outputs has been conducted separately, but using the same perturbed climate parameters to determine changes in deployable outputs.
77. As required the climate scenarios considered in the assessment are as follows:
- UKCIP02-M scenario – Global Climate Models (GCM) to predict changes in the UK climate under a medium greenhouse gas emissions scenario;
 - CCSR/NIES scenario – GCM considered to be a conservative estimate of climate change (i.e. more recharge predicted); and
 - ECHAM4/OPYC3 scenario – GCM considered to be a worst-case realisation of climate change (i.e. less recharge predicted).
78. These three scenarios constitute Medium or Mid-range, low range (wet) and high range (dry) realisations of possible future climates, respectively.

Groundwater Climate Change Impact Assessments

79. The assessment of climate change on groundwater outputs is essentially the assessment of source outputs under different drought levels and severity. The assessment of severity for groundwater systems is based upon the estimation of recharge events based on predicted changes to rainfall, potential evapotranspiration (PET) and soil moisture defects.
80. Global Climate Models (GCMs) were used to predict future climatic changes under various scenarios. Using these models the changes in recharge conditions can be predicted at a regional scale in both operational and observational borehole data to estimate potential changes in groundwater levels and therefore deployable output.
81. The approach adopted to determine climate perturbed groundwater deployable output can be summarised as follows:
 - Determine the impact of climate change on the groundwater recharge volumes over various durations;
 - Determine regional and where available local observational borehole groundwater level / recharge interactions to predict forecasted changes in groundwater levels from climate perturbed recharge volumes;
 - Determine climate perturbed changes in regional and local groundwater levels and recharge, and;
 - Determine climate perturbed changes in deployable output.
82. The above method has been applied to both the average deployable output and peak deployable output conditions for each borehole or combination of boreholes in the case of multiple sources.
83. The three GCM scenarios that were used to assess the effect of climate change on groundwater were as follows:
 - UKCIP02-M scenario – Global Climate Models (GCM) to predict changes in the UK climate under a medium greenhouse gas emissions scenario;
 - CCSR/NIES scenario – GCM considered to be a conservative estimate of climate change (i.e. more recharge predicted), and;
 - ECHAM4/OPYC3 scenario – GCM considered to be a worst-case realisation of climate change (i.e. less recharge predicted).
84. An unperturbed baseline scenario consisting of historical recharge time series derived from observed rainfall and PET data was also used within the climate change analysis. A scaling factor was also applied to the climate change figures to represent changes in groundwater levels based upon groundwater assessment models.
85. As generally expected, the changes in groundwater deployable output reflects the severity of the recharge event and the greatest loss of deployable output was observed within the ECHAM4/ OPYC3 climate change scenario, which is considered to be a worst case prediction of climate change impacts. Improvements in deployable output were observed under the CCS/NIES climate change scenario.
86. Given the uncertainties surrounding climate change impacts, the Company has included the difference between the mid-range scenario and both the wet and dry climate change scenarios as a component of uncertainty in the Target Headroom assessment.

87. Table 11 shows the climate change impacts to the mid-2030's for average and peak conditions and the dry, mid and wet climate scenarios. We have applied the mid-range climatic scenario to be incorporated into our WRMP14.

Table 11: Summary of Climate Change Impacts to the mid-2030s.

Resource Zone	Average (dry)	Average (mid)	Average (wet)	Peak (dry)	Peak (mid)	Peak (wet)
RZ 1	-2.92	-0.04	0.00	-4.37	-0.05	0.00
RZ 2	-17.68	-6.09	5.83	-17.46	-5.45	5.83
RZ 3	-7.80	-1.64	1.00	-7.77	-1.30	1.00
RZ 4	-9.09	-0.05	0.00	-9.15	-0.06	0.00
RZ 5	-5.11	-0.01	0.00	-6.14	0.00	0.00
RZ 6	-4.72	-1.92	0.00	-3.82	-0.65	0.00
RZ 7	-2.22	0.00	0.00	-3.21	0.00	0.00
RZ 8	-7.08	-2.88	0.00	-5.74	-0.98	0.00
Total	-56.62	-12.63	6.83	-57.65	-8.49	6.83

88. Discussions between the company and Southern Water and Affinity Water indicate that there will be no climate change impacts on Bulk Supply agreements.
89. The mid-range case climate change impacts have been included in the WRMP14 and subtracted from deployable output. The values are similar to those adopted in WRMP09. The recent work has identified a greater range of variability around the central case assumption and other more extreme scenarios; this variability is legitimately included as a component of uncertainty and risk in target headroom.
90. The joint UKWIR and Environment Agency led project 'Future flows and groundwater levels' outputs and tools have been consulted in the formulation of the WRMP14 and (as per the Guidelines) we have discussed our approach and the results with the Environment Agency throughout our analysis.

Sustainability Reductions

AMP5 National Environment Programme (NEP)

91. The National Environment Programme (NEP) is investigating the sustainability of abstractions across England and Wales. A number of the Company's sources have been investigated during the 2010/15 period under the NEP programme to determine if any further measures relating to sustainability reductions to existing deployable outputs should be factored into its WRMP14.
92. The NEP studies have been run in conjunction with the Environment Agency and other key stakeholders have been included as appropriate. Two of these investigations have concluded that the Company's existing operation is having an unacceptable impact on the environment and therefore we are required to take action to reduce the adverse impacts.
93. The NEP study at Greywell demonstrated that the abstraction at Greywell Pumping Station is having an adverse impact on Greywell Fen SSSI. At a stakeholder meeting held on the November 2012 the long term decision, as requested by Natural England, was to close the abstraction and manage the site to allow the recovery of the SSSI. On the December 2012 the Environment Agency issued an updated sustainability change NEP spreadsheet and Greywell Fen pro-forma in which Sustainability Reductions for Greywell are now classified as 'certain' and a reduction of 6.8MI/d is required. The timescales for implementing this

sustainability change is uncertain; however it is likely to be implemented before 2020 due to the urgency of the recovery of the SSSI.

94. Following the guidelines, the Company has incorporated both confirmed and likely sustainability reductions into the baseline assessment.
95. We have excluded any other reductions in deployable output in respect of the 2010-15 NEP and WFD investigations; however the Company has considered it prudent to plan for potential losses of deployable output which could occur. Further sustainability reductions may occur in the future as a result of new Environment Agency investigations. We have recently received a list of new investigations for the NEP for 2015 -20, however these have not yet been finalised with the Regulator, and these are listed below:
- Western Rother (Greatham, Sheet, Oakshott, Hawkley)
 - River Meon (East Meon)
 - Seaford Chalk (Group)
 - Eastbourne Chalk (Group) and Birling Farm
 - Underhills Chalk (Group)
 - Dry Valley west of Faversham
 - White Drain (Broughton)

However, the outcomes of any new investigations are unlikely to impact deployable output during 2015 to 2025.

96. South East Water has followed guidance from the Environment Agency on how to determine and report on water company sustainability changes
97. A sustainability change is any change to a water company abstraction licence to help restore or protect the environment. A change may be required to meet one of five drivers: Habitats Directive, SSSI, BAP, local or WFD. The WFD driver includes actions needed to prevent deterioration in status and actions needed to meet or move towards good status or potential.
98. A change will be classified as one of three categories: 'confirmed', 'likely' or 'unknown', depending on the amount of evidence to support the change. The definitions for each category are given below:
- **Confirmed:** A confirmed sustainability change is an actual change to a licence required following completion of an investigation and an options appraisal.
 - **Likely:** The likely category is split into three sub categories: Likely Category 1, Likely Category 2a and Likely Category 2b. The likely category represents a full or part change to a sustainability reduction whether or not an investigation has been completed.
 - Likely Category 1: a probable change to a licence *following* completion of investigation but before completion of an options appraisal.
 - Likely Category 2a: a probable change to a licence *before* completion of an investigation and options appraisal.
 - Likely Category 2b: a probable initial change to a licence *before* completion of an investigation and options appraisal, where there is the possibility of a further licence change in the future.
 - **Unknown:** An unknown sustainability change should be stated where the evidence is not sufficient to determine a confirmed or likely sustainability change.

Adopted Sustainability Reductions

99. The Environment Agency provided South East Water with a list of proposed sustainability changes in June 2012. The Greywell source has subsequently been added to this list in November 2012. Key sustainability reductions are given in Table 12 below.

Table 12: Advised and Adopted Sustainability Reductions

Licence number	Licence Name	Sustainability change status	Change (AA) ML/d	Change (Daily) ML/d	New Annual Licence Volume (ML/a)
10/41/436102	Sheet & Oakshott	Likely 2b	n/a	n/a	2,073
10/41/436202	Hawkley	Likely 2b	n/a	n/a	568
28/39/24/108	Greywell	Confirmed	6.82	6.82	n/a

100. In line with the Environment Agency's guidance, South East Water has included the sustainability reductions as above in the WRMP14. Likely category 2b will be implemented from 2025 and the likely category 1 will be implemented from 2020.

101. No allowance for sustainability reductions in target headroom has been made.

Baseline Supply Forecast

102. Tables 13 and 14 below show the forecast in WAFU between 2015 and 2040. Due to climate change impacts, sustainability reductions and reductions to the River Medway Scheme, mean WAFU reduces from 639.3 MI/d to 614.4 MI/d (4.5%) for the dry year average, and from 735.5 MI/d to 714.2 MI/d (3.4%) for the summer peak. These figures are before any new schemes are developed, referred to as the baseline WAFU.

Table 13: Supply Forecast

	Dry Year Annual Average (MI/d)					Summer Peak Period (MI/d)				
	Base Year 2015	Sustainability Reductions 2020 to 2025	RMS 2020 to 2025	Climate Change 2040	Total at 2040	Base Year 2015	Sustainability Reductions 2020 to 2025	RMS 2020 to 2025	Climate Change 2040	Total at 2040
Deployable Output										
Ground water	496.1	-6.8	0.0	-6.0	483.3	571.5	-6.8	0.0	-2.5	562.2
Surface Water	126.6	0.0	-5.5	-6.7	114.4	155.7	0.0	-6.0	-6.0	143.7
Bulk Imports	56.4	0.0	0.0	0.0	56.4	57.3	0.0	0.0	0.0	57.3
Bulk Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	679.0	-6.8	-5.5	-12.7	654.1	784.5	-6.8	-6.0	-8.5	763.2
Process Losses	-12.3	0.0	0.0	0.0	-12.3	-12.3	0.0	0.0	0.0	-12.3
Outage	-27.4	0.0	0.0	0.0	-27.4	-36.7	0.0	0.0	0.0	-36.7
Total (WAFU)	639.3	-6.8	-5.5	-12.7	614.4	735.5	-6.8	-6.0	-8.5	714.2

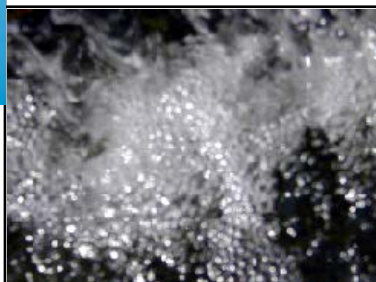
Table 14 below shows the changes in WAFU across the planning horizon for each WRZ.

Table 14: Changes in Baseline WAFU at the Resource Zone level across the planning period

MI/d	2015		2020		2025		2030		2035		2040	
	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak	Ave	Peak
RZ1	40.1	48.7	40.1	48.6	40.1	48.6	40.1	48.6	40.1	48.6	40.1	48.6
RZ2	70.4	95.0	68.9	93.6	67.4	92.3	65.9	90.9	64.3	89.5	64.3	89.5
RZ3	68.2	77.3	67.7	76.9	67.3	76.6	66.9	76.3	66.5	76.0	66.5	76.0
RZ4	216.0	224.9	209.1	218.0	209.1	218.0	209.1	218.0	209.1	218.0	209.1	218.0
RZ5	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6	53.4	61.6
RZ6	76.2	89.0	75.7	88.9	72.0	84.2	71.6	84.0	71.1	83.9	71.1	83.9
RZ7	15.5	21.6	15.5	21.6	13.2	20.1	13.2	20.1	13.2	20.1	13.2	20.1
RZ8	99.6	117.5	98.9	117.2	98.2	117.0	97.5	116.7	96.7	116.5	96.7	116.5
TOTAL	639.3	735.5	629.3	726.6	620.7	718.4	617.5	716.3	614.4	714.19	614.4	714.2



south east water



2014 WRMP

PROJECT NUMBER: 67951

2014 Water Resources Management Plan

REVIEW OF EXISTING SOURCES DEPLOYABLE OUTPUTS

Executive Summary

October 2013

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DOCUMENT RECORD SHEET

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Version	Date	Changes

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1.0 EXECUTIVE SUMMARY

As part of the Water Resource Management Plan (WRMP) process, a review of the deployable outputs (DO) of existing South East Water sources has been undertaken.

For surface water sources on the Rivers Ouse and Cuckmere, updated river flow and rainfall data were obtained and the synthetic flow data used for PR09 were extended to November 2011; the source yields were then re-assessed using the PR09 models. The results demonstrated that no change to the PR09 deployable outputs were required for surface water abstractions. For sources linked to River Medway licences in association with Southern Water Services (SWS), average deployable outputs have not been changed, being controlled by licensed values, but the future DOs post 2020 have been modified to align with SWS.

For groundwater sources, deployable outputs have been reviewed to take account of the very low groundwater levels occurring in late 2011 and early 2012; in some cases, pumped water levels were beneath the previously established 1 in 50 year operational drought curves indicating an improved understanding of the severity of recent conditions. Previous treatment works and network constraints on deployable outputs have also been reviewed including identification of improvements as a result of AMP4 and AMP5 capital projects; network analysis using the latest models has been undertaken within zones where constraints were suspected.

The DO review has established a change in the total combined outputs for all sources in each water resource zone as indicated in Table 1 below. There has been an overall decrease of 0.75MI/d for average deployable output (ADO) and a decrease of 2.31MI/d in peak deployable output (PDO) when compared with values in the final PR09 WRMP (dated 2010). There are many factors contributing to the change in DO, with write-down in ADO and PDO counteracting the increases in many source ADO and PDO values derived primarily from new source development and enhancement and infrastructural improvements. A full list of DO values is shown in Table 2.

2.0 WRZ DEPLOYABLE OUTPUTS

The key changes to the deployable outputs for each Resource Zone are summarised in the sections below:

2.1 Water Resource Zone 1:

Oak Lane

The ADO and PDO has been reduced at Oak lane due to turbidity at higher outputs. The water quality constraint of 0.5MI/d is based upon information provided by Water Quality and Production. It was also noted that turbidity may have been linked with low water levels due to the drought.

2.2 Water Resource Zone 2:

Poverty Bottom

The most notable reduction in DO has been at Poverty Bottom (Seaford Chalk Block) where the ADO has been reduced from 7.00MI/d to 4.75MI/d and the PDO from 7.00MI/d to 5.75MI/d as a result of lowering the drought curve to the 2011 observed groundwater level. High chloride concentrations also reduced abstraction during the drought. South East Water is currently undertaking a study within the Seaford Chalk to understand the link between groundwater levels and salinity in the Chalk aquifer.

Rathfinney

The ADO at Rathfinney has been reduced by 0.5MI/d and the PDO by 1.50MI/d due to high chloride concentrations during the 2011/12 drought. Rathfinney abstracts from the same Chalk Block as Poverty Bottom and is therefore linked to the same saline intrusion issue. South East Water is currently undertaking a study within the Seaford Chalk to understand the link between groundwater levels and salinity in the Chalk aquifer.

Cow Wish

There was a decrease of 0.34MI/d PDO from Cow Wish as it was recognised that there are network constraints on the PDO by Production. Although Cow Wish also abstracts from the Seaford Chalk block this source was not affected by increasing chloride concentrations during the 2011/12 drought.

Clayton

There has been a 0.15MI/d reduction in PDO from Clayton due to low levels and declining yields in October / November 2011. The operational information provided by Production has been used to amend the PDO to reflect this condition.

2.3 Water Resource Zone 3:

Filching

The Filching source has been decommissioned and is no longer in use. The Filching Borehole has been turned off since mid-2008 due to the detection of cryptosporidium in the raw water. Initially South East Water proposed to install a UV disinfection system to mitigate the risk. Further studies have found that the installation of a standalone UV system will not meet DWI regulations for the disinfection of drinking water, primarily due to the frequency of elevated turbidity.

Water Works Road

The operational pump capacity was reviewed and Production confirmed that 7.8MI/d is unattainable from Waterworks Road. Productions have confirmed that the maximum output from Waterworks Road is likely to be 7.00MI/d. The ADO and PDO has been amended to reflect this information from Production.

2.4 Water Resource Zone 4:

Bray Gravels

Abstraction meters installed on individual boreholes and logger data has allowed for improved yield analysis. Further data analysis alongside water levels monitoring and numerical groundwater modelling is required to improve confidence of DO in individual boreholes.

Bray (SW)

The Bray surface water deployable outputs (average and peak) have been reduced from the previous value of 45 MI/d to 35.9 MI/d due to Bray treated water main improvements leading to an improved understanding of treatment constraints. The clarifier sludge system is the pinch point due to flow balancing limiting output.

Hurley

The ADO and PDO was reduced by 2MI/d and 0.62MI/d, respectively, due to revised drought curves relating to low groundwater levels during the 2011/12 drought. Hurley constitutes part of the Beenhams licence which has recently been modified to include the abstraction from the new White Waltham boreholes. The Beenhams licence is time limited to 2016.

Woodgarston

The ADO has been reduced from 6MI/d to 3MI/d and the PDO from 6.4MI/d to 3MI/d at Woodgarston due to high nitrates. Currently South East Water can only operate one of the two boreholes at Woodgarston (BH2). BH 1 has concentrations of nitrate above the PCV value and cannot be put into supply. The increase in nitrates is attributed to the local farmer uphill of BH1. South East Water is undertaking catchment management initiatives with the farmer (and the Environment Agency) to

reduce nitrate pollution from this farm. In the meantime South East Water cannot operate BH1. It may take several years for the nitrates peaks to flush through this Chalk aquifer.

2.5 Water Resource Zone 5:

Oakhanger

The ADO and PDO from Oakhanger (only) has been reduced due to loss of yield at Oakhanger BH1; however the ADO and PDO for all Oakhanger sources has increased due to the new Oaklands and Southlands boreholes.

Tilford Wellesley Road

The ADO has reduced by 1.50MI/d and the PDO by 1.50MI/d at Tilford Wellesley Road due to borehole failure.

2.6 Water Resource Zone 6:

Forstal / Cossington

The ADO at Forstal has increased by 3MI/d and the PDO by 2.8MI/d due to an upgrade at Forstal WTW to treat ammonia in Forstal well. Work has also been undertaken to remove the restriction from Cossington and a new booster station has been designed.

2.7 Water Resource Zone 7:

Goudhurst

The ADO at Goudhurst have been reduced from 5.5MI/d to 4.9MI/d and the PDO from 5.9MI/d to 5.3MI/d due to low water levels observed in 2011/12 drought, particularly in BH's 13 and 14. The low groundwater levels were also noted in South East Water's drought trigger observation borehole Elphicks during the 2011/12 drought, where water levels in the Ashdown aquifer dropped significantly below the severe drought curve.

Bewl

The PDO from the Bewl boreholes has been reduced by 1MI/d. It has been noted that the raw water main may be the constraint and is being reviewed by Assets, however groundwater output also tailed off to 3MI/d during the 2011/12 drought. Further work is required to ascertain if the output from the Bewl boreholes is sustainable longer term.

2.8 Water Resource Zone 8:

Stockbury

The ADO and PDO at Stockbury have both been reduced to 2.8MI/d due to turbidity. Turbidity is an issue at higher outputs and the water quality constraint has been set to 2.8MI/d based on information provided by Assets.

Charing

The ADO and PDO at Charing has been reduced to 3.63MI/d following the loss of BH2 due to sand pumping, However South East Water is still attaining strong yields from BH's 3, 4 and 5.

Table 1: Deployable Output Assessment Review 2012: Resource Zone Totals

Resource Zone	Average (MI/d)			Peak (MI/d)		
	2010 Final WRMP ADO	Proposed 2015 ADO (2012 Review)	Change in ADO	2010 Final WRMP PDO	Proposed 2015 PDO (2012 Review)	Change in PDO
RZ1	36.43	41.1	4.67	42.48	45.92	3.44
RZ2	75.04	72.63	-2.41	101.25	98.51	-2.74
RZ3	67.47	66.13	-1.34	79.68	78.60	-1.08
RZ4	187.28	184.33	-2.95	195.62	196	0.38
RZ5	54.34	56.44	2.1	65.92	68.39	2.47
RZ6	59.46	60.8	1.34	75.36	74.98	-0.38
RZ7	17.50	16.4	-1.1	25.70	22.3	-3.4
RZ8	114.42	113.36	-1.06	129.28	128.28	-1.00
Total	611.94	611.19	-0.75	715.29	712.98	-2.31

Note: ^{1/} Proposed ADO (2012 Review) refers to the DO assessment review carried out between December 2011 & February 2012

^{2/} Change in ADO/PDO established within this DO Review is Proposed ADO minus the 2010 Final WRMP ADO

Table 2. Deployable Output Assessment Review 2012 – Source DO

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	Proposed PDO (2012 Review)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ1										
RZ1	Cramptons Road (total licence)	17.66	17.66	0.00	Annual Licence	A3	21.68	21.68	0.00	Daily Licence / Treatment Capacity	A3
RZ1	Kemsing Bh	3.70	3.70	0.00	Hydrological / Water Quality	B3	5.20	4.20	-1.00	Hydrological / Water Quality	B3
RZ1	Oak Lane	0.70	0.50	-0.20	Water Quality (Turbidity)	B2	0.75	0.50	-0.25	Water Quality (Turbidity)	B2
RZ1	Pembury Boreholes (Ashdown Beds)	3.25	3.94	0.69	Hydrological (Theoretical DAPWL / Pump Capacity)	B3	3.55	4.24	0.69	Hydrological (Theoretical DAPWL / Pump Capacity)	B3
RZ1	Pembury - T Wells Springs	0.30	0.30	0.00	Hydrological (1 in 50 spring flow)	C3	0.30	0.30	0.00	Hydrological (1 in 50 spring flow)	C3
RZ1	Hartlake (Wells)	3.10	3.10	0.00	Hydrological (Pump Intake)	B3	3.10	3.10	0.00	Hydrological (Pump Cut-Out level)	B3
RZ1	Saints Hill	5.52	7.00	1.48	Annual Licence	B3	5.70	7.00	1.30	Daily Licence	B3
RZ1	Tonbridge Gravels	1.30	3.70	2.40	Hydrological (Operational DAPWL)	B3	1.30	3.70	2.40	Hydrological (Pump depth)	B3
RZ1	Tonbridge Ashdown Beds	0.90	1.20	0.30	Licence (subject to pump depth confirmation)	B3	0.90	1.20	0.30	Hydrological (Pump depth)	B3
RZ1	TOTAL	36.43	41.1	4.67			42.48	45.92	3.44		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints..

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (Dwrmp14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ2										
RZ2	Coggins Mill & Sharnden	1.80	1.80	0.00	Distribution Network	B3	1.80	1.80	0.00	Distribution Network	B3
RZ2	Forest Row	1.25	1.25	0.00	Source Capacity / Distribution Network	B3	1.60	1.60	0.00	Source Capacity / Distribution Network	B3
RZ2	Groombridge (Excluding Eridge)	3.90	3.90	0.00	Annual Licence	B3	4.00	4.00	0.00	Apportioned Treatment Works Constraint	B3
RZ2	Eridge (BH1)	2.00	2.50	0.50	Annual Licence	B3	2.40	2.90	0.50	Daily Licence/ Pump Capacity / Treatment Capacity	B3
RZ2	Hempsted	1.16	1.16	0.00	Treatment Capacity	B3	1.16	1.16	0.00	Treatment Capacity	B3
RZ2	Holywell (Cockhaise)	1.50	1.50	0.00	Pump Intake / Operational Pump Capacity	C3	1.90	1.90	0.00	Pump Depth / DAPWL	C3
RZ2	Seaford Chalk - Cow Wish	5.36	5.36	0.00	Pump Intake, Transfer Main and Water Quality (Salinity)	A3	5.70	5.36	-0.34	Pump Intake, Transfer Main and Water Quality (Salinity)	A3
RZ2	Seaford Chalk - Poverty Bottom	7.00	4.75	-2.25	Hydrological / Water Quality (Salinity)	B3	7.00	5.75	-1.25	Hydrological / Water Quality (Salinity)	B3
RZ2	Seaford Chalk - Rathfinny	6.16	5.50	-0.66	Hydrological / Water Quality (Salinity)	A3	9.00	7.50	-1.50	Hydrological / Water Quality (Salinity)	A3
RZ2	Underhill Chalk - Clayton	0.65	0.65	0.00	Distribution Network	B3	1.10	0.95	0.00	Alarm level / Adit DAPWL	B3
RZ2	Underhill Chalk - Coombe	0.24	0.24	0.00	Pump Intake	B3	0.39	0.39	0.00	Pump Cut-Out	B3

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (Dwrmp14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	Down (BH1)										
RZ2	Underhill Chalk - Whitelands (BH1)	0.22	0.22	0.00	Pump Intake	B3	0.40	0.40	0.00	Pump Cut-Out	B3
RZ2	Underhill Chalk - Offham (springs)	0.20	0.20	0.00	Pump Intake	B3	0.20	0.20	0.00	Pump depth / DAPWL	B3
RZ2	Underhill Chalk - Saddlescombe	1.00	1.00	0.00	Hydrological (Groundwater Level)	B3	1.10	1.10	0.00	Operational DAPWL	B3
RZ2	Shellbrook /Ardingly Res	4.50	4.50	0.00	Treatment Capacity	A3	4.50	4.50	0.00	Treatment Capacity	A3
RZ2	Barcombe Res (=R Ouse)	38.10	38.10	0.00	Hydrological	A3	59.00	59.00	0.00	Hydrological	A3
RZ2	TOTAL	75.04	72.63	-2.41			101.25	98.51	-2.74		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ3										
RZ3	Arlington	14.00	14.00	0.00	Hydrological	A3	17.44	17.44	0.00	Hydrological	A3
RZ3	Crowhurst Bridge (Conj / GW - SW) Group	9.53	9.24	-0.29	Annual Licence (apportioned) & Pump Capacity	B3	9.93	9.66	-0.29	Source Capacity	B3
RZ3	Crowhurst Bridge - Turzes Farm - 5/6 Replacement	1.73	1.44	-0.29	Source Capacity	A3	1.73	1.44	-0.29	Source Capacity	A3
RZ3	Crowhurst Bridge (GW) Stonegate - 7	3.02	3.02	0.00	Group Annual Licence (apportioned)	A3	3.02	3.02	0.00	Source Capacity	A3
RZ3	Crowhurst Bridge (SW)	2.00	2.00	0.00	Source Capacity	A3	2.00	2.00	0.00	Source Capacity	A3
RZ3	Hazards Green (GW)	1.12	1.12	0.00	Annual Licence	B2	1.20	1.20	0.00	Daily Licence	B2
RZ3	Waller's Haven / Hazards Green (SW)	6.80	6.80	0.00	Treatment Capacity	A3	6.80	6.80	0.00	Treatment Capacity / Distribution Network	A3
RZ3	Waterworks Road	7.80	7.00	-0.80	Operational Pump Capacity	A2	7.80	7.00	-0.80	Operational Pump Capacity	A2
RZ3	Filching	0.25	0.00	-0.25	Water Quality	B2	0.45	0.00	-0.45	Water Quality	B2
RZ3	Friston and Deep Dean	16.04	16.04	0.00	Group Licence (apportioned) / Pump Cut-Off	B2	20.90	21.2	0.30	Daily licence / Pump Cut-Out	B2

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
RZ3	Holywell	1.00	1.00	0.00	Pump Cut-Out / Group Licence (apportioned)	B2	1.90	1.90	0.00	Pump Cut-Out / Daily Licence	B2
RZ3	Cornish (Wigdens Bottom)	3.31	3.31	0.00	Group Licence (apportioned)	B3	4.32	4.32	0.00	Pump Capacity	B3
RZ3	Powdermill (Group)	2.96	2.96	0.00	Annual Licence (Group)	B3	4.20	4.20	0.00	Daily Licence (Group)	B3
RZ3	Sweet Willow Wood	2.18	2.18	0.00	Annual Licence	B3	2.24	2.40	0.16	Treatment Capacity	B3
RZ3	Birling Farm	2.48	2.48	0.00	Treatment Capacity	B3	2.48	2.48	0.00	Treatment Capacity	B3
RZ3	TOTAL	67.47	66.13	-1.34			79.68	78.60	-1.08		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ4										
RZ4	Hurley	28.00	26.00	-2.00	Operational DAPWL	B3	30.00	34.00	4.00	Operational DAPWL	B3
RZ4	Beenhams Heath (including W Waltham)	2.50	4.30	1.80	Annual Licence (time-limited)	B3 / C3	4.00	4.00	0.00	DAPWL (Adit) / Daily Licence	B3 / C3
RZ4	Tongham	1.81	2.24	0.34	Annual licence / Pump Cut-Off	B3	1.54	1.54	0.00	Apportioned Mains Capacity	B3
RZ4	Boxalls Lane GS	3.80	3.80	0.00	Pump Capacity	B3	1.71	1.71	0.00	Apportioned Mains Capacity	B3
RZ4	Boxalls Lane Chalk	10.59	10.59	0.00	Annual Licence	A3	13.29	13.29	0.00	Apportioned Mains Capacity	A3
RZ4	Bray Gravels	9.00	18.10	9.10	Theoretical DAPWL / Critical Depth	B3	9.10	18.10	9.00	Theoretical DAPWL / Critical Depth	B3
RZ4	Bray SW	45.00	35.90	-9.10	Treatment Capacity	B3	45.00	35.90	-9.10	Treatment Capacity	B3
RZ4	College Avenue	18.50	18.50	0.00	Theoretical DAPWL	B3	18.50	18.50	0.00	Theoretical DAPWL / Critical Flow Horizon	B3
RZ4	Cookham	18.68	18.68	0.00	Annual Licence	B3	20.46	20.46	0.00	Treatment Capacity	B3
RZ4	Greywell	6.82	6.82	0.00	Annual Licence	B2	6.82	6.82	0.00	Daily Licence	B2
RZ4	Itchel	3.45	3.45	0.00	Source Capacity	B3	3.45	3.45	0.00	Source Capacity	B3
RZ4	Lasham	14.95	14.95	0.00	Annual Licence	B3	15.73	15.73	0.00	Pump Cut-Out	B3

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
RZ4	West Ham PS	7.00	7.00	0.00	Pump Cut-Out	B3	7.00	7.00	0.00	Pump Cut-Out	B3
RZ4	West Ham Park	11.00	11.00	0.00	Pump Cut-Out	B3	12.40	12.40	0.00	Pump Cut-Out	B3
RZ4	Cliddesden	0.18	0.00	-0.18	not in use	B3	0.22	0.00	-0.22	not in use	B3
RZ4	Woodgarston	6.00	3.00	-3.00	Water Qulaity (Nitrates)	B3	6.40	3.00	-3.40	Water Qulaity (Nitrates)	B3
RZ4	TOTAL	187.28	184.33	-2.95			195.62	196.00	0.38		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ5										
RZ5	Bourne (The Victoria Bourne)	3.08	3.08	0.00	Pump Intake Depth	A3	3.45	3.39	-0.06	Pump Cut-Out (Theoretical DAPWL)	A3
RZ5	Britty Hill	3.14	3.14	0.00	Theoretical DAPWL	B3	5.50	5.50	0.00	Hydrological – 1992 Max Output	B3
RZ5	East Meon	0.66	0.66	0.00	Pump Cut-Out	B3	0.73	0.73	0.82	Source Capacity	B3
RZ5	Greatham	5.18	5.18	0.00	Hydrological – 2005 Max Output	B3	7.00	7.00	0.00	Hydrological – 2006 Max Output	B3
RZ5	Hawkey (- Catchpit)	1.38	1.38	0.00	Pump Capacity / Mains Capacity	B3	1.38	1.38	0.00	Pump Capacity / Mains Capacity	B3
RZ5	Headley Park	9.09	9.09	0.00	Annual Licence	B3	9.50	9.50	0.00	Pump Cut-Out	B3
RZ5	Hindhead London Road	0.21	0.25	0.04	Pump Cut-Out	B3	0.21	0.25	0.04	Pump Cut-Out	B3
RZ5	Hindhead Tower Road	0.50	0.50	0.00	Sustainable Abstraction	B3	0.50	0.70	0.20	Sustainable Abstraction	B3
RZ5	Oakhanger (Group inc. Oaklands/Southlands)	4.98	8.60	3.62	Annual Licence (Group)	B3 / C3	7.85	11.90	4.05	Licence / Hydrological (critical level)	B3 / C3
RZ5	Sheet & Oakshott	5.44	5.44	0.00	Pump Cut Out	B3	5.44	5.44	0.00	Pump Cut Out	B3
RZ5	Tilford Meads	9.09	9.03	-0.06	Treatment Capacity	B3	9.09	9.03	-0.06	Treatment Capacity	B3
RZ5	Tilford Wellesley Road	4.98	3.48	-1.50	Hydrological	B3	5.00	3.50	-1.50	Hydrological	B3
RZ5	Rushmoor (Tilford Wellesley Road - 2)	4.56	4.56	0.00	Annual Licence	B3	6.82	6.82	0.00	Daily Licence / Treatment Capacity	B3

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
RZ5	Alton Windmill Hill (transferred from RZ4)	2.05	2.05	0.00	Annual Licence	B3	3.45	3.45	0.00	Pump Capacity	B3
RZ5	TOTAL	54.34	56.44	2.1			65.92	68.39	2.47		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ6										
RZ6	Burham WTW (SWS)	8.18	8.18	0.00	Bulk supply	A3	9.00	9.00	0.00	Bulk supply	A3
RZ6	Halling Chalk (Inc No.7)	2.2	2.23	0.00	Annual Licence	B3	3.50	3.50	0.00	Distribution Network	B3
RZ6	Halling Greensand - BH6	3.00	3.04	0.04	Annual Licence	B3	4.00	4.00	0.00	Distribution Network	B3
RZ6	Thurnham	8.4	8.4	0.00	Hydrological / Source Capacity	B3	10.00	10.00	0.00	Hydrological / Source Capacity	B3
RZ 6	Harple Lane	2.28	2.28	0.00	Hydrological- Critical Flow Horizon	B3	2.29	2.29	0.00	Hydrological- Critical Flow Horizon	B3
RZ6	Forstal Source works (Forstal sources combined)	7.20	8.40	1.20	Apportioned Annual licence	B3	11.20	11.20	0.00	Treatment Capacity / Daily licence (grouped)	B3
RZ6	Cossington Greensand	0.94	0.94	0.00	Pump Intake	B3	1.10	1.00	-0.10	Pump Intake	B3
RZ6	Cossington Springs	1.50	1.50	0.00	Hydrological	C3	1.44	1.44	0.00	Hydrological	C3
RZ6	Boxley GS (and Boarley)	2.20	2.50	0.30	Treatment Capacity / Pump Capacity	B3	2.20	2.50	0.30	Treatment Capacity	B3
RZ 6	Boxley Chalk	1.94	1.94	0.00	Hydrological – Critical Level	B3	2.23	2.23	0.00	Hydrological – Critical Level	B3
RZ6	Borough Green	1.24	1.24	0.00	Pump Intake	B3	1.18	1.18	0.00	Pump Intake / Estimated daily licence	B3
RZ6	Nepicar Lane	1.50	1.60	0.10	Critical flow horizon	B3	2.80	2.75	-0.05	Pump Intake / Estimated daily licence	B3

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
RZ6	Trosley	8.20	8.20	0.00	Hydrological	B3	9.77	9.80	0.03	Hydrological	B3
RZ6	Ryarsh and Paddlesworth	3.00	3.00	0.00	Hydrological	B3	5.14	5.14	0.00	Hydrological	B3
RZ6	Hartley Greensand	2.20	2.20	0.00	Treatment Capacity	B3	2.20	2.20	0.00	Treatment Capacity	B3
RZ6	Hartley Chalk	4.30	3.95	-0.35	Combined Pump Capacity / Critical level	B3	4.55	3.95	-0.60	Combined Pump Capacity / Critical level	B3
RZ6	Ridley	1.20	1.20	0.00	Critical Level	B3	2.80	2.80	0.00	Critical Level	B3
RZ6	TOTAL	59.46	60.8	1.34			75.36	74.98	-0.38		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ7										
RZ7	Goudhurst Source works	5.50	4.90	-0.60	Critical Level	B3	5.90	5.30	-0.60	Critical Level	B3
RZ7	Lamberhurst Source works	0.50	0.50	0.00	Treatment Capacity/ Hydrological	B3	2.00	2.00	0.00	Treatment Capacity/ hydrological	B3
RZ7	Maytham Farm	0.50	0.00	-0.50	No longer used	B3	1.80	0.00	-1.80	No longer used	B3
RZ7	Bewl Bridge BHs	3.00	3.00	0.00	Critical Level	B3	4.00	3.00	-1.00	Operational Source Capacity	B3
RZ7	Bewl Bridge SW	8.00	8.00	0.00	Annual Licence (apportioned)	B3	12.00	12.00	0.00	Daily Licence (apportioned)	B3
RZ7	TOTAL	17.50	16.40	-1.1			25.70	22.30	-3.4		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

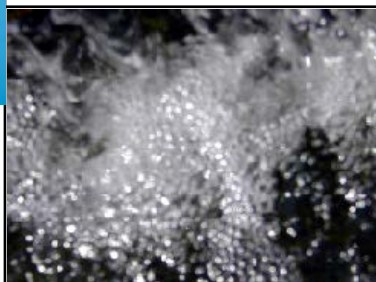
Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
	RZ8										
RZ8	Chilham	13.64	13.64	0.00	Annual Licence	B3	13.64	13.64	0.00	Daily Licence	B3
RZ8	Godmersham	13.64	13.64	0.00	Annual Licence	B3	13.64	13.64	0.00	Daily Licence	B3
RZ8	Charing	4.43	3.63	-0.80	Pump Capacity	B3	4.40	3.63	0.77	Pump Capacity	B3
RZ8	Westwell and Henwood	2.53	2.53	0.00	DAPWL	B3	3.82	3.82	0.00	Cortical Flow Horizon / Per cent de-watered	B3
RZ 8	Kingston	10.00	10.00	0.00	Pump Capacity	B3	10.00	10.00	0.00	Pump Capacity	B3
RZ8	Thannington	18.18	18.18	0.00	Annual Licence	B3	20.46	20.46	0.00	Daily Licence	B3
RZ8	Howfield	13.64	13.64	0.00	Annual Licence	B3	13.64	13.64	0.00	Daily Licence	B3
RZ8	Hoplands Farm	4.55	4.55	0.00	Annual Licence	B3	6.82	6.82	0.00	Daily Licence	B3
RZ8	Ford	2.00	2.00	0.00	Water Quality (Salinity)	B3	4.00	4.00	0.00	Transfer Main	B3
RZ8	Wichling	7.50	7.50	0.00	Hydrological	B3	7.50	8.40	0.90	Hydrological	B3
RZ8	Winecock Shaw	3.27	3.64	0.37	Annual Licence (apportioned)	B3	5.43	6.00	0.00	Hydrological	B3
RZ8	Newnham	6.24	6.24	0.00	Hydrological	B3	7.83	7.83	0.00	Hydrological	B3

Resource Zone	Source	Average					Peak				
		2010 Final WRMP ADO	2015 ADO (dWRMP14)	Change in ADO	Main constraint to ADO	Confidence Ratings	2010 Final WRMP PDO	2015 PDO (dWRMP14)	Change in PDO	Main constraint to PDO	Confidence Ratings
RZ8	Ospringe	7.10	7.10	0.00	Annual Licence (Apportioned)	B3	9.00	9.00	0.00	Transfer Main	B3
RZ8	Boughton	4.27	4.27	0.00	Annual Licence (Apportioned)	B3	4.60	4.60	0.00	Daily Licence	B3
RZ8	Stockbury (via Bottom Pond)	3.40	2.80	-0.60	Water Quality (Turbidity)	A3	4.50	2.80	-1.70	Water Quality (Turbidity)	A3
RZ8	TOTAL	114.42	113.36	-1.06			129.28	128.28	-1.00		
All	TOTAL	611.94	611.19	-0.75			715.29	712.98	-2.31		

Note: The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.



south east water



2014 WRMP

PROJECT NUMBER: 67951

2014 Water Resources Management Plan

REVIEW OF PROCESS LOSSES

Executive Summary

October 2013

	Name / Position	Signature	Date
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DOCUMENT RECORD SHEET

Revision Register

Version	Date	Changes

Document Issue Register

Version	Date	Changes
1a	July 12	Original
2	October 13	Revised

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EXECUTIVE SUMMARY

1. As part of South East Water's (SEW) Water Resource Management Plan (WRMP), it is necessary to present the deployable outputs (DO) and water available for use (WAFU) of existing South East Water (SEW) sources.
2. A review of DO constraints and values has been undertaken as part of the WRMP process.
3. Process losses within treatment works will reduce the quantity of water delivered to the distribution system. The Environment Agency WRMP Guidance acknowledges that process losses can be accounted for in different ways.
4. Typically, the method of accounting for process losses depends on whether a source constraint is upstream or downstream of the treatment works.
5. In the past, process losses have not generally been quantified explicitly by SEW in WRMPs.
6. There have been two stages to this assessment. The stage one assessment provided a high level summary based on treatment process at each site (Table 1). These figures were reviewed by operational staff to form the second stage of the assessment. A more detailed assessment was undertaken for a number of sites after the initial assessment following review and discussion with operational staff using their expertise and review of telemetry data (Table 2).
7. For this assessment, process losses have been estimated at a number of key sites by reviewing treatment processes and discussing operation with SEW production staff. The losses have then been quoted as a percentage of treatment works throughput. The calculated percentages for each process have subsequently been applied to those treatment works with similar processes but which were not individually reviewed as part of this study.
8. SEW process losses have been estimated for all surface water sites (with the exception of Barcombe, which was completed as a separate site audit earlier in 2012) and for selected groundwater sites for the following treatment processes:
 - Clarification
 - Rapid gravity filtration
 - GAC Adsorption
 - Water quality monitoring.
9. This evaluation establishes an approximate representative value of process loss using operational data and information from SEW Production Managers and Process Scientists. This assessment does not include a detailed site

audit of each SEW source. Where details were unknown and not obtainable within the constraints of this study, data has been estimated by assuming plants were designed and operated in line with best practice.

10. Process losses for each site are estimated at both full design and typical throughputs and are also calculated as a percentage of typical throughput to allow comparison between sites and identification of atypical losses. Waste disposal routes for all studied sites were obtained and are listed below.
11. Process losses are also shown as a percentage of typical throughput categorised by treatment flowsheet. It is concluded that application of the average process losses shown would produce a reasonable approximation of company losses if applied across all South East Water sites. However, it is noted that significant errors may occur when determining process losses for individual sites where the design or method of operation was atypical.
12. Process losses for all sources in each water resource zone are shown in Table 1 below; this is based on high level generic summary. This assessment shows an overall company process loss of 13.48 ML/d for design throughput and a process loss of 11.61 ML/d for typical throughput.
13. When considered in terms of DO constraints, the total company loss between DO and Amended DO attributable to process losses for all the SEW water treatment works is approximately 7.36 ML/d on average deployable output and 8.24 ML/d on peak deployable output. This is less than the figures in the paragraph above as in many cases the process loss within the treatment process does not affect the dominant DO constraint.
14. A full list of revised process losses and Amended DO values identified for each source is shown in Table 2. The process loss assessment of sources has identified a number of design, monitoring, operational and maintenance issues where resolution would allow greater efficiency and greater confidence in the assessment of process loss and its contribution within WAFU.
15. South East Water will improve the process loss assessment at all of its sites, including those study sites in preparation of the next draft WRMP. A more accurate estimate of site process losses will be obtained through site visits and discussing the design and operation in more detail, including data from Scopex. This would inform a better understanding of process losses and would inevitably help to put in place measures to reduce those losses.

Table 1: Process Loss Assessment 2012: Resource Zone Totals

Resource Zone			Amended Average DO 2012 Review Value			Amended Peak DO 2012 Review Value		
	Process loss at design thro'put (Ml/day)	Process loss at typical thro'put (Ml/day)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO (2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Amended Actual Current PDO (2012 Review)
RZ1	0.084	0.084	36.09	41.57	34.02	40.56	46.18	39.60
RZ2	2.721	2.546	74.44	78.92	82.39	98.72	102.42	88.61
RZ3	1.267	1.179	75.07	76.15	80.61	91.08	92.48	92.79
RZ4	7.525	6.385	224.11	224.11	209.67	232.53	232.53	204.73
RZ5	0.449	0.390	58.57	58.57	45.83	69.85	69.85	48.23
RZ6	0.405	0.316	65.96	65.96	52.17	84.82	84.82	67.32
RZ7	0.281	0.181	17.18	17.18	20.42	23.62	23.62	27.37
RZ8	0.749	0.526	110.59	110.59	99.67	124.35	124.35	111.85
Total	13.481	11.607	662.00	673.04	624.78	765.54	776.26	680.51

Note: ^{1/} Proposed ADO (2012 Review) refers to the DO assessment review carried out between December 2011 and June 2012

^{2/} Increase in Planned ADO established within this DO Review is Proposed ADO minus the 2010 Final WRMP ADO

^{3/} The source abstraction licences, ADO and PDO values are provided in the Deployable Output Assessment Review Main Report

Table 2. Process Loss Assessment 2012 – Source Process Losses

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (Ml/day)	Process loss at typical thro'put (Ml/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ1										
RZ1	Cramptons Road (total licence)	0.002	0.002	1	17.66	17.66	17.52	21.68	21.68	21.00
RZ1	Kemsing	0.005	0.004	1	3.70	4.20	3.00	3.70	4.50	3.50
RZ1	Oak Lane	0.001	0.001	1	0.50	0.50	0.50	0.50	0.50	0.50
RZ1	Pembury Boreholes (Ashdown Beds)	0.006	0.006	1	3.93	3.93	3.41	4.23	4.23	4.23
RZ1	Pembury - T Wells Springs	0.011	0.011	1	0.29	0.29	0.29	0.29	0.29	0.29
RZ1	Hartlake (Wells)	0.003	0.003	1	3.10	3.10	3.33	3.10	3.10	3.10
RZ1	Saints Hill	0.007	0.007	1	5.51	6.99	4.47	5.69	6.99	4.49
RZ1	Tonbridge (Combined)	0.049	0.049	0	1.40	4.90	1.81	1.38	4.90	2.50
RZ1	Tonbridge Gravels	0.040	0.037	1	1.26	3.66	1.25	1.26	3.96	1.69
RZ1	Tonbridge Ashdown Beds	0.020	0.017	0	0.50	1.70	0.52	0.70	2.00	0.40
RZ1	TOTAL	0.084	0.084	-	36.09	41.57	34.02	40.56	46.18	39.60

Note: : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (ML/day)	Process loss at typical thro'put (ML/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR 14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR 14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ2										
RZ2	Coggins Mill & Sharnden	0.104	0.104	1	1.00	2.63	1.08	1.70	2.63	1.70
RZ2	Forest Row	0.002	0.003	0	2.53	2.53	1.40	1.60	1.60	1.40
RZ2	Groombridge (Including Eridge)	0.285	0.202	1	5.70	6.50	4.80	6.12	6.62	4.62
RZ2	Groombridge (Excluding Eridge)	0.166	0.117	1	3.78	4.43	4.58	4.73	4.73	3.83
RZ2	Eridge (BH1)	0.119	0.084	1	1.92	2.42	1.92	2.28	2.78	1.88
RZ2	Hempsted	0.032	0.029	0	0.00	2.05	0.00	0.00	2.27	0.00
RZ2	Holywell (Cockhaise)	0.000	0.000	1	1.50	1.50	1.70	1.90	1.90	1.70
RZ2	Seaford Chalk - Group	0.015	0.014	1	15.60	15.60	17.47	17.60	17.60	20.23
RZ2	Seaford Chalk - Cow Wish	0.005	0.005	0	5.36	5.36	5.06	5.36	5.36	5.70
RZ2	Seaford Chalk - Poverty Bottom	0.004	0.004	1	4.75	4.75	6.47	5.75	5.75	7.54
RZ2	Seaford Chalk – Rathfinny	0.007	0.006	1	5.49	5.49	5.94	6.49	6.49	6.99

RZ2	Underhill Chalk – Group	0.000	0.000	1		2.31	2.31	2.70		3.19	3.19	2.86
RZ2	<i>Underhill Chalk – Clayton</i>	0.001	0.001	0		0.65	0.65	0.96		1.10	1.10	1.04
RZ2	<i>Underhill Chalk - Coombe Down (BH1)</i>	0.000	0.000	1		0.24	0.24	0.15		0.39	0.39	0.24
RZ2	<i>Underhill Chalk - Whitelands (BH1)</i>	0.000	0.000	1		0.22	0.22	0.10		0.40	0.40	0.20
RZ2	<i>Underhill Chalk - Offham (springs)</i>	0.000	0.000	1		0.20	0.20	0.25		0.20	0.20	0.42
RZ2	<i>Underhill Chalk - Saddlescombe</i>	0.001	0.001	1		1.00	1.00	1.13		1.10	1.10	1.35
RZ2	Shellbrook /Ardingly Res	0.284	0.195	1		4.30	4.30	4.30		4.22	4.22	3.06
RZ2	Barcombe Res (=R Ouse)	2.000	2.000	1		36.10	36.10	43.54		57.00	57.00	47.65
RZ2	Weir Wood Res (SWS)	n/a	n/a	0		5.40	5.40	5.40		5.40	5.40	5.40
RZ2	TOTAL	2.721	2.546	-		74.44	78.92	82.39		98.72	102.42	88.61

Note: : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.

^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value				
Resource Zone	Source	Process loss at design thro'put (ML/day)	Process loss at typical thro'put (ML/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)		Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)		Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ3												
RZ3	Arlington	0.009	0.009	1		13.99	13.99	15.89		17.43	17.43	17.03
RZ3	Crowhurst Bridge (Conj / GW - SW) Group	0.661	0.604	1		8.93	10.01	8.05		9.29	10.69	8.19
RZ3	Crowhurst Bridge (GW – Group – supply only)	0.522	0.477	1		7.05	8.13	6.20		7.43	8.83	6.33
RZ3	Crowhurst Bridge (GW) Waterworks	0.522	0.477	1		3.40	3.40	3.40		4.48	4.48	4.48
RZ3	Crowhurst Bridge - Turzes Farm - 5/6 Replacement	0.087	0.079	1		1.36	1.65	1.65		1.35	1.64	1.64
RZ3	Crowhurst Bridge (GW) Stonegate - 7	0.274	0.251	1		2.75	2.75	2.75		2.75	2.75	2.75
RZ3	Crowhurst Bridge (GW) Witherenden	0.000	0.000	1		1.75	1.75	1.75		3.00	3.00	3.00
RZ3	Crowhurst Bridge (SW)	0.139	0.127	1		1.87	1.87	1.78		1.86	1.86	1.86
RZ3	Hazards Green (GW)	0.000	0.000	1		1.12	1.12	1.10		1.20	1.20	0.83
RZ3	Walters Haven /Hazards Green (SW)	0.258	0.258	0		6.80	6.80	8.38		6.80	6.80	9.15
RZ3	Walters Haven Augmentation BHs (GW - grouped)	0.000	0.000	1		5.77	5.77	5.77		9.70	9.70	9.70

RZ3	Eastbourne Chalk (Group)	0.249	0.243	1		27.91	27.91	27.91		34.67	34.67	27.90
RZ3	Waterworks Road	0.226	0.226	0		4.81	7.80	4.81		5.00	7.80	5.00
RZ3	Filching	0.000	0.000	1		0.00	0.00	0.00		0.00	0.00	0.00
RZ3	Friston and Deep Dean	0.021	0.016	1		16.02	16.02	12.16		20.88	20.88	16.98
RZ3	Holywell	0.002	0.001	1		1.00	1.00	1.26		1.90	1.90	1.90
RZ3	Cornish (Wigdens Bottom)	0.004	0.003	1		3.31	3.31	2.92		4.32	4.32	4.00
RZ3	Powdermill (Group)	0.054	0.032	1		2.93	2.93	2.72		4.15	4.15	3.35
RZ3	Sweet Willow Wood	0.034	0.031	1		2.15	2.15	1.47		2.37	2.37	2.17
RZ3	Birling Farm	0.002	0.002	0		2.48	2.48	1.39		2.48	2.48	2.48
RZ3	Darwell raw water transfer	0.000	0.000	1		3.00	3.00	8.00		3.00	3.00	12.00
RZ3	TOTAL	1.267	1.179	-		75.07	76.15	80.61		91.08	92.48	92.79

Note : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (ML/day)	Process loss at typical thro'put (ML/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ4										
RZ4	Beenhams Heath, Hurley & White Waltham (previously & Toutley, not W Waltham) (Group)	1.461	1.289	0	33.68	33.68	28.98	38.00	38.00	32.00
RZ4	Hurley	1.128	0.995	1	28.38	28.38	27.01	28.25	28.25	26.87
RZ4	Beenhams Heath (including W Waltham) up to Mar2016 (after Apr 2016)	0.402 0.402	0.354 0.354	1	3.95 2.76	3.95 2.76	3.95 2.76	9.65 9.65	9.65 9.65	3.64 3.64
RZ4	Boxalls Lane & Tongham (Group)	0.000	0.000	1	16.63	16.63	28.98	16.54	16.54	16.00
RZ4	Tongham	0.000	0.000	1	2.24	2.24	1.43	1.54	1.54	1.50
RZ4	Boxalls Lane GS	0.000	0.000	1	3.80	3.80	2.47	1.71	1.71	3.00
RZ4	Boxalls Lane Chalk	0.318	0.228	1	10.36	10.36	10.19	12.97	12.97	12.68
RZ4	Bray Gravels	0.760	0.760	1	17.34	17.34	16.95	17.34	17.34	22.24
RZ4	Bray SW	3.296	2.478	0	35.90	35.90	27.76	35.90	35.90	23.00
RZ4	College Avenue	0.000	0.000	0	18.50	18.50	15.66	18.50	18.50	16.00

RZ4	Cookham	0.593	0.542	1	18.14	18.14	11.16	19.87	19.87	12.41
RZ4	Greywell	0.007	0.007	1	6.83	6.83	6.71	6.81	6.81	6.49
RZ4	Itchell	0.035	0.035	1	3.42	3.42	3.49	3.42	3.42	3.47
RZ4	Lasham	0.016	0.015	1	14.94	14.94	11.03	15.71	15.71	11.48
RZ4	West Ham Group	1.358	1.260	1	16.74	16.74	19.97	18.04	18.04	22.64
RZ4	<i>West Ham PS</i>	0.490	0.490	1	6.51	6.51	6.51	6.51	6.51	6.51
RZ4	<i>West Ham Park</i>	0.521	0.462	1	10.54	10.54	10.54	11.88	11.88	11.88
RZ4	<i>Cliddesden</i>	0.000	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00
RZ4	Woodgarston	0.000	0.000	1	6.00	6.00	2.99	6.40	6.40	3.00
RZ4	TVW Egham transfer to RZ4 (TWUL)	n/a	n/a	0	36.00	36.00	36.00	36.00	36.00	36.00
RZ4	TOTAL	7.525	6.385	-	224.11	224.11	209.67	232.53	232.53	204.73

Note: : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (Ml/day)	Process loss at typical thro'put (Ml/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ5										
RZ5	Bourne (The Victoria Bourne)	0.034	0.031	1	3.05	3.05	2.07	3.36	3.36	2.27
RZ5	Britty Hill	0.050	0.031	1	3.11	3.11	1.92	4.95	4.95	2.45
RZ5	East Meon	0.001	0.001	1	0.66	0.66	0.54	0.66	0.66	0.55
RZ5	Greatham	0.070	0.052	1	5.13	5.13	5.28	6.93	6.93	5.11
RZ5	Hawkley (- Catchpit)	0.014	0.014	1	1.37	1.37	0.63	1.37	1.37	0.89
RZ5	Headley Park	0.095	0.091	1	9.00	9.00	8.50	9.41	9.41	9.41
RZ5	Hindhead London Road & Tower Road	0.001	0.001	1	0.75	0.75	0.67	0.71	0.71	0.46
RZ5	Hindhead London Road	0.000	0.000	1	0.25	0.25	0.21	0.21	0.21	0.21
RZ5	Hindhead Tower Road	0.001	0.001	1	0.50	0.50	0.46	0.50	0.50	0.46
RZ5	Oakhanger (including Oaklands and Southlands)	0.000	0.000	1	9.53	9.53	5.87	12.83	12.83	6.80
RZ5	Oakhanger	0.037	0.026	1	4.95	4.95	4.02	7.81	7.81	4.36
RZ5	Oaklands	0.000	0.000	1	2.40	2.40	1.82	2.40	2.40	2.40
RZ5	Southlands	0.000	0.000	1	2.15	2.15	0.00	2.58	2.58	0.00
RZ5	Sheet & Oakshott	0.054	0.054	1	5.39	5.39	4.86	5.39	5.39	5.35
RZ5	Tilford Meads	0.090	0.090	0	9.03	9.03	6.95	9.03	9.03	8.00

RZ5	Tilford Wellesley Road and Rushmoor (Grouped)	0.041	0.025	1	9.51	9.51	6.43	11.78	11.78	4.46
RZ5	Tilford Wellesley Road	0.022	0.014	1	3.47	4.97	2.82	3.48	4.98	4.48
RZ5	<i>Rushmoor (Tilford Wellesley Road - 2)</i>	0.018	0.011	1	2.82	4.55	2.82	3.50	6.80	3.50
RZ5	Alton Windmill Hill (transferred from RZ4)	0.000	0.000	0	2.05	2.05	2.12	3.45	3.45	2.50
RZ5	TOTAL	0.449	0.390	-	58.57	58.57	45.83	69.85	69.85	48.23

Note: ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value				
Resource Zone	Source	Process loss at design thro'put (Ml/day)	Process loss at typical thro'put (Ml/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)		Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)		Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ6												
RZ6	Hartley / Ridley Chalk (combined)	0.068	0.052	1		5.10	5.10	5.75		6.68	6.68	5.73
RZ6	Hartley Chalk	0.040	0.040	1		3.91	3.91	3.89		3.91	3.91	3.89
RZ6	Ridley	0.003	0.001	1		1.20	1.20	1.16		2.80	2.80	1.16
RZ6	Hartley Greensand	0.022	0.022	0		2.20	2.20	1.87		2.20	2.20	1.87
RZ6	Trosley / Borough Green (incl Nepicar Ln, Ryarsh and Paddlesworth - total combined)	0.172	0.120	1		11.86	11.86	11.38		17.04	17.04	9.60
RZ6	Borough Green	0.036	0.036	1		1.20	1.20	1.14		1.20	1.20	1.05
RZ6	Nepicar Lane	0.016	0.015	1		1.53	1.52	1.42		1.58	1.58	0.52
RZ6	Trosley	0.098	0.062	1		6.14	6.14	6.14		9.67	9.67	5.36
RZ6	Ryarsh and Paddlesworth	0.046	0.030	1		2.97	2.97	2.65		4.55	4.55	2.63
RZ6	Ryarsh	0.020	0.020	0		2.00	2.00	1.68		2.00	2.00	2.00
RZ6	Paddlesworth	0.026	0.010	0		1.00	1.00	1.00		2.60	2.60	2.60
RZ6	Halling Chalk and Greensand (combined)	0.039	0.039	1		5.23	5.23	4.39		7.46	7.46	3.21

RZ6	Halling Chalk (Inc No.7)	0.000	0.000	1	2.23	2.23	2.14	3.50	3.50	3.25
RZ6	Halling Greensand - BH6	0.000	0.000	1	3.04	3.04	2.29	4.00	4.00	2.75
RZ6	Forstal / Boxley / Boarley / Cossington LGS + Chalk total combined (for reference)	0.020	0.016	0	15.88	15.88	8.00	20.13	20.13	18.94
RZ6	Forstal Sourceworks (Forstal sources combined)	0.014	0.010	0	9.64	9.64	10.36	13.89	13.89	11.20
RZ6	Cossington Greensand	0.000	0.000	1	0.94	0.94	0.27	0.94	0.94	0.27
RZ6	Boxley Greensand (No1&No.2)	0.025	0.025	0	2.50	2.50	1.28	2.50	2.50	1.50
RZ6	Cossington Springs	0.003	0.002	1	1.50	1.50	2.59	2.66	2.66	2.56
RZ6	Boxley Well Source	0.002	0.002	1	2.16	2.16	1.93	2.30	2.30	2.47
RZ6	Thurnham Sourceworks + Hockers Lane	0.123	0.107	1	10.57	10.57	6.57	12.18	12.18	7.88
RZ6	Thurnham	0.100	0.084	1	8.32	8.32	6.60	9.90	9.90	7.90
RZ6	Hockers Lane (Harple Lane)	0.023	0.023	1	2.28	2.28	1.65	2.28	2.28	1.68
RZ6	Burham WTW (SWS)	n/a	n/a	0	8.18	8.18	7.27	10.29	10.29	8.50
RZ6	Matts Hill (Belmont)	n/a	n/a	0	6.30	6.30	6.30	7.80	7.80	7.80
RZ6	Pitfield Booster	n/a	n/a	0	0.20	0.20	0.20	0.20	0.20	0.20
RZ6	Tunbury Ave (SWS)	n/a	n/a	0	0.40	0.40	0.40	0.80	0.80	0.80
RZ6	TOTAL	0.405	0.316	-	65.96	65.96	52.17	84.82	84.82	67.32

Note: ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (MI/day)	Process loss at typical thro'put (MI/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ7										
RZ7	Goudhurst Sourceworks	0.257	0.157	1	5.84	5.84	9.44	7.64	7.64	12.39
RZ7	Lamberhurst Sourceworks	0.041	0.025	1	0.47	0.47	0.47	1.96	1.96	1.21
RZ7	Maytham Farm	0.000	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00
RZ7	Bewl Bridge BHs	0.006	0.006	1	3.35	3.35	2.99	3.99	3.99	2.99
RZ7	Bewl Bridge SW	0.017	0.017	1	7.98	7.98	7.98	11.98	11.98	11.98
RZ7	TOTAL	0.281	0.181	-	17.18	17.18	20.42	23.62	23.62	27.37

Note: : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

		Process Loss 2012 Review Value			Amended ADO 2012 Review Value			Amended PDO 2012 Review Value		
Resource Zone	Source	Process loss at design thro'put (MI/day)	Process loss at typical thro'put (MI/day)	Process Loss in DO calcs: 0 = included (Amended DO=DO); 1 = not included (Amended DO=DO-PL)	Amended ADO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended ADO (2012 Review; 2015 value)	Actual Current Amended ADO(2012 Review)	Amended PDO Value (2012 Review; current position of AMP5 delivery)	PR14 Amended PDO (2012 Review; 2015 value)	Actual Current Amended PDO(2012 Review)
RZ8										
RZ8	Chilham	0.014	0.014	1	13.63	13.63	12.61	13.63	13.63	13.63
RZ8	Godmersham	0.014	0.014	1	13.63	13.63	12.72	13.63	13.63	13.63
RZ8	Charing	0.047	0.034	1	4.12	4.12	3.71	4.10	4.10	3.95
RZ8	Westwell and Henwood	0.004	0.003	1	2.53	2.53	2.20	3.85	3.85	3.82
RZ8	Kingston	0.004	0.004	1	10.00	10.00	7.71	10.00	10.00	8.00
RZ8	Thannington	0.020	0.018	1	18.16	18.16	17.88	20.44	20.44	19.98
RZ8	Howfield	0.014	0.014	1	13.63	13.63	9.87	13.63	13.63	10.99
RZ8	Hoplands Farm	0.007	0.005	1	4.55	4.55	3.75	6.81	6.81	3.99
RZ8	Ford	0.004	0.002	0	2.00	2.00	0.85	3.54	3.54	2.00
RZ8	Wichling/ WCS / Newnham (Total combined)	0.608	0.408	1	16.60	16.60	17.75	20.15	20.15	18.59
RZ8	Wichling	0.278	0.187	1	7.31	7.31	9.87	8.12	8.12	10.22
RZ8	Wineycock Shaw	0.111	0.074	1	3.20	3.20	2.40	3.39	3.39	2.66
RZ8	Newnham	0.227	0.153	1	6.09	6.09	5.48	7.60	7.60	7.02

RZ8	Ospringe	0.009	0.007	1	7.09	7.09	6.70	8.99	8.99	7.99
RZ8	Boughton	0.005	0.004	1	4.27	4.27	3.62	4.60	4.60	4.30
RZ8	Stockbury (via Bottom Pond)	n/a	n/a	1	2.40	2.40	2.32	3.00	3.00	3.00
RZ8	To Veolia SE	n/a	n/a	0	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00
RZ8	TOTAL	0.749	0.526	-	110.59	110.59	99.67	124.35	124.35	111.85

All	TOTAL	13.481	11.607	-	662.00	673.04	624.78	765.54	776.26	680.51
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Note: : ^{1/} The totals ADO and PDO presented for each RZ is not the sum of individual source DO values; considering groups of sources constrained at treatment works and network constraints.
^{2/} DO values include planned AMP5 SOSI delivery;

1.0 INTRODUCTION

1.1 Objective

The objective of this project is to determine the volume attributable to process losses through South East Water's water treatment works. These losses were not explicitly taken account of in previous Water Resource Management Plans and have in general not been considered when defining the company 'Water Available for Use' (WAFU) values.

This initial high level evaluation is to approximate a representative value of process losses for various site types ranging from very simple groundwater sites to very complex surface water treatment sites.

1.2 Constraints

Due to time constraints this initial high level evaluation has been completed through telephone discussions with a number of front line operational staff rather than site visits. It has been assumed that processes are designed and operated in accordance with best practice although it is accepted that this is unlikely to be universally the case.

This exercise evaluates all the surface water WTWs and the two largest groundwater WTWs in each SEW resource zone. Process losses at all other sites are determined using the results of this study. Representative values of losses for each type of process are established for the sites assessed. Using data from SEW defining the type of treatment processes on each of the remaining sites, the process losses are established as a proportion of the output.

The Method Input Statement proposed that inputs and outputs at each study site should be determined for a fixed period via South East Water databases such as Scopex and Aquanet. This work was attempted but access to the data proved impossible within this study.

Relevant meters were identified in Scopex and passed to the Hydrogeology team and it is hoped that this data may be extracted at a later date as a sense check on estimated values.

Assumptions made and constraints for each process stage are identified in the Section 2.0 Methodology.

South East Water will improve the process loss assessment at all of its sites, including those study sites in preparation of the next draft WRMP. A more accurate estimate of site process losses will be obtained through site visits and discussing the design and operation in more detail, including data from Scopex. This would inform a better understanding of process losses and would inevitably help to put in place measures to reduce those losses.

2.0 METHODOLOGY

2.1 Introduction

Spreadsheets 'SEW Surface Water Proc Losses' and 'SEW Groundwater Proc Losses' are associated with this report and were developed to facilitate and record calculation of process losses from the various treatment processes. The calculations are based on information collected from operational staff (see Appendix One) and calculations assume that treatment processes are designed and operated in accordance with best practice.

The method of calculation of process losses and assumptions made for each process stage are outlined in the following section. Monitor losses have also been estimated for each site.

Table 2.1: Processes which produce waste for each of the sites involved in this high level study

Site	Clarification	Filtration	GAC
Shellbrook	✓	✓	✓
Arlington	✓	✓	✓
Hazards Green	✓	✓	✓
Bray	✓	✓	✓
Bewl Bridge	✓	✓	✓
Cramptons Road	✗	✗	✗
Pembury	✓	✓	✓
Groombridge	✓	✓	✗
Poverty Bottom	✗	✗	✗
Crowhurst Bridge	✓	✓	✗
Powdermill	✗	✓	✗
Beenhams Heath, Hurley and White Waltham	✓	✓	✓
Boxalls Lane	✗	✓	✗
Oakhanger	✗	✓	✗
Tilford-Wellesley Road	✗	✓	✗
Forstal	✗	✓	✗
Trosley	✗	✓	✗
Goudhurst	✓	✓	✗
Charing	✗	✓	✗
Kingston	✗	✓	✗
Wichling	✗	✓	✗

Note: ^{1/} Water quality monitors are in place at all sites and associated losses have been estimated

2.1.1 Clarification

Clarification is the physical separation of solid and liquid phases and results in the production of a waste sludge. This sludge has a high water content (low dry solids content) which depends on the clarifier design and the sophistication of the clarifier desludging system. For settlement clarifiers desludging is often via desludging valves in the clarifier hopper but gravilectric systems also are in use where desludging is controlled by the weight of accumulated sludge in a collection cone and these systems tend to waste less water. Dissolved Air Flotation (DAF) clarifiers have a variety of desludging mechanisms but sludge consistency is thought to be broadly similar for the different types.

As a result of the variety of desludging mechanisms and differences in the way they are operated, it has only been possible to make a high level approximation of clarification losses which in most cases have been assumed to be similar to the calculated rapid gravity filter backwash losses since this has often been found to be the case. Site visits would need to be made to refine these estimates.

2.1.2 Rapid Gravity Filtration

Rapid gravity filters run until the head loss becomes unacceptably high at which point the filters are backwashed. Head loss is normally the driver for backwashing filters although poor water quality may also be used. Filters are often washed at a frequency of 24 hours although good filter feed water quality often results in the filter run times being extended, sometimes to a frequency as low as once every 72 hours (every 3 days.).

The three pieces of information needed to calculate filter backwash volumes are backwash water flow rate, backwash duration and backwash frequency. SEW Production Managers and Process Scientists provided duration and frequency of filter backwash; however, in some cases the flow rate of the backwash was not available. In these cases, backwash flow rates have been estimated, and the assumptions as presented in Table 2.2 were applied:

Table 2.2 Filter backwash flow rates assumptions

Filter hydraulic loading rate = /hr	This was used to estimate the filter surface area and is generally accepted to be an acceptable filtration rate for good performance although design rates do vary from plant to plant.
Backwash rate = /hr	This is a typical water backwash rate in line with good practice but backwash rates can vary from /hr to in excess of /hr Multiplying the backwash rate in /hr by the filter surface area gives the backwash flow rate in /hr and in this way the backwash flow rate was derived where it wasn't available via operational contacts.

2.1.3 GAC

GAC system design is based on Empty Bed Contact Time (EBCT) and EBCT can vary enormously dependent on the pesticide or taste and odour challenge. GAC absorbers are washed at a much lower frequency than rapid gravity sand filters since they act as adsorption vessels rather than physical filters. A typical vessel run time between backwashes is 7 days although in most cases actual backwash frequencies were provided by operational contacts.

Information needs are the same as for rapid gravity filters and operational contacts were mostly able to provide duration and frequency but not backwash flow rate. As a result many GAC backwash flow rates have been estimated. Table 2.3 shows the assumptions applied for sites where it is necessary to estimate GAC backwash flow rates.

Table 2.3 GAC backwash flow rate estimation assumptions

Adsorber hydraulic loading rate = /hr	EBCT is a more usual design parameter for GAC but a GAC plant recently designed by Jacobs for Scottish Water at Peterhead, Aberdeen has a hydraulic loading rate of /hr and this will be used to estimate the surface area of GAC adsorption medium.
Backwash rate = /hr	GAC adsorber backwash rates have to be adjusted with water temperature to allow for changing water viscosity which impacts on the expansion of the low density GAC particles. A backwash rate of /hr will be used and this would be suitable for a water temperature of Multiplying the backwash rate in /hr by the filter surface area gives the backwash flow rate in /hr and in this way the backwash flow rate was derived.

GAC is removed for regeneration periodically. In South East Water a 4 year regeneration cycle is planned but the actual regeneration frequency tends to be much less frequent than this.

Regeneration process losses include:

- Motive water used to remove and replace the GAC
- Backwash water used to remove fines
- Conditioning water used to wash off leachates after regeneration.

Volumes are considerable (as much as 3, for larger sites) but these losses have been discounted since they occur so infrequently and, when calculated as a daily average, losses are miniscule.

2.1.4 Water quality monitoring

Water quality monitors are fed via sample lines pressurised either by sample pumps or natural head through the treatment process. Waste derived from water quality

monitoring comprises water which has passed through the quality monitor and this water is usually uncontaminated.

Various disposal routes are in place for quality monitor waste including return to raw water storage, return to the head of the works, passage to sewer, passage to waste lagoons and passage direct to a watercourse.

Waste volumes will vary with sample pipe diameter, sample line pressure, sample line length and whether or not the sample flow is throttled back but high level estimates have been made based on typical monitor sample feed requirements obtained from two water quality monitoring specialist companies (ProcessPlus and ABB) as shown in Table 2.4 .

More accurate estimates of water quality monitoring process losses would require site visits.

Table 2.4. Typical water quality monitor feed rates

Monitor type	Expected sample feed rate (litres/minute)
Chlorine analyser	0.5
Turbidimeter	0.75
pH monitor	0.5
Colour monitor	0.5
Metals residual monitor	0.5
Ammonia monitor	0.5
Ozone monitor	0.5
Hydrocarbons monitor	0.5

3.0 RESULTS AND DISCUSSION

3.1 Waste disposal routes

Waste disposal routes were established in discussion with operational contacts and are listed in Table 3.1.

Operational contacts were extremely helpful in all cases and are listed in Appendix 1.

Table 3.1 Waste disposal routes

Shellbrook	All waste streams pass to lagoon and river. There is no recovery
Arlington	Waste is recovered to the raw water reservoir with the exception of monitors which pass to waste and the small volume of thickened sludge which is tankered away.
Hazards Green	A small volume of pressed sludge (approx 25% Dry Solids) is removed from site but other than that waste is returned to the Head of the Works (HoW.)
Bray	Sludge is discharged to sewer and top water to river after settlement. No water is recovered.
Bewl Bridge	Supernatant and monitor waste are recovered to the HoW. Exceptions to this are a small volume of sludge and waste from filter and GAC turbidimeters.
Cramptons Rd	All waste passes to drain
Pembury	Clarification, filtration and GAC waste returned to Bank Side Storage. 50% of monitor losses are returned to HoW, 50% run to waste.
Groombridge	Clarification and filtration supernatant passes to river, monitor losses are returned to HoW.
Poverty Bottom	Monitor waste is discharged to sewer
Crowhurst Bridge	Clarification and filtration losses pass to lagoon where they soak away. Only settled and filter inlet chlorine monitor wastes are returned to Flash Mixer.
Powdermill	All wastes pass to lagoons. There has historically been return to Head of Works but no longer.
Beenhams Heath, Hurley and White Waltham Group	All wastes pass to a local stream
Boxalls Lane and Tongham Group	All waste passes to the wash water chamber and then to sewer
Oakhanger	All waste passes to an adjacent stream after settlement in a lagoon
Tilford Wellesley Rd and Rushmoor	All waste passes to a lagoon from where it permeates into the ground
Forstal sourceworks	Approximately 50% of monitor waste is recycled with the other 50% passing to waste. There is some large diameter sample pipework and plans are in place to replace it. No allowance made for this in calculations.
Trosley Borough Green	All top water and monitor waste is returned to HoW
Halling Chalk and Greensand comb	All monitor and greensand filtration waste passes to quarry
Goudhurst sourceworks	Waste passes to drain with the exception of clarifier blanket sample water which is recovered and constitutes 85% of monitor waste.
Bewl Bridge boreholes	No waste - these boreholes just feed to Surface Water plant
Charing	All monitors run to waste
Kingston	No return of monitor waste
Wichling	Monitors run to waste

3.2 Surface water results

Table 3.2 (surface water) summarises calculated process losses for the 5 surface water sites involved in this study. Losses are estimated at both full design and typical throughputs and are also shown as a % of typical throughput to allow comparison between sites and identification of atypical losses.

Table 3.2 Surface Water Process Losses

Site	Throughput (Ml/d)		Process Losses (Ml/day)						Total Process Losses (% of typical thro'put)
	Design	Typical	Clarification	Filter b/w	GAC b/w	Monitors	Total site at design flow	Total site at typical flow	
Shellbrook	4.3	3.5	0.086	0.086	0.006	0.022	0.20	0.167	4.8
Arlington	19	15	0.3	0.3	0.07	0.018	0.688	0.547	3.6
Hazards Green	18	11.8	0.34	0.34	0.03	0.03	0.74	0.495	4.2
Bray	40	30	1.2	1.2	0.17	0.022	2.592	1.950	6.5
Bewl Bridge	20	14	0.36	0.13	0.07	0.019	0.579	0.411	2.9
	65	42.2	-	-	-	-	2.0	2.0	4.0

Note: : ^{1/} Barcombe process loss calculations were established as part of a separate site audit

3.2.1 Surface water process losses discussion

Bray backwash waste is atypically high as a result of longer than normal Rapid Gravity Filtration and GAC backwash run times (11mins for RGF and 15 mins for GAC.)

Bewl Bridge by contrast produces much less waste due to reduced Rapid Gravity Filtration and GAC backwash run times (5 mins for RGF and 10 mins for GAC.). Bewl RGFs are also only washed every 40 hours compared to every 24 hours for Bray.

There may be good reasons for the differences but site process investigations are recommended to determine whether process losses could be reduced at Bray.

Barcombe process losses were determined from a site audit and assessment of flow meter data. The Distribution Input meter to Horstead Keynes is not currently working (has not been working for approximately 2 years) as a result the flow to Horstead Keynes (>30Ml/d) is an assessment based on an estimate of the flow through the high

lift pumps. There are no other meters on Horstead Keynes which could be used to measure the flow into Horstead Keynes. The Popeswood Distribution Input meter has also recently failed, and the SCOPEX flow data is currently assessed based on the ratings of the high lift pumps. As the Distribution Input meters are not working, the GAC output meters (which are well sited), offer an alternative calculation of DI. However an allowance for imports/exports from/to Barcombe and Arlington needs to be included in the output from the GAC. The transfer to/from Arlington is bi-directional and SCOPEX and the OPD systems record the flows to/from Arlington differently, so that in SCOPEX flow to Arlington is recorded as positive, but in OPD this same flow is recorded as negative. Care needs to be taken with the calculation to ensure that the flows are treated correctly. When Barcombe is receiving water from Arlington the flow from Arlington needs to be added to the output from the GAC.

Process losses of between 3% and 5% of incoming flow are regarded as typical for surface water treatment plants.

3.3 Groundwater results

Table 3.3 (groundwater process losses) summarises process losses calculated for the 18 groundwater sites assessed as part of this study.

Table 3.3 – Groundwater Process Losses

Zone	Site	Throughput (Ml/d)		Process Losses (Ml/d)						Total Process Losses (% of typical thro'put)
		Design Thro'put	Typical Thro'put	Clarification	Filter b/w	GAC b/w	Monitors	Total site at design flow	Total site at typical flow	
RZ1	Cramptons Rd	21	17				0.002	0.002	0.002	0.01
	Pembury	20	11	0.086	0.086	0.04	0.013	0.225	0.13	1.2
RZ2	Groombridge	7.2	5.1	0.127	0.127		0.012	0.266	0.19	3.8
	Poverty Bottom	9.4	8.3				0.004	0.004	0.004	0.05
RZ3	Crowhurst Bridge	10.4	9.5	0.17	0.45		0.007	0.63	0.57	6.0
	Powdermill	4.2	2.2		0.028		0.008	0.036	0.02	1.0
RZ4	Beenhams Heath, Hurley and White Waltham Group	32.9	29		1.32	0.03	0.009	1.33	1.17	4.0
	Boxalls Lane and Tongham Group	14.2	10.1		0.222		0.006	0.228	0.16	1.6
RZ5	Oakhanger	5.5	3.6		0.022		0.004	0.026	0.02	0.5
	Tilford Wellesley Rd and Rushmoor	5	2.8		0.089		0.006	0.10	0.06	2.0
RZ6	Forstal sourceworks	12	8		0.052		0.02	0.072	0.05	0.7
	Trosley Borough Green	16	11		0.069		0.014	0.083	0.06	0.6
	Halling Chalk and Greensand comb	8	8		0.018		0.008	0.03	0.03	0.3
RZ7	Goudhurst sourceworks	10	6	0.075	0.075		0.049	0.12	0.09	1.6
	Bewl Bridge boreholes	1.9	3.6					Zero	Zero	Zero
RZ8	Charing	4.4	3		0.026		0.005	0.031	0.023	0.8
	Kingston	7	4				0.004	0.004	0.004	0.1
	Wichling	14	10		0.6		0.008	0.57	0.408	4.1

3.3.1 Groundwater process losses discussion

Groundwater WTW sites where the total process losses exceed 2% are discussed below:

Groombridge WTW waste volumes are higher than typical for groundwater treatment processes as a result of very long filter backwash times – 14 minutes for the chemical oxidation stream and 20 minutes for the biological oxidation stream.

Crowhurst Bridge WTW has Enelco style filters with 2 units each containing 13 cells. This type of filter is extremely wasteful of water resulting in the estimated % waste volume for Crowhurst Bridge being much higher than normal at 6.9%.

Beenhams Heath WTW incorporates a microfiltration plant for which the recovery rate has been assumed to be 96% and this results in a relatively high waste volume being recorded against 'filtration.' It has not been possible in the time available to establish the actual recovery rate.

Wichling WTW also incorporates a microfiltration plant for which the recovery rate has been assumed to be 96% and this results in a relatively high waste volume being recorded against 'filtration.' It has not been possible in the time available to establish the actual recovery rate.

4.0 CONCLUSIONS

- Of the 24 sites assessed, only Arlington, Hazards Green, Bewl, Pembury and Trosley return a significant percentage of process losses back to Bank Side Storage or to the Head of the Works. Process losses from the other 19 sites pass to waste.
- Process losses as a percentage of typical throughput are shown in Table 6, categorised by treatment flowsheet. Application of the average process losses shown would produce a reasonable approximation of company losses if applied across all South East Water sites. However, it must be accepted that there will be significant errors for individual sites due to atypical designs or methods of operation as has been found at some sites reviewed in this high level study.

Table 4.1 Summary of process losses by treatment flowsheet Expressed as a percentage of typical throughput

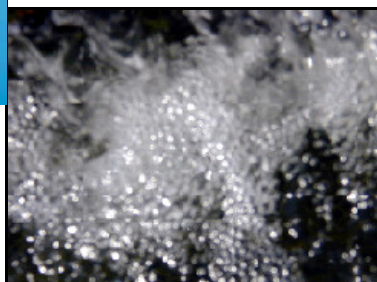
	Disinfection only	Filtration	Clarification + Filtration	Clarification + Filtration + GAC	Microfiltration
	0.01	1.0	1.0	4.8	4.0
	0.05	1.6	1.6	3.6	4.1
	0.1	0.5		4.2	
		2.0		3.8	
		0.7			
		0.6			
		0.3			
		0.8			
Average	0.1	0.9	1.3	4.1	4.1

Appendix A South East Water Operational Contacts

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south east water



2014 WRMP

PROJECT NUMBER: 67951

2014 Water Resources Management Plan

Outage Assessment for PR14

Draft Report

September 2013

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EXECUTIVE SUMMARY

1. South East Water (SEW) requires as part of the Periodic Review (PR14) process an assessment of outage for the Water Resource Management Plan (WRMP). Results will be used to inform the Water Resources in South East (WRSE) project and the Water Resources Management Plan (WRMP).
2. As part of the outage assessment process, a review of the outage models created for PR09 has been undertaken and the models updated with current data and new assumptions.
3. This report describes the various outage categories, the key assumptions made in the models for these outages and the outputs from the models. The report also shows the changes in assumptions made in the current outage models in comparison to those made for PR09.
4. Outages are of two types – Planned Outage and Unplanned Outage. Unplanned Outage is further categorised into pollution of source, power failure, system failure, turbidity, nitrate or algal issues.
5. For PR09, two models were created for the draft WRMP to assess outage; one from the former South East Water (fSEW) data for WRZ 1 to 5 and another from the former Mid-Kent Water (fMKW) data for WRZ 6 to 8. fMKW used the control room log database to log outage data whereas fSEW used zero flow data and interviews with control room operators to collect outage information. The fMKW method of calculating outage was considered more realistic and it was subsequently also applied to the fSEW WRZs 1 to 5 for the final WRMP.
6. Since PR09, SEW has developed a common control room log database system for all eight WRZs. For the PR14 outage models, actual data logged in this database from 2011 to 2012 has been analysed to obtain outage durations.
7. Some assumptions adopted for calculating Planned and Unplanned Outages for PR09 have been retained for the PR14 outage calculations. These are:
 - Pollution of Source Methodology: For confined sources, a most credible probability of (3 months) / (50 years) = 0.005 has been used with a minimum and maximum probability of 1 month in 100 years and 3 months in 40 years. In the case of unconfined sources, a most credible probability of (3 months) / (40 years) = 0.006 has been used with a minimum and maximum probability of 1 month in 50 years and 3 months in 30 years.
 - Unplanned outage methodology (excluding pollution of source): For turbidity failures, nitrate pollution, algal pollution, power failures and

system failures, the methodology is as was adopted by fMKW in PR09 and the calculation of outage durations was undertaken from data recorded from 2011 to 2012.

- There is no seasonal trend in outage; the risk of a source being out due to power failure is assumed to be the same in all months.
- No planned outage occurs within the critical planning period, as maintenance of a sourceworks occurs outside of peak demand periods.

8. Specific Assumptions

The following new assumptions have been incorporated in the PR14 outage calculations:

- Planned outage methodology: From 2012 onwards, SEW is implementing planned maintenance at its various sites so as to move away from reactive maintenance. Planned outages have been worked out based on analysis of the SEW planned maintenance framework. A review of the planned maintenance schedules revealed that all sites would experience outages from 2 to 4 days per year. This has been used to develop a new probability distribution with a minimum probability of 2 days in 1 year i.e. $2/365 = 0.005$, most credible probability of 3 days in 1 year i.e. $3/365 = 0.008$ and maximum probability of 4 days in 1 year i.e. $4/365 = 0.011$.
 - Following analysis of control room logs, it was noted that in many cases the logs failed to capture any outages due to power failure and turbidity. However, staff confirmed that there were outages at some of these sites. It was therefore recognised that there are likely to be outages which do not get logged in the control room logs. To take account of this, outage categories without data were populated with a normalised outage duration from one of the other categories.
9. Magnitude Information: The updated deployable output assessment data has been used in the outage models for assessing the magnitude. No change has been made in the way minimum likely, most likely and maximum likely values for loss of outputs from specific sources have been estimated as compared to PR09. For PR09 and PR14 outage calculations, these were assumed to be 0.1MI/d less than the total deployable output (DO) value for each case with the maximum likely being equal to the DO value.
10. Outage Durations: Control room log database incidents have been analysed for duration of incident and categorised based on the type of outage.
11. The Outage Analysis shows that SEW have utilised their control room log database as a source of actual outage events. This actual data has been used effectively to provide resilience to the updated methodology for

calculating outage allowance. Where data is not available information from other sites has been used as a proxy.

12. The sensitivity analysis shows that the outage assessment is sensitive to the assumptions used. Because of this SEW is proposing to undertake further work in AMP6 which will aim to improve its Outage assessment.

1.0 INTRODUCTION

1.1 GENERAL INTRODUCTION

Outage is a term used in water industry to describe a temporary loss of the Deployable Output (DO) from a source or group of sources. An interruption of longer than three months is considered to be more than temporary and is therefore included elsewhere in the supply demand balance (i.e. in target headroom, or as reduction in DO).

South East Water (SEW), as part of the Periodic Review (PR14) process, requires an assessment of the company's outage for the supply demand balance forecasting. This will be calculated using the existing model used by the former Mid Kent Water (fMKW), which was developed in accordance with the UK Water Industry Research (UKWIR) methodology. This report outlines the methodology and the assumptions used in determining the outage allowance for each water resource zone (RZ).

Outage values can be calculated for annual average and critical peak periods. Data on the likelihood, duration and magnitude of outage events in each month of the year are required to estimate outage for the whole year, or for any part of a year. In accordance with the UKWIR methodology (1995) only unplanned events would be considered in the assessment of outage during critical peak period, as a water company is unlikely to plan maintenance during peak demand periods.

This report provides a brief introduction to the water industry guidelines. The methodology to be used in estimating outage for each RZ is explained. In addition a discussion of unplanned and planned outage events, an explanation of the outage calculations used and details of any assumptions made are given.

The final outage results to be incorporated in the Final Water Resources Management Plan (FWRMP) are detailed within this report.

1.2 BACKGROUND INFORMATION ON OUTAGE

The methodology used to determine sources and causes of outage, and the probability distribution of losses that may be expected from each source / cause is set out in 1995 UKWIR report '*Outage allowances for water resources planning*'. This report identifies the planned and unplanned circumstances that may result in a temporary outage. For these events, the resulting estimated loss in DO may be used in the estimation of water available for use (WAFU) in a given RZ. An outage allowance expressed in MI/d may be made for such outages.

It is assumed outage may occur on any assets between the point of abstraction and the point at which water is first fit for purpose. These include:

- Abstraction works (rivers, boreholes and reservoirs)
- Raw water storage
- Raw water pumping plant

- Raw water transfer mains
- Water treatment works
- Treated water storage
- Treated water pumping plant

The outage calculation methodology uses two sets of data to populate a model;

1. An assessment of the least likely, most likely and maximum likely values for loss of output from specific sources; and
2. An assessment of the least likely, most likely and maximum likely duration of the period over which loss of output from such sources may occur (taking frequency of occurrence into account).

The probability distribution represented by the magnitude and normalised duration (the duration divided by the sample period) of each outage caused are then selected. The resultant probability of loss of output arising from the combination of all possible sources is determined via repeated co-sampling from the determined input distribution using @Risk software.

The outage allowance for each RZ is then selected by taking the outage value determined by an exceedance probability. The sum of the RZ outage allowance values is used to provide a company-wide value.

1.3 PREVIOUS OUTAGE ASSESSMENT

In PR09, the fMKW methodology used real time data for calculating outage at each source based on the control room log database. The results presented in the PR09 report are considered realistic and accurate.

The control room log database is a log of all the planned and unplanned outage events that have occurred at any given source. The incidents are logged in the database by the site controller. Details recorded include time of event, cause of event (e.g. power failure, system failure, turbidity etc.), and the person who dealt with the problem and when was it resolved. Using this information SEW was able to accurately obtain and analyse data showing frequency and duration of every outage event for every source. SEW recognised the benefits in the approach developed by using control room log database system, and for PR14 has rolled out the system across the whole business.

2.0 METHODOLOGY

2.1 UNPLANNED OUTAGE

The UKWIR Outage Methodology (1995) defined the following as legitimate unplanned outage events:

- Pollution of source
- Turbidity
- Nitrate
- Algae
- Power failure
- System failure

Unplanned events are outage caused by unforeseen or unavoidable legitimate outage events affecting any part of the source works and occurs with sufficient regularity that the probability of occurrence and severity of effect may be predicted from previous events or perceived risk.

Extreme events are not considered in the unplanned outage methodology as they can skew the results. Extreme events are occasional, unpredictable events which cannot reasonably be foreseen, but which still reduce the DO.

As per PR09, data on unplanned events across all RZs is based on information collected in the control room log database between March 2011 and March 2012.

Data on unplanned outage events are entered as a duration (i.e. the number of days the event has an impact) and a magnitude (i.e. the loss of output in MI/d). A triangular distribution is used as a reasonable representation of the actual distribution. The result is a distribution of allowable outage for a RZ, expressed as MI/d against a return period.

The first phase of data collection involves observed outage data for each sourceworks. Historic data can only highlight outage events have actually occurred; therefore a more robust methodology should also include an outage allowance for events that have a real chance of occurring in the future, but have yet to be observed.

The methodology relating to the unplanned outage events listed above are discussed in more detail below.

2.1.1 Pollution of Source

One source of unforeseen outage is the result of a gross pollution event. A calculated value of outage is added to each source where there is a perceived risk of such a pollution event interrupting DO. This methodology applies to groundwater sources only.

In PR09, fMKW used the following values to determine the minimum, maximum and most likely probabilities of occurrence. These values are considered reliable for use

by SEW in PR14. The 'most credible' probability of (3 months) / (50 years) = 0.005 has been used for this event in the case of confined sources with a minimum and maximum probability of 1 month in 100 years and 3 months in 40 years. In the case of unconfined sources a most credible" probability of (3 months / (40 years) = 0.006 has been used for this event with a minimum and maximum probability of 1 month in 50 years and 3 months in 30 years.

All SEW groundwater sources (RZ 1-8) use this hypothetical pollution of source outage allowance calculation based on whether the groundwater source is in a confined or unconfined aquifer.

SEW has experienced outage incidents in the past of this type, and the table below summarises recent examples where sources have not been operated because of Outage for significant periods of time.

Table 1 – Examples of significant outage

Site	Period of outage	Cause of outage
Forest Row (Ashdown Formation, unconfined)	12 years	Leakage from fuel storage into groundwater
Stockbury (Chalk, unconfined)	Periodically during intense rainfall over past 10 years, for periods of 1 – 2 weeks	Overflows from private sewage tanks
Newnham (Chalk, unconfined)	5 years	Discharge from abattoir
Ospringe	2 years	Leakage from fuel storage into groundwater
East Meon	Periodically, up to 1 month	Occurrence of freshwater shrimp in borehole.
Woodgarston	6 years	Storage of animal slurry on adjacent land
Lasham	2 years	Fire at storage depot of electrical goods
Charing (Greensand, unconfined)	5 years	Nitrates in Bh 2, now decommissioned
Forstal Well (Hythe Beds, unconfined)	Periodically, up to periods of 4 weeks.	Ammonia in the main well.

2.1.2 Turbidity, Nitrate, Algae, Power Failure and System Failure

Turbidity failures, nitrate pollution, algae pollution (often related to surface water rather than groundwater), power failures and system failures are the main sources of unplanned outage that are related to treatment plant failures and therefore unplanned outage events.

A good set of historic and real-time data is available on all outage events for RZ 1-8. Outage events are recorded by the control room as they occur. As outlined above control room staff log the duration and cause of outage occurrence. This data is then used in the @Risk models for all sources.

Calculations for average outage were taken from data recorded between March 2011 and March 2012. This is considered a representative period for use in the final outage modelling, however it is recognised that this is a period of relatively low demand. If our system had been more stressed, as a result of drought or higher demands, then it is possible maintenance would have been undertaken more quickly. We consider the impact of this in our sensitivity analysis in Section 4.

Analysis of the Control Room logs shows that the outage events can be mainly categorised under three categories of unplanned outage such as system failure, power failure and turbidity. Treatment work failures due to high nitrate levels or algal blooms are not events that occur very often and have been accounted for under the pollution of source category.

The Turbidity component of outage has been reduced at a number of sites due to improvements at the works, including:

- Kingston (0.022 to 0)
- Ford (0.044 to 0)
- Forstal (0.014 to 0)
- Boxley (0.013 to 0)
- Wichling (0.069 to 0.019)
- Stockbury (0.044 to 0.008)

The company is in discussions with the DWI to further improve the capability of the Kingston and Stockbury plants to handle turbidity and these developments have been already taken into account in assessing this component of the overall Outage for the sources.

2.2 PLANNED OUTAGE

All sources require occasional foreseen and pre-planned maintenance to ensure they continue operating in an efficient manner. Planned outages have been determined based on analysis of the SEW planned maintenance framework.

A review of planned maintenance schedules showed that all sites would experience outages between 2 to 4 days per year. This observed frequency has been used to develop a new probability distribution for PR14, which is as follows:

- A minimum probability of 2 days per year i.e. $2/365 = 0.005$;
- A most credible probability of 3 days per year i.e. $3/365 = 0.008$; and
- A maximum probability of 4 days in 1 year i.e. $4/365 = 0.011$.

2.3 SURFACE WATER SOURCES OUTAGE

There are four surface water sources in RZ 1 to 5: Barcombe, Shellbrook, Arlington and Bray. These are seen as fairly typical Surface Water Treatment Works with good real-time information on all outage events planned and unplanned. All three sites have a normalised 'most likely' planned outage duration of 0.008 and normalised 'maximum' planned outage duration of 0.011. The normalised 'most likely' unplanned outage duration for different categories ranges from 0.002 to 0.064.

There are two surface water sources in RZ 6 to 8: Burham and Bewl Bridge. Due to lack of availability of data, a normalised 'most likely' outage duration of 0.008 and normalised 'maximum' outage duration of 0.011 has been used as template values for these two surface water sources.

2.4 MAGNITUDE INFORMATION

The most up-to-date source of deployable output information was used in the outage models. Updates have occurred where further information has been made available. The final baseline DOs used in the final outage assessment presented in this report are the most up to date DOs for sources

This data is called the site magnitude data. It is multiplied by the outage duration data and averaged out for a year to obtain an outage figure that can then be used input to the @Risk software.

The data used for the outage assessment is considered to be the most robust and up-to-date information available enabling calculation of the most accurate outage allowance figures.

2.5 ACTUAL OUTAGE CALCULATION

Summary spreadsheets were used as the base data for the model. This incorporated the minimum likely, most likely, and maximum likely values for loss of output from specific sources and by specific causes. Together with the minimum likely, most likely, and maximum likely duration of the period over which the loss of output from such sources/causes may occur, this data was used to populate the @Risk model for the outage calculation.

In accordance with the UKWIR (1995) methodology, @RISK and Monte Carlo simulation was used to analyse the likely loss of output and likely duration of output information for outage events. The output is a single distribution for each scenario. The methodology used is broadly as follows:

1. A random value from a magnitude distribution is multiplied by a random value from the normalised duration distribution to give a value equivalent to the 98% exceedance probability (equivalent to 1 in 50 year event) of event magnitude (MI/d).
2. The values calculated in step 1 are then summed for all outage events occurring in the same analysis period for all sourceworks in the RZ. Values across all RZs

are summed to provide a company-wide figure for both average and peak scenarios.

3. Steps 1 and 2 are repeated a sufficient number of times (500) to ensure sufficient accuracy of the combined distribution. The final figures are used in the Final WRMP.

2.6 ASSUMPTIONS

In calculating the outage allowance, below are the analysis assumptions:

Table 2 – Assumptions in PR14 Outage Analysis

S.No.	Assumption
1	All the events are mutually exclusive therefore no two sourceworks will be out at the same time.
2	There is no seasonal trend in outage therefore the risk of a source being out due to power failure is assumed to be the same in all months.
3	No planned outage will occur within the critical planning period, as maintenance of a sourceworks occurs outside of peak demand periods.
4	Halling Membrane is not a sourcework, but will affect both Halling Chalk and Halling Greensand sites.
5	Outage at Halling Membrane is considered within both Halling Chalk and Halling Greensand borehole sourceworks outage duration.
6	The 98 percentile exceedance probability equivalent to a 1 in 50 year outage allowance has been used to define the outage of each RZ for water Resource planning purposes.
7	Planned outages have been worked out based on analysis of the SEW planned maintenance framework. A review of the planned maintenance schedules revealed that all sites would experience outages from 2 to 4 days per year.
8	A small number of outages are not logged. To take account of this, empty outage categories were populated with a normalised outage duration from one of the other categories.

3.0 RESULTS

It should be noted that there are considerable changes in the datasets used between PR09 and PR14 for WRZ 1 to 5.

Based on the methodology outlined above, the tables below present the outputs to be used in the Final WRMP.

Table 3 - Outage Allowance Figures (MI/d)

Resource Zone	Average Outage (MI/d of ADO) Draft WRMP	Average Outage (% of ADO)	Peak Outage (MI/d of PDO) Draft WRMP	Peak Outage (% of PDO)
RZ1	2.2	6.1%	1.0	2.4%
RZ2	4.9	6.3%	6.2	4.2%
RZ3	5.7	7.6%	9.3	10.5%
RZ4	7.3	4.3%	10.0	5.4%
RZ5	2.6	4.6%	6.3	9.3%
RZ6	1.6	2.8%	1.4	1.8%
RZ7	0.6	3.0%	0.3	1.4%
RZ8	2.5	2.2%	2.1	1.6%

Table 4 - Outage Review 2012: Comparison of outage values for PR09 and PR14 (ADO)

WRZ	PR-1999 (MI/d)	PR-04 (MI/d)	PR-09 (MI/d)	PR-14 (MI/d)
WRZ 1	-	2.5	1.3	2.2
WRZ 2	-	2.3	2.5	4.9
WRZ 3	-	5.0	2.0	5.7
WRZ 4	10.0	16.8	6.6	7.3
WRZ 5	8.0	0.7	1.7	2.6
WRZ 6	2.1	0.7	2.1	1.6
WRZ 7	0.8	0.7	0.4	0.6
WRZ 8	3.4	0.7	2.3	2.5
Total	24.3	29.4	18.9	27.4

Table 5 - Outage Review 2012: Comparison of outage values for PR09 and PR14 (PDO)

WRZ	PR-1999 (MI/d)	PR-04 (MI/d)	PR-09 (MI/d)	PR-14 (MI/d)
WRZ 1	2.8	2.5	1.4	1.0
WRZ 2	8.3	2.3	3.0	6.2
WRZ 3	3.9	5.0	2.2	9.3
WRZ 4	10.0	16.8	6.6	10.0
WRZ 5	8.0	0.8	1.8	6.3
WRZ 6	2.2	0.8	2.5	1.4
WRZ 7	1.1	0.8	0.5	0.4
WRZ 8	2.5	0.8	2.4	2.1
Total	38.7	29.6	20.5	36.7

4.0 SENSITIVITY ANALYSIS

Based on discussions with the Environment Agency in 2013, SEW was asked to show how outage values would vary if SEW applied different assumptions. SEW carried out a sensitivity analysis on the dWRMP outage models. The dWRMP base models were created using the logged outage duration data. No constraints were applied on the duration of outage in the base model. It was however, recognised that there are likely to be outages which do not get logged in the control room logs. To take account of this, for developing the base dWRMP outage models, categories without data were populated with a normalised outage duration from one of the other categories.

- For sensitivity analysis scenario 1, the total outage was calculated based only on logged outage incidents.
- For sensitivity analysis scenario 2, base dWRMP model was changed for Planned Outage duration of 3 to 5 days
- For sensitivity analysis scenario 3, a duration constraint of 3 days maximum was applied on unplanned outage categories such as power failure and turbidity in the base dWRMP model.

Table 6– Sensitivity Analysis Scenario - 1 with no additional data and assuming 2 to 4 days Outage

WRZ	ADO (MI/d)	PDO (MI/d)
WRZ 1	1.7	0.8
WRZ 2	3.2	3.1
WRZ 3	4.1	5.3
WRZ 4	5.9	6.2
WRZ 5	2.4	5.9
WRZ 6	0.6	0.5
WRZ 7	0.2	0.1
WRZ 8	1.6	0.8
Total	19.6	22.7

Table 7 – Sensitivity Analysis Scenario - 2 with additional data and assuming 3 to 5 days Outage

WRZ	ADO (MI/d)	PDO (MI/d)
WRZ 1	2.3	1.0
WRZ 2	5.1	6.2
WRZ 3	5.9	9.3
WRZ 4	7.9	10.0
WRZ 5	2.8	6.3
WRZ 6	1.9	1.4
WRZ 7	0.7	0.3
WRZ 8	2.8	2.1
Total	29.6	36.7

Table 8 – Sensitivity Analysis Scenario – 3: Application of 3 day constraint on power and turbidity outages.

WRZ	ADO (MI/d)	PDO (MI/d)
WRZ 1	1.8	0.8
WRZ 2	4.9	6.2
WRZ 3	4.7	7.7
WRZ 4	6.8	8.4
WRZ 5	2.2	3.1
WRZ 6	1.6	1.4
WRZ 7	0.6	0.4
WRZ 8	2.5	2.1
Total	25.2	30.0

The Sensitivity Analysis results from Tables 6 to 8 shows that the duration of outage for an outage incident has a significant impact on the calculated Outage Value for a resource zone. So when the sensitivity analysis scenario was run for a bigger outage duration, the outage values calculated for the resource zones were much higher. Similarly applying a constraining factor on a particular outage category also has a similar impact.

5.0 CONCLUSIONS

This report has set out how South East Water has calculated the outage allowance to be used in the supply demand balance forecasting in the Final WRMP for PR14.

This report has explained where methodologies have been updated and what calculations have been adopted to obtain the final outage allowance figures. Assumptions have been stated and sensitivity analysis around these assumptions has been undertaken.

SEW have utilised their control room log database as a source of actual outage events. This actual data has been used effectively to provide resilience to the updated methodology for calculating outage allowance. Where data is not available information from other sites has been used as a proxy.

The methodology for calculating outage allowance uses @Risk modelling in conjunction with the best available data and UKWIR (1995) Methodology

The final figures to be used in the Final Water Resource Management Plan have been set out in Tables 3 to 5.

The sensitivity analysis shows that the outage assessment is sensitive to the assumptions used. Because of this SEW is proposing to undertake further work in AMP6 which will aim to improve its Outage assessment.

6.0 RECOMMENDATIONS

It is recognised that further work may improve our understanding of Outage and how we can plan for mitigation.

During the early stages of the development of the options for the dWRMP options to reduce outages were considered in the Options Appraisal process while putting together the Unconstrained Option list. However, the benefits from these options were too small and hence these options were not carried on to the Feasible Options stage. The options were filtered out at an early stage and therefore they are not included in the options reports. Nevertheless there are examples of where SEW has undertaken improvements to sites to reduce or mitigate outage, and examples are set out in the table below:

Table 10 – Examples of Options to Reduce or Mitigate Outage

Site	Outage Improvements	Result
Wichling	Installation of micro-filtration membrane plant	Significant reduction in outage due to quality and turbidity failure
Halling Chalk	Installation of micro-filtration membrane plant	Significant reduction in outage due to quality and turbidity failure
Stockbury	Changes to the operational regime, and progressing discussions for new plant	Reductions in outage
Woodgarston	Agreement with landowner	Recommissioning of borehole, assumed improvement in loss from outage
Boxley	New treatment works	Commissioning off site borehole and assumed improvement in loss from outage
Charing	Installation of nitrate treatment for Borehole 2	Unsuccessful due to ingress of sand and final loss of borehole

Appendix 3 of this report provides summary outage statistics for each source, and it can be seen which sources have the highest outage levels. It is possible to look over a longer data set and identify any trends in outage at particular sources. Now we have approximately 3 years of data, we propose to undertake a study in AMP6 to identify those sources with high outage and implement a programme in either AMP6 or AMP7 to reduce risk of outage at those sites.

We propose that this work be linked with our PR19 Business Plan submission on capital maintenance.

7.0 REFERENCES

South East Water (2008) – South East Water Draft Water Resources Management Plan, March 2008. (*Document Ref: Draft Water Resources Management Plan Final 1.0.*)

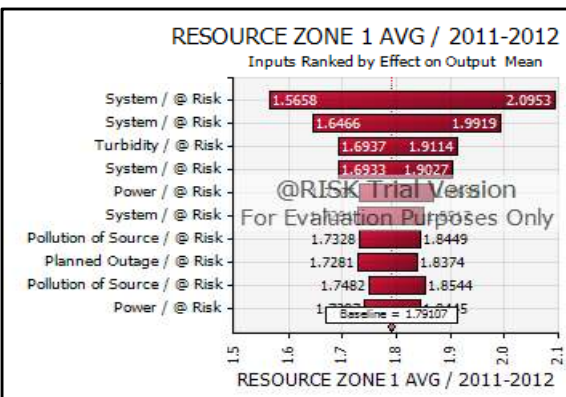
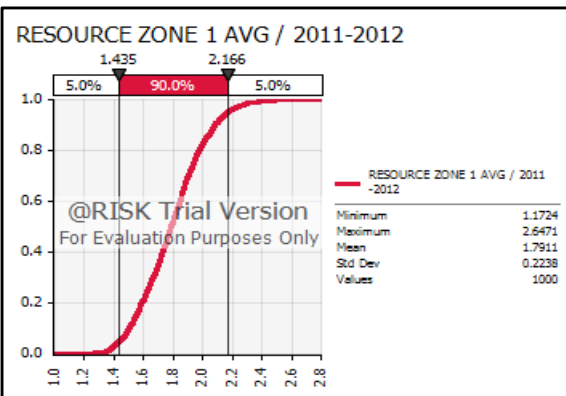
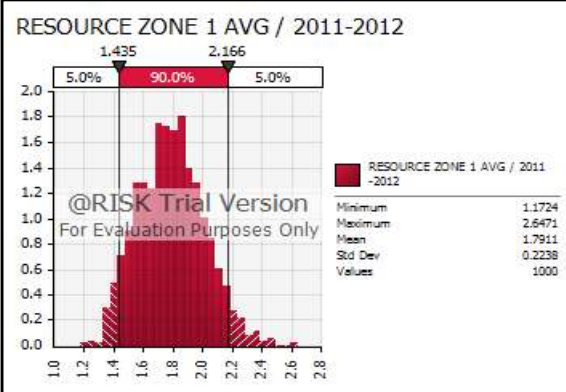
UKWIR (1995) –Outage Allowances for Water Resource Planning. United Kingdom Water Industry Research Limited. March 1995. (*Document Ref: WRP-0001/B outage Allowances for Water Resource Planning.*)

APPENDIX 1 - 4

@RISK Output Report for RESOURCE ZONE 1 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:45

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-2012 30.09.13_R3_a.xls
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 1 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 1.435
Maximum	10% 1.499
Mean	15% 1.546
Std Dev	20% 1.586
Variance	25% 1.627
Skewness	30% 1.665
Kurtosis	35% 1.699
Median	40% 1.727
Mode	45% 1.759
Left X	50% 1.784
Left P	55% 1.817
Right X	60% 1.846
Right P	65% 1.870
Diff X	70% 1.903
Diff P	75% 1.939
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Filter Min	85% 2.022
Filter Max	90% 2.081
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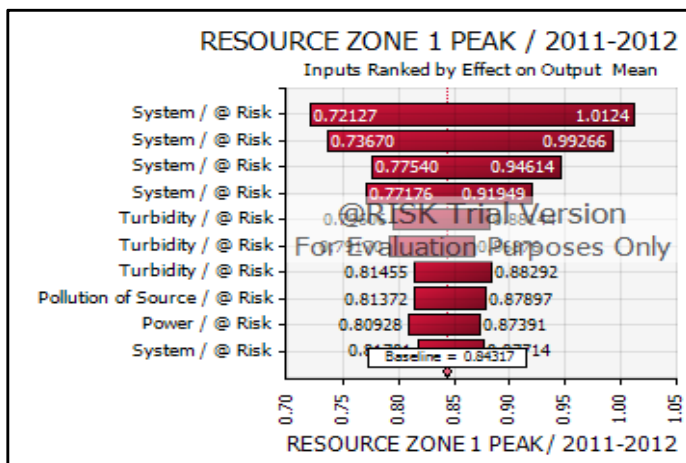
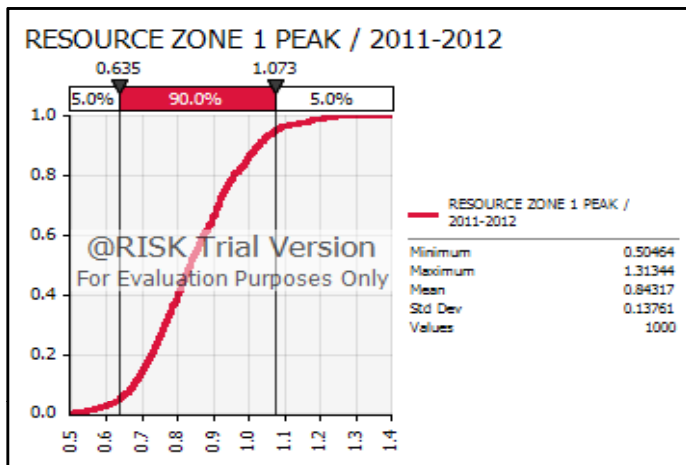
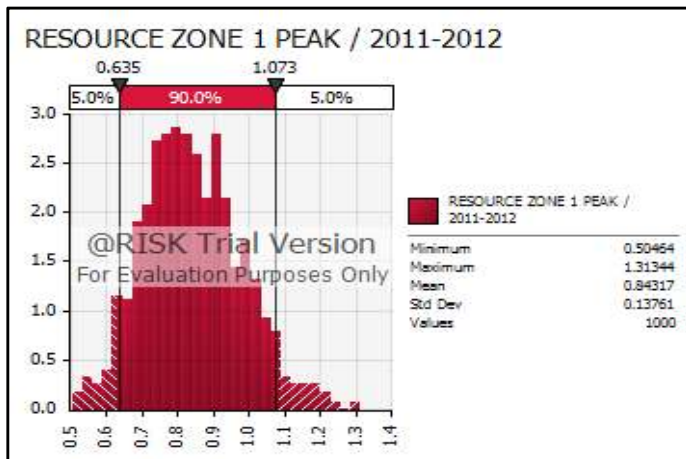
Change in Output Statistic for RESOURCE ZONE 1 AVG / 2011-2012

Rank	Name	Lower	Upper
1	System / @ Risk	1.566	2.095
2	System / @ Risk	1.647	1.992
3	Turbidity / @ Risk	1.694	1.911
4	System / @ Risk	1.693	1.903
5	Power / @ Risk	1.733	1.869
6	System / @ Risk	1.729	1.852
7	Pollution of Source	1.733	1.845
8	Planned Outage / @	1.728	1.837
9	Pollution of Source	1.748	1.854
10	Power / @ Risk	1.740	1.845

@RISK Output Report for RESOURCE ZONE 1 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:46

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 1 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 0.635
Maximum	10% 0.675
Mean	15% 0.700
Std Dev	20% 0.724
Variance	25% 0.745
Skewness	30% 0.761
Kurtosis	35% 0.780
Median	40% 0.800
Mode	45% 0.818
Left X	50% 0.834
Left P	55% 0.852
Right X	60% 0.871
Right P	65% 0.895
Diff X	70% 0.913
Diff P	75% 0.931
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Filter Max	90% 1.027
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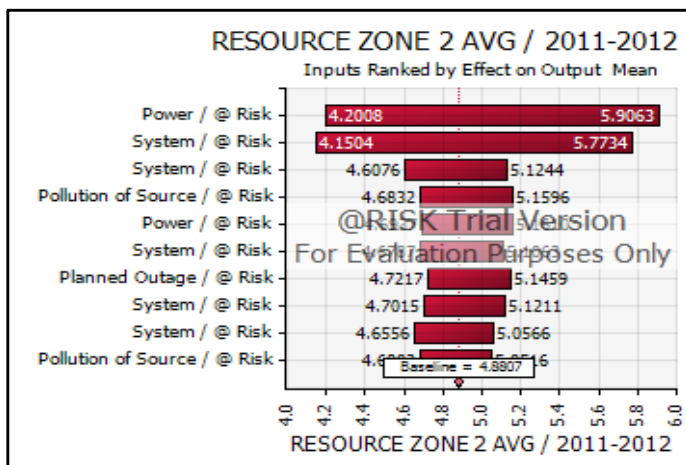
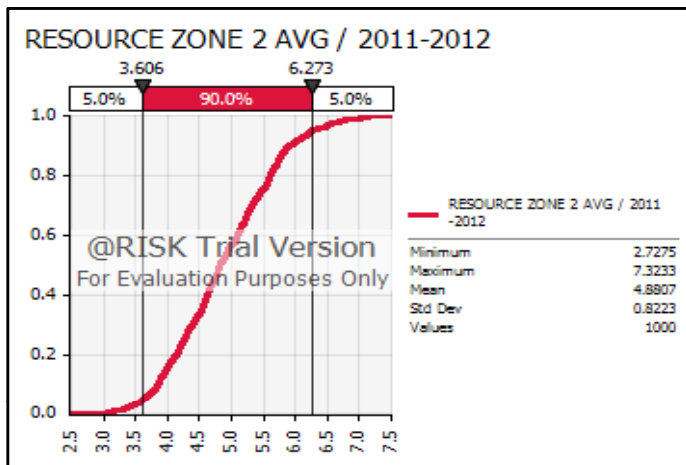
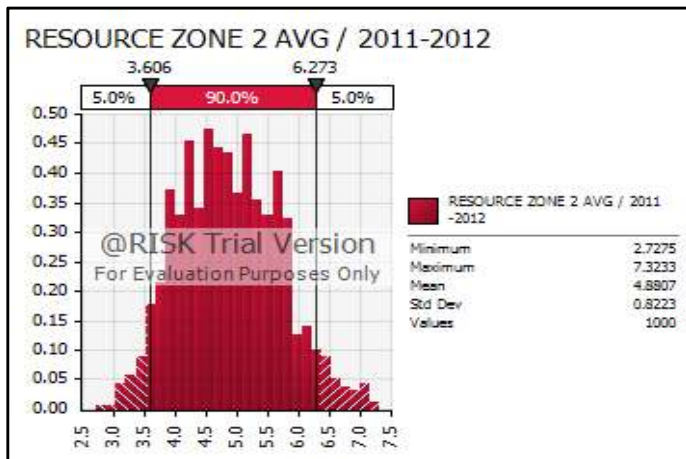
Change in Output Statistic for RESOURCE ZONE 1 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	System / @ Risk	0.721	1.012
2	System / @ Risk	0.737	0.993
3	System / @ Risk	0.775	0.946
4	System / @ Risk	0.772	0.919
5	Turbidity / @ Risk	0.796	0.881
6	Turbidity / @ Risk	0.792	0.869
7	Turbidity / @ Risk	0.815	0.883
8	Pollution of Source / @ Risk	0.814	0.879
9	Power / @ Risk	0.809	0.874
10	System / @ Risk	0.817	0.877

@RISK Output Report for RESOURCE ZONE 2 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:47

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 2 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 3.606
Maximum	10% 3.854
Mean	15% 3.970
Std Dev	20% 4.126
Variance	25% 4.257
Skewness	30% 4.385
Kurtosis	35% 4.535
Median	40% 4.620
Mode	45% 4.718
Left X	50% 4.823
Left P	55% 4.949
Right X	60% 5.095
Right P	65% 5.209
Diff X	70% 5.332
Diff P	75% 5.480
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Filter Max	90% 5.895
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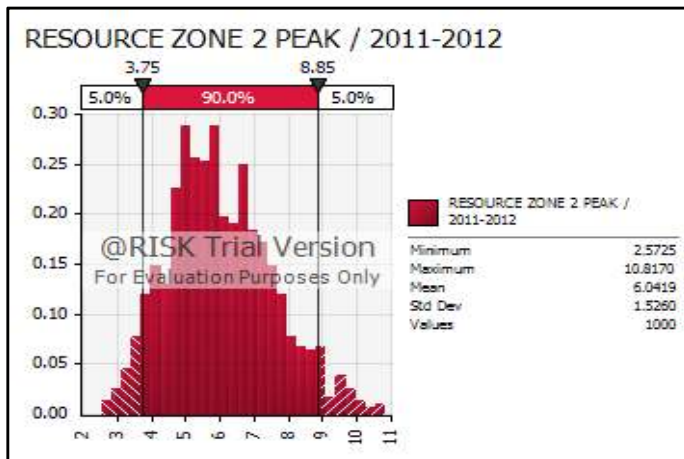
Change in Output Statistic for RESOURCE ZONE 2 AVG / 2011-20

Rank	Name	Lower	Upper
1	Power / @ Risk	4.201	5.906
2	System / @ Risk	4.150	5.773
3	System / @ Risk	4.608	5.124
4	Pollution of Source / @ Risk	4.683	5.160
5	Power / @ Risk	4.694	5.161
6	System / @ Risk	4.679	5.106
7	Planned Outage / @ Risk	4.722	5.146
8	System / @ Risk	4.702	5.121
9	System / @ Risk	4.656	5.057
10	Pollution of Source / @ Risk	4.680	5.052

@RISK Output Report for RESOURCE ZONE 2 PEAK / 2011-2012

Performed By: Administrator

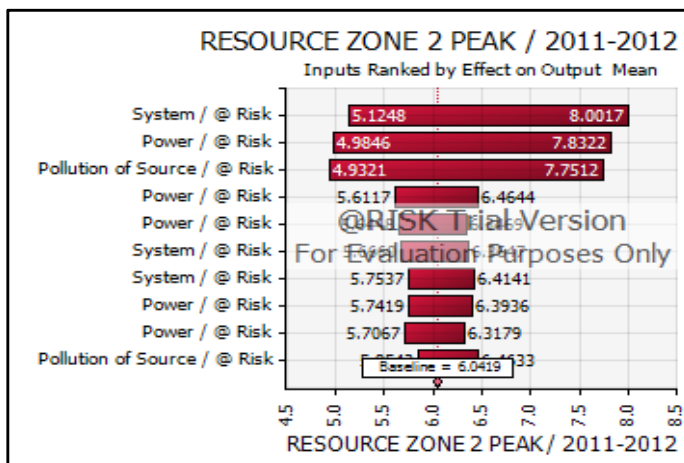
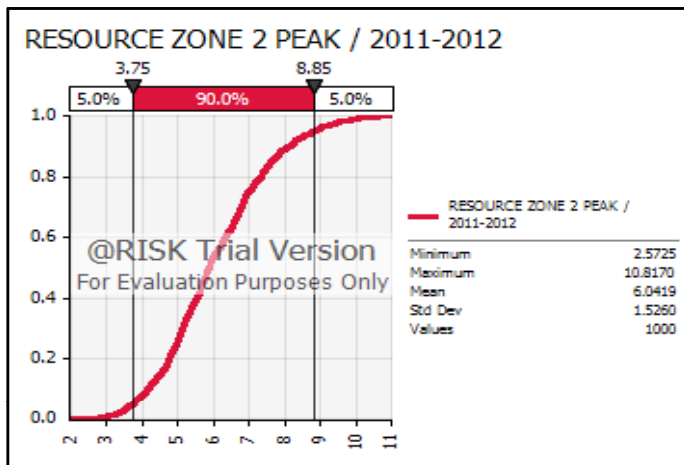
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Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 2 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 3.747
Maximum	10% 4.119
Mean	15% 4.489
Std Dev	20% 4.752
Variance	25% 4.963
Skewness	30% 5.118
Kurtosis	35% 5.297
Median	40% 5.522
Mode	45% 5.697
Left X	50% 5.868
Left P	55% 6.058
Right X	60% 6.329
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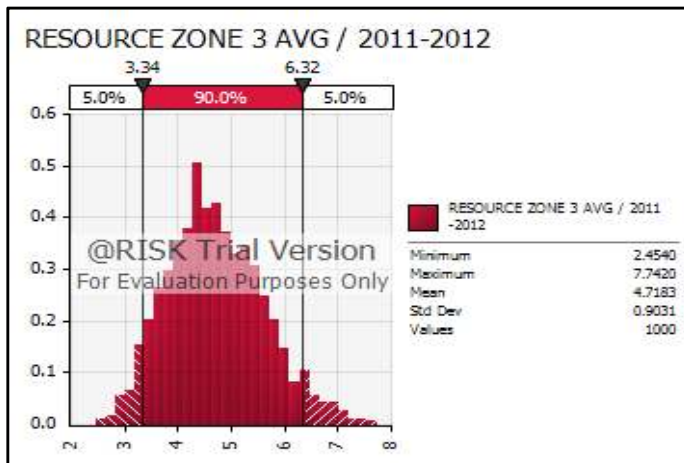
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Rank	Name	Lower	Upper
1	System / @ Risk	5.125	8.002
2	Power / @ Risk	4.985	7.832
3	Pollution of Source / @ Risk	4.932	7.751
4	Power / @ Risk	5.612	6.464
5	Power / @ Risk	5.645	6.347
6	System / @ Risk	5.666	6.365
7	System / @ Risk	5.754	6.414
8	Power / @ Risk	5.742	6.394
9	Power / @ Risk	5.707	6.318
10	Pollution of Source / @ Risk	5.854	6.463

@RISK Output Report for RESOURCE ZONE 3 AVG / 2011-2012

Performed By: Administrator

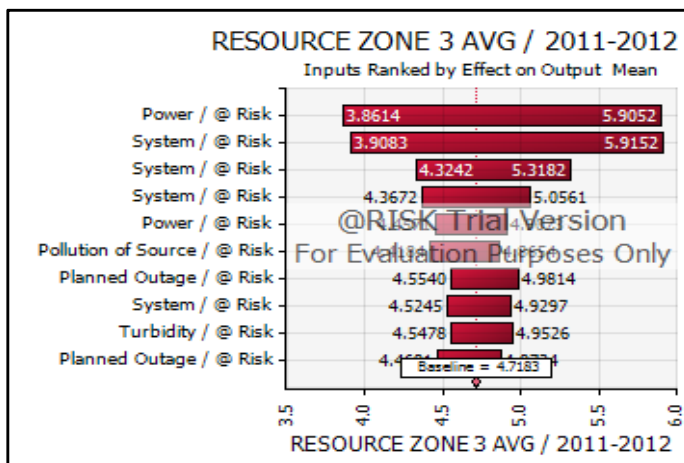
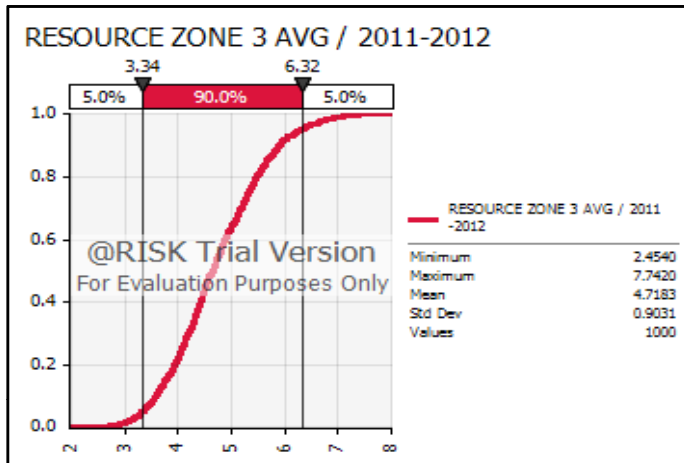
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Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 3 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 3.339
Maximum	10% 3.575
Mean	15% 3.751
Std Dev	20% 3.923
Variance	25% 4.058
Skewness	30% 4.184
Kurtosis	35% 4.318
Median	40% 4.420
Mode	45% 4.511
Left X	50% 4.653
Left P	55% 4.767
Right X	60% 4.870
Right P	65% 5.042
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Diff P	75% 5.326
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Filter Max	90% 5.901
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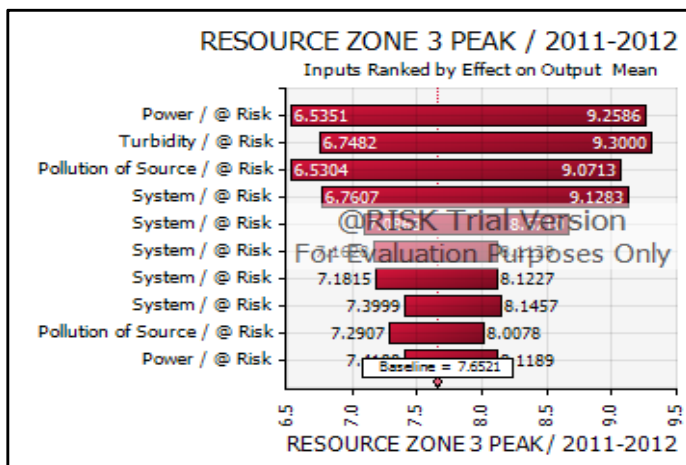
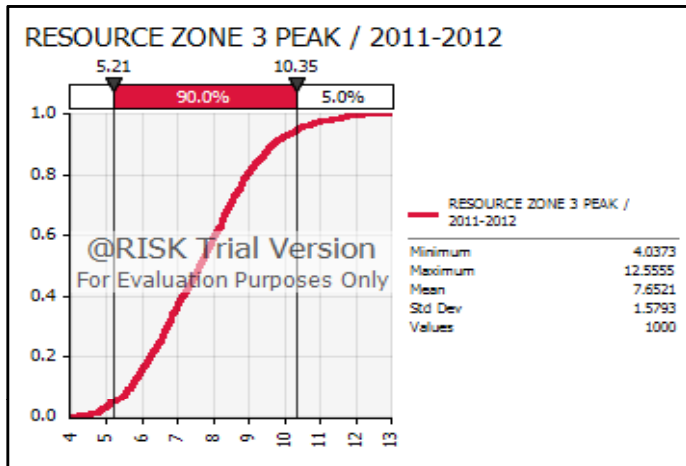
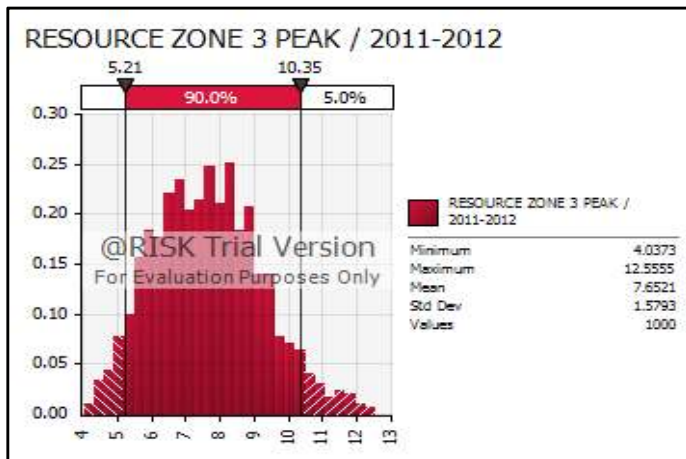
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Rank	Name	Lower	Upper
1	Power / @ Risk	3.861	5.905
2	System / @ Risk	3.908	5.915
3	System / @ Risk	4.324	5.318
4	System / @ Risk	4.367	5.056
5	Power / @ Risk	4.457	4.907
6	Pollution of Source / @ Risk	4.418	4.865
7	Planned Outage / @ Risk	4.554	4.981
8	System / @ Risk	4.524	4.930
9	Turbidity / @ Risk	4.548	4.953
10	Planned Outage / @ Risk	4.468	4.872

@RISK Output Report for RESOURCE ZONE 3 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:48

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 3 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 5.213
Maximum	10% 5.672
Mean	15% 5.935
Std Dev	20% 6.215
Variance	25% 6.483
Skewness	30% 6.701
Kurtosis	35% 6.889
Median	40% 7.109
Mode	45% 7.390
Left X	50% 7.615
Left P	55% 7.813
Right X	60% 8.040
Right P	65% 8.252
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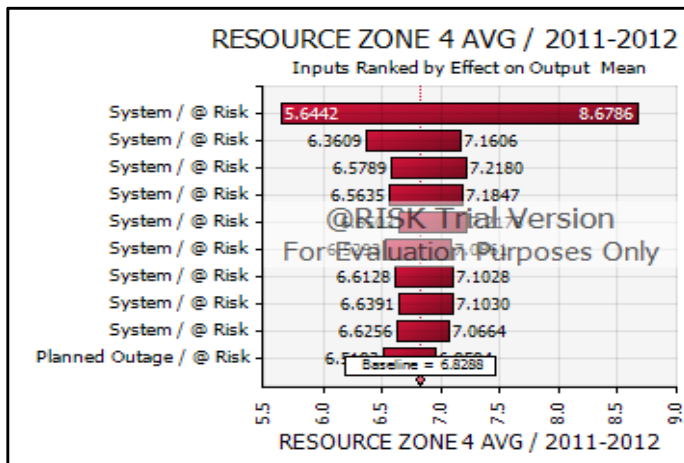
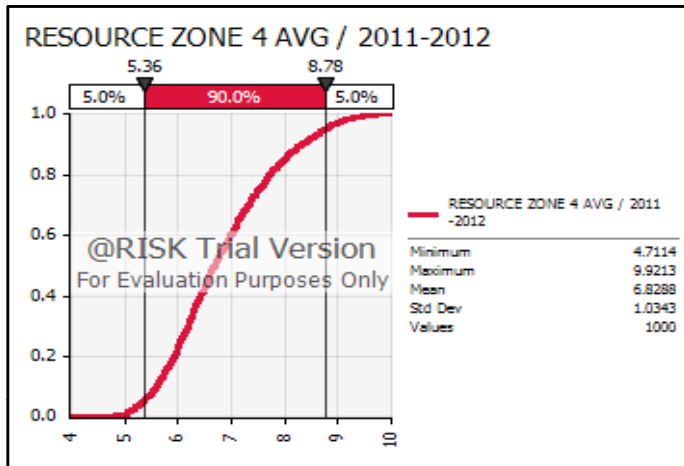
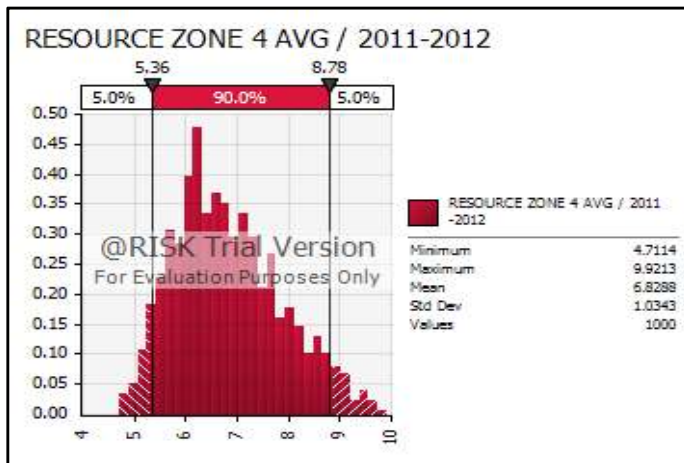
Change in Output Statistic for RESOURCE ZONE 3 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	Power / @ Risk	6.535	9.259
2	Turbidity / @ Risk	6.748	9.300
3	Pollution of Source / @ Risk	6.530	9.071
4	System / @ Risk	6.761	9.128
5	System / @ Risk	7.087	8.671
6	System / @ Risk	7.163	8.113
7	System / @ Risk	7.182	8.123
8	System / @ Risk	7.400	8.146
9	Pollution of Source / @ Risk	7.291	8.008
10	Power / @ Risk	7.410	8.119

@RISK Output Report for RESOURCE ZONE 4 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:48

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 4 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 5.357
Maximum	10% 5.580
Mean	15% 5.754
Std Dev	20% 5.921
Variance	25% 6.035
Skewness	30% 6.187
Kurtosis	35% 6.283
Median	40% 6.410
Mode	45% 6.550
Left X	50% 6.689
Left P	55% 6.820
Right X	60% 6.985
Right P	65% 7.126
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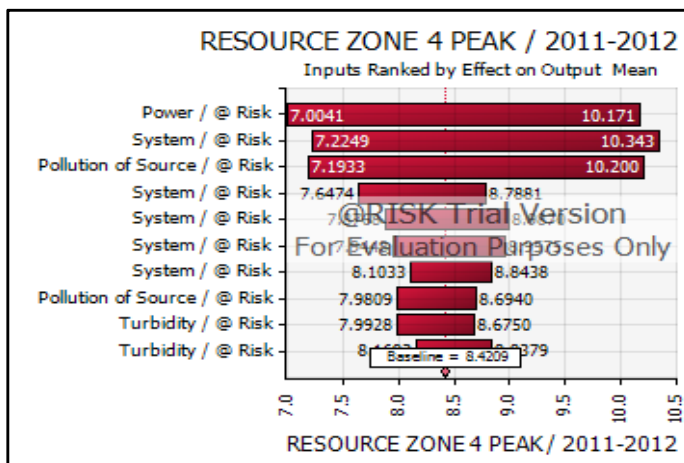
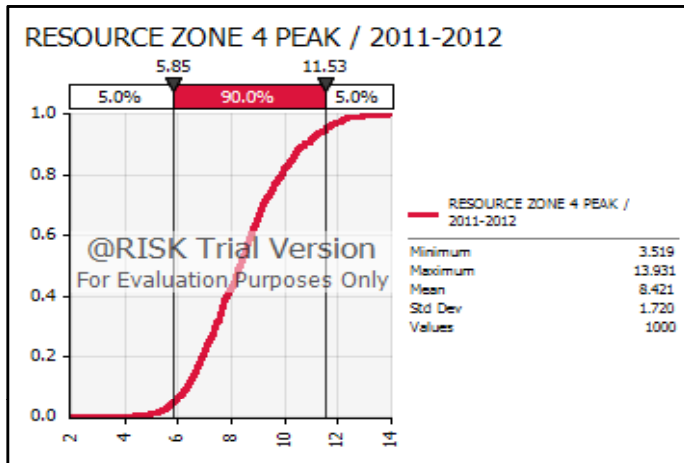
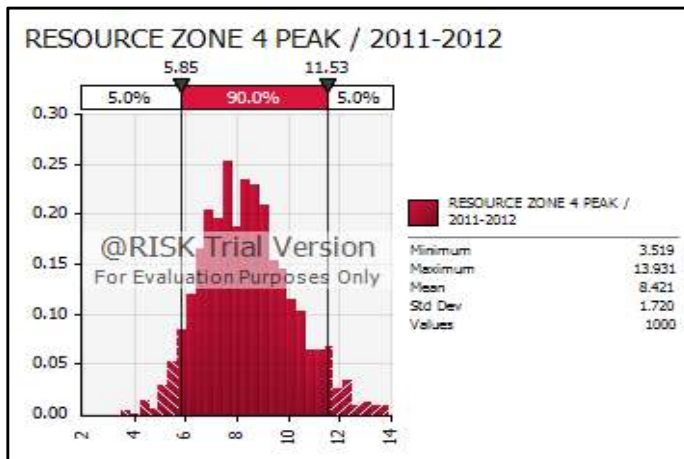
Change in Output Statistic for RESOURCE ZONE 4 AVG / 2011-2012

Rank	Name	Lower	Upper
1	System / @ Risk	5.644	8.679
2	System / @ Risk	6.361	7.161
3	System / @ Risk	6.579	7.218
4	System / @ Risk	6.564	7.185
5	System / @ Risk	6.650	7.218
6	System / @ Risk	6.529	7.086
7	System / @ Risk	6.613	7.103
8	System / @ Risk	6.639	7.103
9	System / @ Risk	6.626	7.066
10	Planned Outage / @ Risk	6.519	6.959

@RISK Output Report for RESOURCE ZONE 4 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:48

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 4 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 5.849
Maximum	10% 6.318
Mean	15% 6.643
Std Dev	20% 6.898
Variance	25% 7.156
Skewness	30% 7.387
Kurtosis	35% 7.614
Median	40% 7.810
Mode	45% 8.131
Left X	50% 8.311
Left P	55% 8.528
Right X	60% 8.738
Right P	65% 8.960
Diff X	70% 9.187
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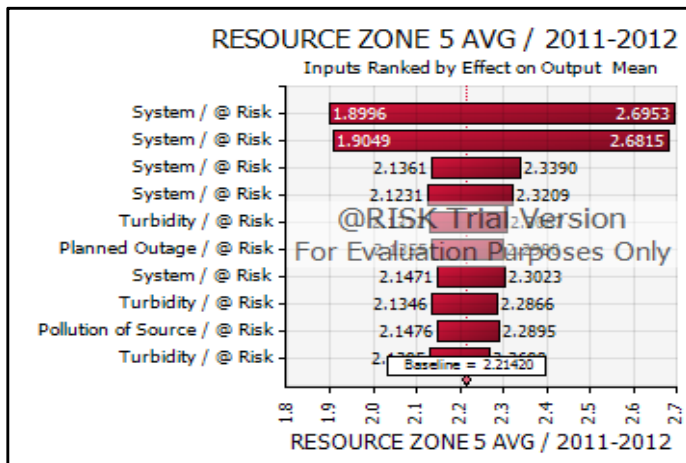
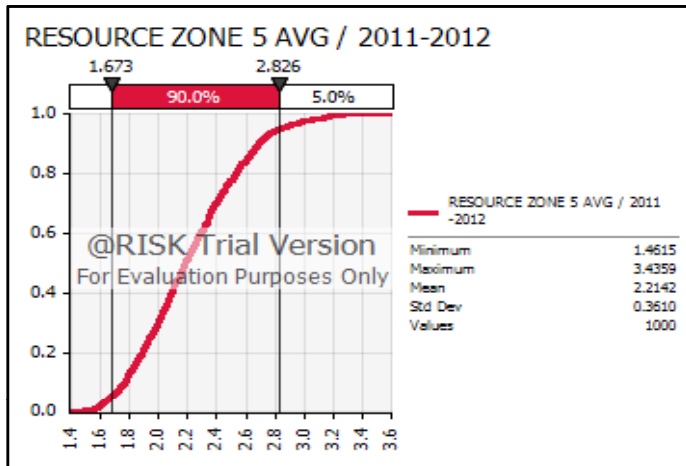
Change in Output Statistic for RESOURCE ZONE 4 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	Power / @ Risk	7.004	10.171
2	System / @ Risk	7.225	10.343
3	Pollution of Source / @ Risk	7.193	10.200
4	System / @ Risk	7.647	8.788
5	System / @ Risk	7.877	8.987
6	System / @ Risk	7.945	8.957
7	System / @ Risk	8.103	8.844
8	Pollution of Source / @ Risk	7.981	8.694
9	Turbidity / @ Risk	7.993	8.675
10	Turbidity / @ Risk	8.169	8.838

@RISK Output Report for RESOURCE ZONE 5 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:49

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 5 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 1.673
Maximum	10% 1.765
Mean	15% 1.823
Std Dev	20% 1.887
Variance	25% 1.938
Skewness	30% 1.995
Kurtosis	35% 2.047
Median	40% 2.085
Mode	45% 2.139
Left X	50% 2.182
Left P	55% 2.238
Right X	60% 2.291
Right P	65% 2.342
Diff X	70% 2.397
Diff P	75% 2.458
#Errors	80% 2.530
Filter Min	85% 2.612
Filter Max	90% 2.688
#Filtered	95% 2.826

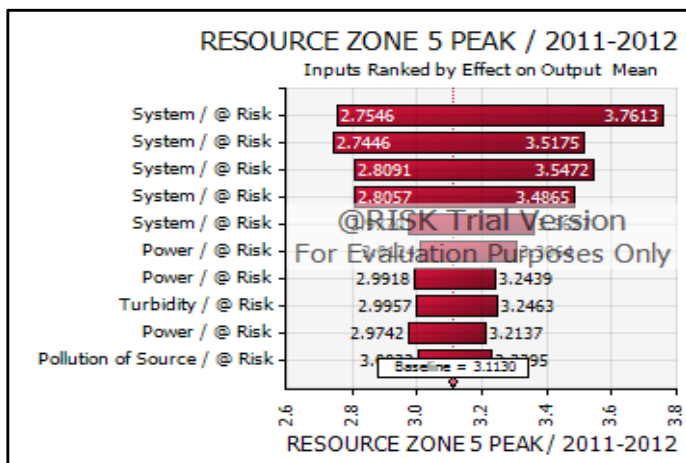
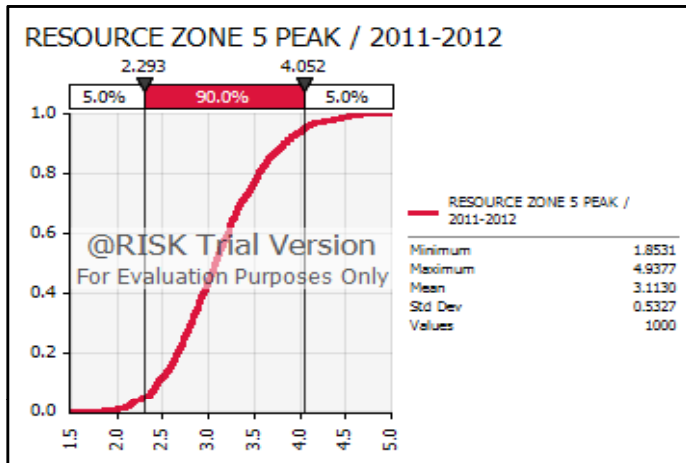
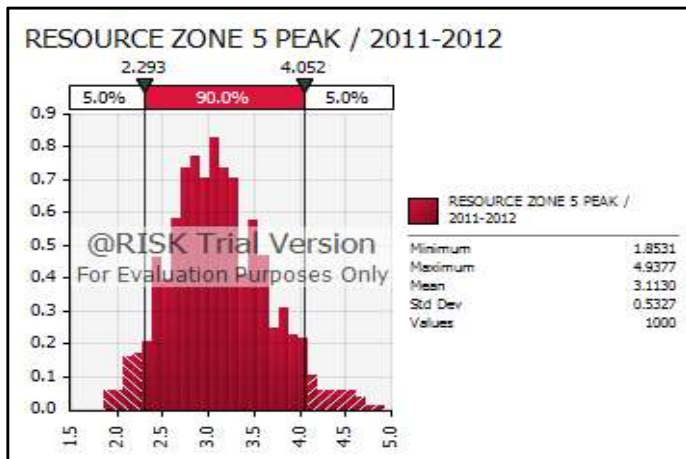
Change in Output Statistic for RESOURCE ZONE 5 AVG / 2011-20

Rank	Name	Lower	Upper
1	System / @ Risk	1.900	2.695
2	System / @ Risk	1.905	2.681
3	System / @ Risk	2.136	2.339
4	System / @ Risk	2.123	2.321
5	Turbidity / @ Risk	2.131	2.307
6	Planned Outage / @ Risk	2.136	2.298
7	System / @ Risk	2.147	2.302
8	Turbidity / @ Risk	2.135	2.287
9	Pollution of Source / @ Risk	2.148	2.290
10	Turbidity / @ Risk	2.129	2.270

@RISK Output Report for RESOURCE ZONE 5 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 09:39:49

**Simulation Summary Information**

Workbook Name	Model RZ1_to_5_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	490
Number of Outputs	10
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 09:08
Simulation Duration	00:00:04
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 5 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 2.293
Maximum	10% 2.447
Mean	15% 2.571
Std Dev	20% 2.658
Variance	25% 2.735
Skewness	30% 2.809
Kurtosis	35% 2.878
Median	40% 2.943
Mode	45% 3.010
Left X	50% 3.072
Left P	55% 3.134
Right X	60% 3.213
Right P	65% 3.273
Diff X	70% 3.349
Diff P	75% 3.463
#Errors	80% 3.550
Filter Min	85% 3.653
Filter Max	90% 3.823
#Filtered	95% 4.052

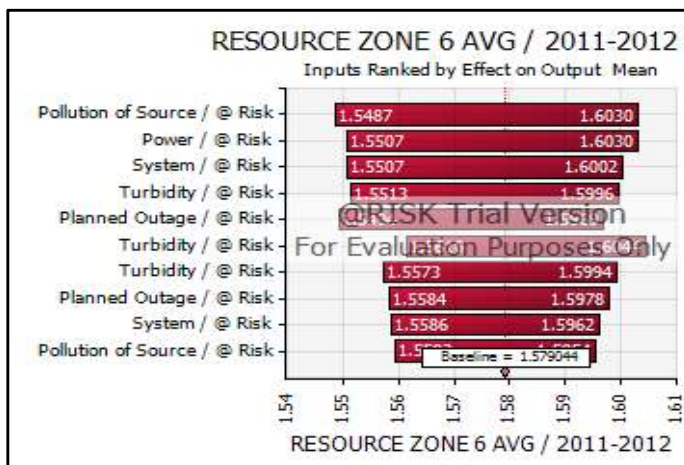
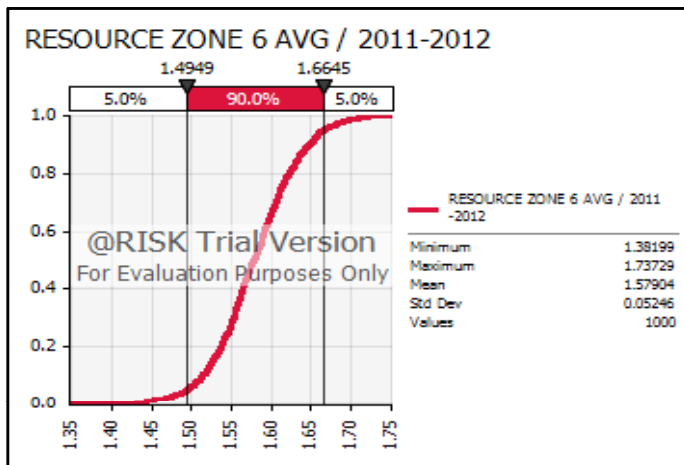
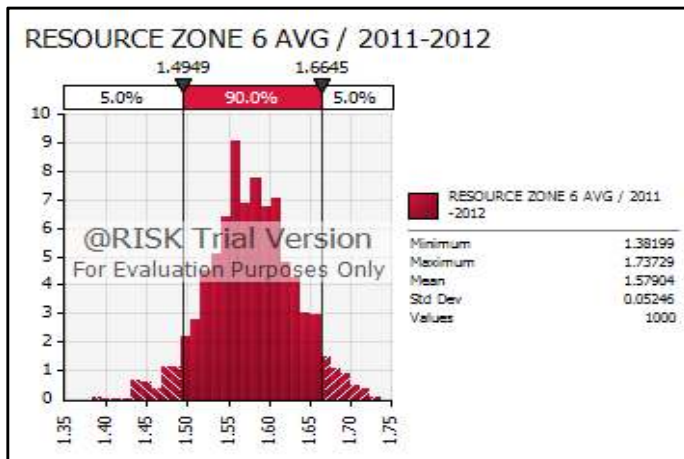
Change in Output Statistic for RESOURCE ZONE 5 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	System / @ Risk	2.755	3.761
2	System / @ Risk	2.745	3.518
3	System / @ Risk	2.809	3.547
4	System / @ Risk	2.806	3.487
5	System / @ Risk	2.977	3.363
6	Power / @ Risk	3.012	3.306
7	Power / @ Risk	2.992	3.244
8	Turbidity / @ Risk	2.996	3.246
9	Power / @ Risk	2.974	3.214
10	Pollution of Source / @ Risk	3.002	3.229

@RISK Output Report for RESOURCE ZONE 6 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 12:01:00

**Simulation Summary Information**

Workbook Name	Model RZ6_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 6 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 1.495
Maximum	10% 1.514
Mean	15% 1.526
Std Dev	20% 1.537
Variance	25% 1.546
Skewness	30% 1.553
Kurtosis	35% 1.558
Median	40% 1.564
Mode	45% 1.572
Left X	50% 1.578
Left P	55% 1.586
Right X	60% 1.591
Right P	65% 1.598
Diff X	70% 1.605
Diff P	75% 1.612
#Errors	80% 1.622
Filter Min	85% 1.633
Filter Max	90% 1.646
#Filtered	95% 1.664

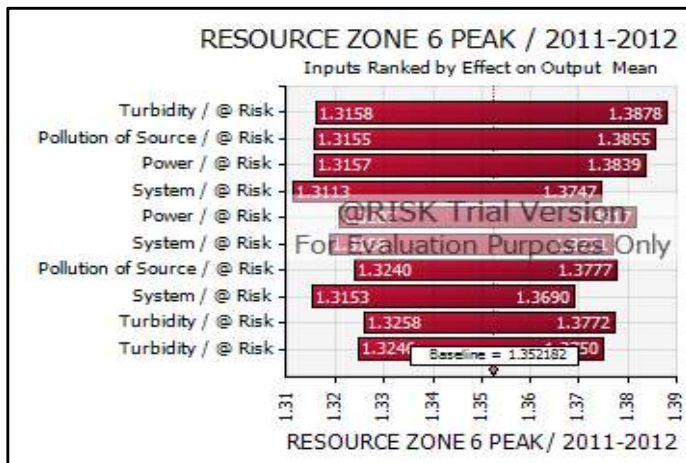
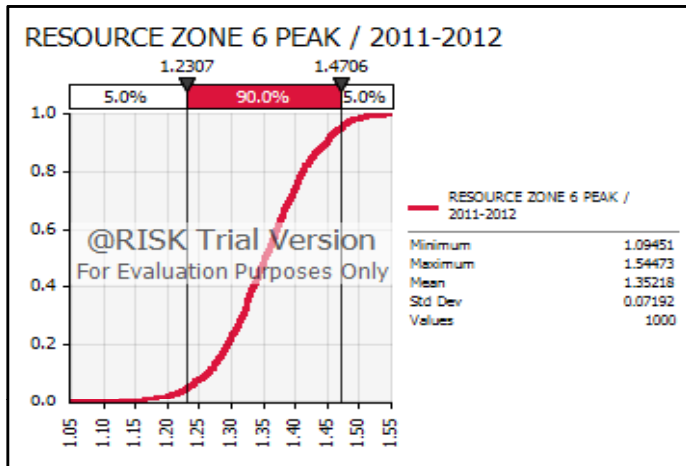
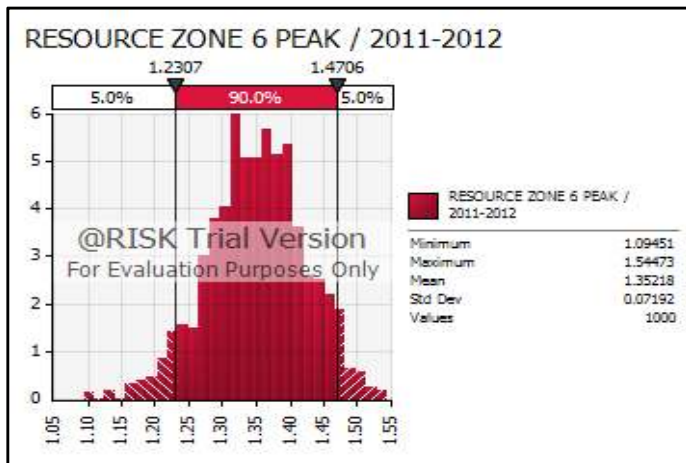
Change in Output Statistic for RESOURCE ZONE 6 AVG / 2011-2012

Rank	Name	Lower	Upper
1	Pollution of Source / @ Risk	1.549	1.603
2	Power / @ Risk	1.551	1.603
3	System / @ Risk	1.551	1.600
4	Turbidity / @ Risk	1.551	1.600
5	Planned Outage / @ Risk	1.549	1.597
6	Turbidity / @ Risk	1.562	1.604
7	Turbidity / @ Risk	1.557	1.599
8	Planned Outage / @ Risk	1.558	1.598
9	System / @ Risk	1.559	1.596
10	Pollution of Source / @ Risk	1.559	1.595

@RISK Output Report for RESOURCE ZONE 6 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 12:01:01

**Simulation Summary Information**

Workbook Name	Model R26_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 6 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 1.231
Maximum	10% 1.261
Mean	15% 1.280
Std Dev	20% 1.293
Variance	25% 1.307
Skewness	30% 1.318
Kurtosis	35% 1.325
Median	40% 1.334
Mode	45% 1.343
Left X	50% 1.353
Left P	55% 1.363
Right X	60% 1.371
Right P	65% 1.381
Diff X	70% 1.391
Diff P	75% 1.401
#Errors	80% 1.411
Filter Min	85% 1.427
Filter Max	90% 1.447
#Filtered	95% 1.471

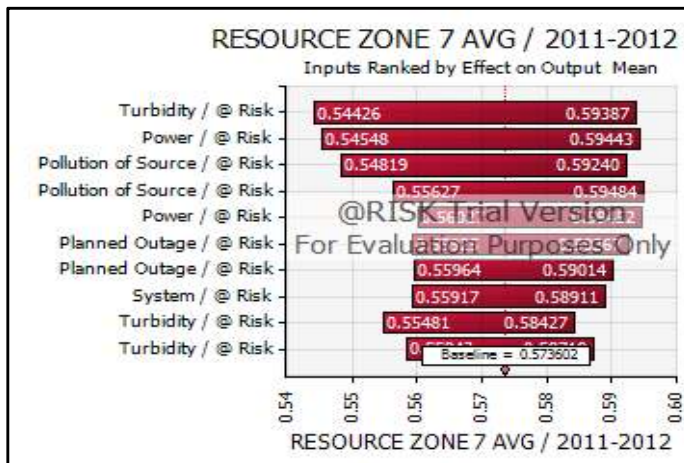
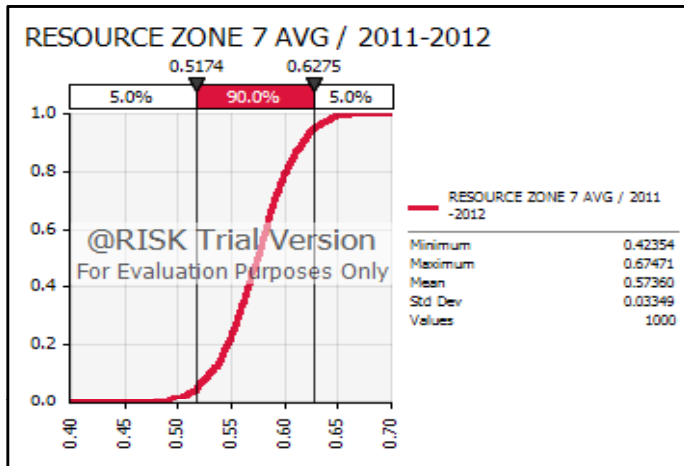
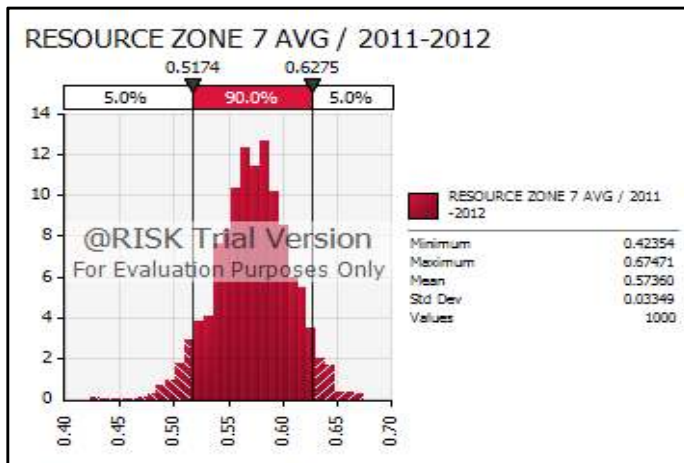
Change in Output Statistic for RESOURCE ZONE 6 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	Turbidity / @ Risk	1.316	1.388
2	Pollution of Source / @ Risk	1.315	1.386
3	Power / @ Risk	1.316	1.384
4	System / @ Risk	1.311	1.375
5	Power / @ Risk	1.321	1.382
6	System / @ Risk	1.319	1.377
7	Pollution of Source / @ Risk	1.324	1.378
8	System / @ Risk	1.315	1.369
9	Turbidity / @ Risk	1.326	1.377
10	Turbidity / @ Risk	1.325	1.375

@RISK Output Report for RESOURCE ZONE 7 AVG / 2011-2012

Performed By: Administrator

Date: 22 October 2013 12:01:01

**Simulation Summary Information**

Workbook Name	Model R26_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 7 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 0.517
Maximum	10% 0.530
Mean	15% 0.540
Std Dev	20% 0.546
Variance	25% 0.552
Skewness	30% 0.557
Kurtosis	35% 0.561
Median	40% 0.566
Mode	45% 0.569
Left X	50% 0.575
Left P	55% 0.579
Right X	60% 0.583
Right P	65% 0.586
Diff X	70% 0.590
Diff P	75% 0.596
#Errors	80% 0.601
Filter Min	85% 0.608
Filter Max	90% 0.617
#Filtered	95% 0.628

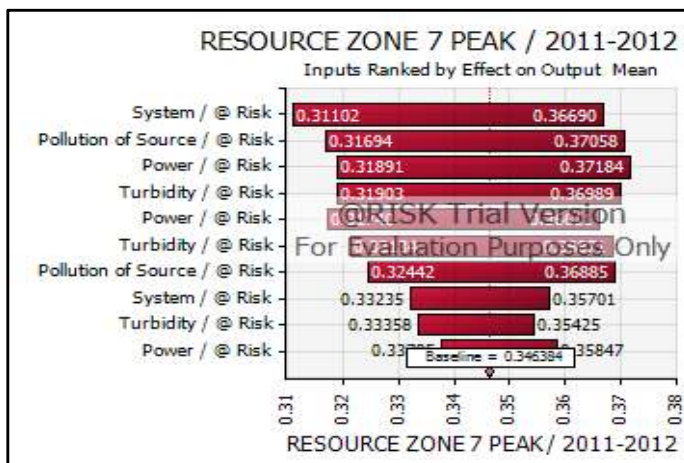
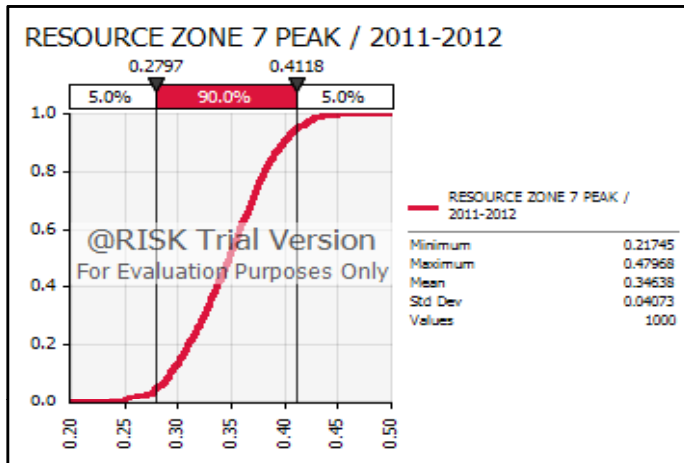
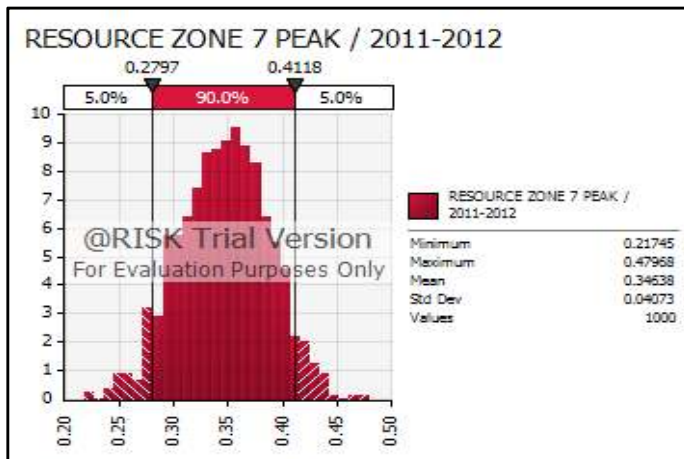
Change in Output Statistic for RESOURCE ZONE 7 AVG / 2011-2012

Rank	Name	Lower	Upper
1	Turbidity / @ Risk	0.544	0.594
2	Power / @ Risk	0.545	0.594
3	Pollution of Source / @ Risk	0.548	0.592
4	Pollution of Source / @ Risk	0.556	0.595
5	Power / @ Risk	0.560	0.595
6	Planned Outage / @ Risk	0.559	0.593
7	Planned Outage / @ Risk	0.560	0.590
8	System / @ Risk	0.559	0.589
9	Turbidity / @ Risk	0.555	0.584
10	Turbidity / @ Risk	0.558	0.587

@RISK Output Report for RESOURCE ZONE 7 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 12:01:01

**Simulation Summary Information**

Workbook Name	Model R26_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 7 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 0.280
Maximum	10% 0.293
Mean	15% 0.302
Std Dev	20% 0.309
Variance	25% 0.317
Skewness	30% 0.324
Kurtosis	35% 0.330
Median	40% 0.336
Mode	45% 0.342
Left X	50% 0.348
Left P	55% 0.353
Right X	60% 0.357
Right P	65% 0.364
Diff X	70% 0.370
Diff P	75% 0.375
#Errors	80% 0.381
Filter Min	85% 0.389
Filter Max	90% 0.399
#Filtered	95% 0.412

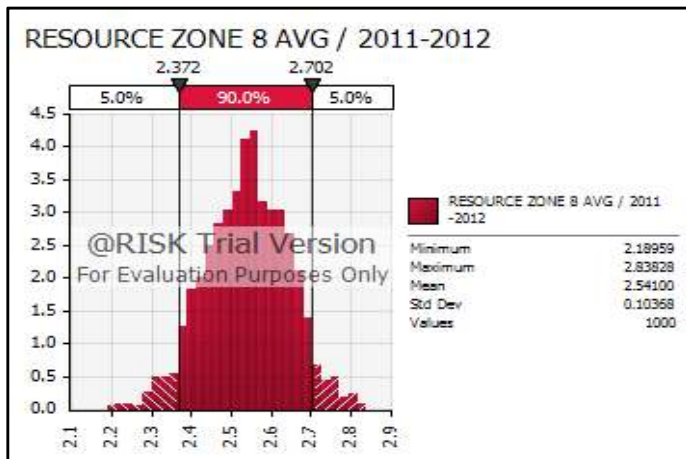
Change in Output Statistic for RESOURCE ZONE 7 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	System / @ Risk	0.311	0.367
2	Pollution of Source / @ Risk	0.317	0.371
3	Power / @ Risk	0.319	0.372
4	Turbidity / @ Risk	0.319	0.370
5	Power / @ Risk	0.317	0.366
6	Turbidity / @ Risk	0.321	0.369
7	Pollution of Source / @ Risk	0.324	0.369
8	System / @ Risk	0.332	0.357
9	Turbidity / @ Risk	0.334	0.354
10	Power / @ Risk	0.338	0.358

@RISK Output Report for RESOURCE ZONE 8 AVG / 2011-2012

Performed By: Administrator

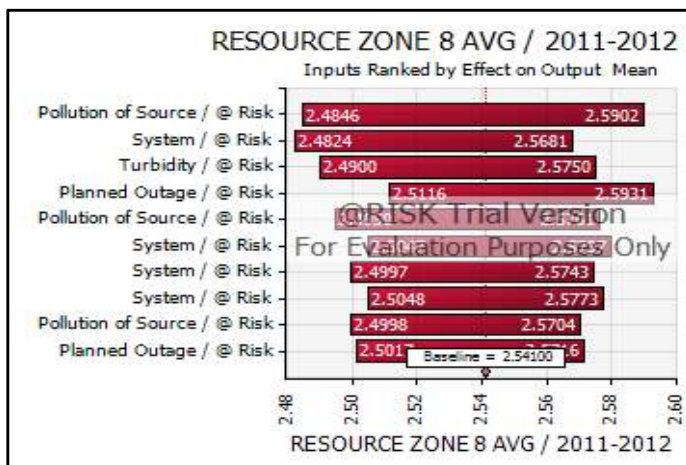
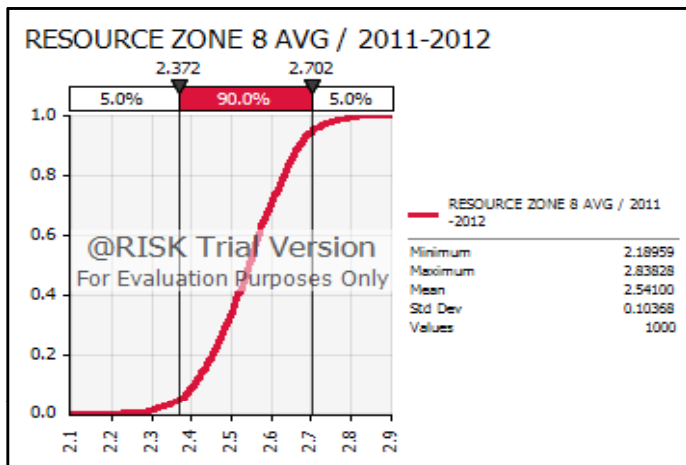
Date: 22 October 2013 12:01:02

**Simulation Summary Information**

Workbook Name	Model R26_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN31
Random Seed	1

Summary Statistics for RESOURCE ZONE 8 AVG / 2011-2012

Statistics	Percentile
Minimum	5% 2.372
Maximum	10% 2.406
Mean	15% 2.432
Std Dev	20% 2.452
Variance	25% 2.469
Skewness	30% 2.486
Kurtosis	35% 2.504
Median	40% 2.515
Mode	45% 2.533
Left X	50% 2.545
Left P	55% 2.556
Right X	60% 2.567
Right P	65% 2.580
Diff X	70% 2.597
Diff P	75% 2.616
#Errors	80% 2.631
Filter Min	85% 2.648
Filter Max	90% 2.670
#Filtered	95% 2.702

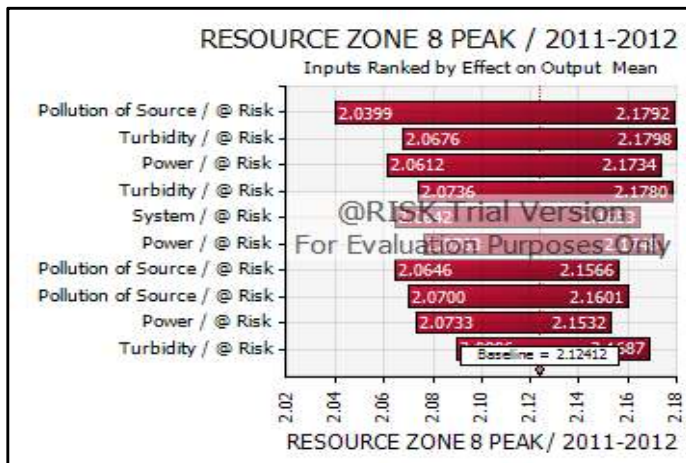
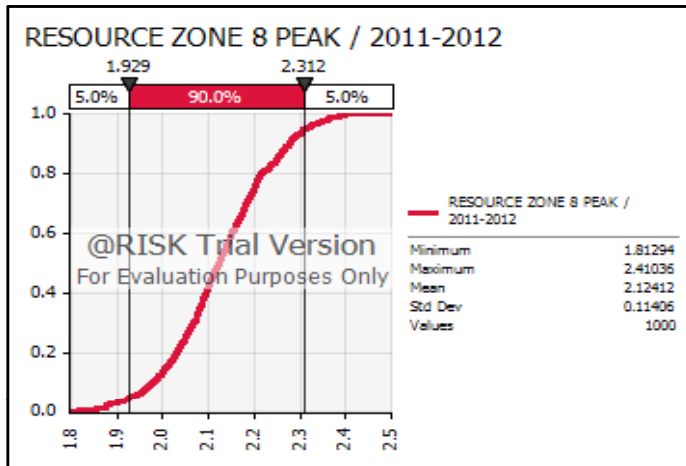
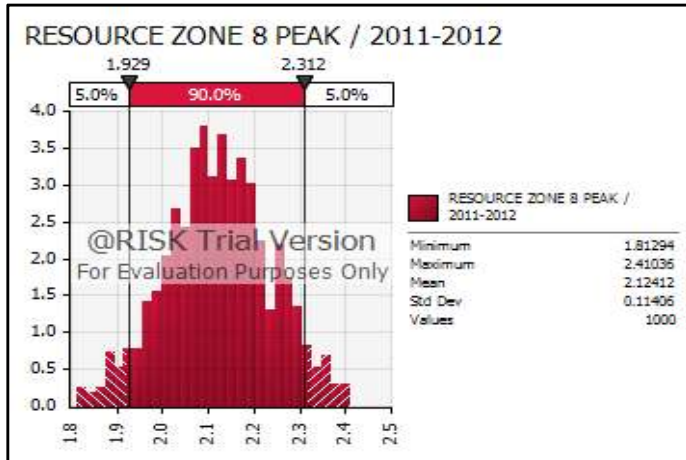
**Change in Output Statistic for RESOURCE ZONE 8 AVG / 2011-2012**

Rank	Name	Lower	Upper
1	Pollution of Source / @ Risk	2.485	2.590
2	System / @ Risk	2.482	2.568
3	Turbidity / @ Risk	2.490	2.575
4	Planned Outage / @ Risk	2.512	2.593
5	Pollution of Source / @ Risk	2.495	2.576
6	System / @ Risk	2.505	2.580
7	System / @ Risk	2.500	2.574
8	System / @ Risk	2.505	2.577
9	Pollution of Source / @ Risk	2.500	2.570
10	Planned Outage / @ Risk	2.502	2.572

@RISK Output Report for RESOURCE ZONE 8 PEAK / 2011-2012

Performed By: Administrator

Date: 22 October 2013 12:01:02

**Simulation Summary Information**

Workbook Name	Model R26_to_8_2011-20
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	275
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	22-10-2013 11:30
Simulation Duration	00:00:03
Random # Generator	RAN3I
Random Seed	1

Summary Statistics for RESOURCE ZONE 8 PEAK / 2011-2012

Statistics	Percentile
Minimum	5% 1.929
Maximum	10% 1.976
Mean	15% 2.005
Std Dev	20% 2.030
Variance	25% 2.049
Skewness	30% 2.066
Kurtosis	35% 2.080
Median	40% 2.094
Mode	45% 2.106
Left X	50% 2.123
Left P	55% 2.137
Right X	60% 2.151
Right P	65% 2.169
Diff X	70% 2.182
Diff P	75% 2.200
#Errors	80% 2.215
Filter Min	85% 2.250
Filter Max	90% 2.277
#Filtered	95% 2.312

Change in Output Statistic for RESOURCE ZONE 8 PEAK / 2011-2012

Rank	Name	Lower	Upper
1	Pollution of Source / @ Risk	2.040	2.179
2	Turbidity / @ Risk	2.068	2.180
3	Power / @ Risk	2.061	2.173
4	Turbidity / @ Risk	2.074	2.178
5	System / @ Risk	2.064	2.165
6	Power / @ Risk	2.076	2.175
7	Pollution of Source / @ Risk	2.065	2.157
8	Pollution of Source / @ Risk	2.070	2.160
9	Power / @ Risk	2.073	2.153
10	Turbidity / @ Risk	2.090	2.169

Comparison of ADO Outages from PR-1999, PR-04, PR-09 & PR-14

WRZ	PR-1999	PR-04	PR-09	PR-14
WRZ 1		2.50	1.31	2.24
WRZ 2		2.30	2.49	4.91
WRZ 3		5.00	2.05	5.73
WRZ 4	10.00	16.83	6.64	7.28
WRZ 5	8.00	0.70	1.71	2.65
WRZ 6		0.70	2.12	1.58
WRZ 7		0.70	0.39	0.57
WRZ 8		0.70	2.29	2.54
Total		29.43	19.00	27.50

Comparison of PDO Outages from PR-1999, PR-04, PR-09 & PR-14

WRZ	PR-1999	PR-04	PR-09	PR-14
WRZ 1		2.50	1.40	1.01
WRZ 2		2.30	3.00	6.21
WRZ 3		5.00	2.20	9.28
WRZ 4	10.00	16.83	6.57	10.02
WRZ 5	8.00	0.75	1.84	6.34
WRZ 6		0.75	2.48	1.35
WRZ 7		0.75	0.53	0.35
WRZ 8		0.75	2.43	2.13
Total		29.63	20.45	36.69

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ1	CRAMPTONS ROAD	Planned Outage	0.14	
		Pollution of Source	0.06	0.02
		Power	0.08	0.02
		System	0.29	0.07
		Turbidity	0.29	0.02
	KEMSING	Planned Outage	0.03	
		Pollution of Source	0.02	0.02
		Power	0.01	0.02
		System	0.03	0.03
		Turbidity	0.02	0.02
	OAK LANE	Planned Outage	0.00	
		Pollution of Source	0.00	0.02
		Power	0.01	0.02
		System	0.00	0.01
		Turbidity	0.01	0.02
	PEMBURY	Planned Outage	0.03	
		Pollution of Source	0.01	0.03
		Power	0.06	0.03
		System	0.05	0.09
		Turbidity	0.00	0.03
	SAINTS HILL	Planned Outage	0.04	
		Pollution of Source	0.03	0.02
		Power	0.09	0.02
		System	0.17	0.15
		Turbidity	0.09	0.02
	TONBRIDGE	Planned Outage	0.04	
		Pollution of Source	0.02	0.03
		Power	0.03	0.03
		System	0.12	0.12
		Turbidity	0.02	0.02

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ2	BARCOMBE	Planned Outage	0.31	
		Pollution of Source	0.52	1.33
		Power	0.86	1.33
		System	0.86	1.33
	CLAYTON	Turbidity	0.07	0.11
		Planned Outage	0.00	
		Pollution of Source	0.00	0.00
		Power	0.01	0.00
	COCKHAISE	System	0.01	0.02
		Turbidity	0.01	0.00
		Planned Outage	0.01	
		Pollution of Source	0.01	0.02
	COGGINS MILL	Power	0.01	0.02
		System	0.06	0.20
		Turbidity	0.00	0.01
		Planned Outage	0.02	
	COOMBE	Pollution of Source	0.01	0.01
		Power	0.01	0.01
		System	0.09	0.09
		Turbidity	0.01	0.01
	COW WISH	Planned Outage	0.00	
		Pollution of Source	0.00	0.00
		Power	0.00	0.00
		System	0.01	0.01
	FOREST ROW	Turbidity	0.00	0.00
		Planned Outage	0.05	
		Pollution of Source	0.03	0.02
		Power	0.03	0.02
	GROOMBRIDGE	System	0.13	0.13
		Turbidity	0.01	0.01
		Planned Outage	0.01	
		Pollution of Source	0.00	0.01
	HEMPSTEAD SITE	Power	0.00	0.01
		System	0.07	0.16
		Turbidity	0.02	0.01
		Planned Outage	0.04	
	OFFHAM	Pollution of Source	0.02	0.02
		Power	0.17	0.02
		System	0.17	0.19
		Turbidity	0.02	0.02
	POVERTY BOTTOM	Planned Outage	0.09	0.02
		Pollution of Source	0.00	
		Power	0.00	0.00
		System	0.01	0.01
	RATHFINNY	Turbidity	0.00	0.00
		Planned Outage	0.04	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
	SADLESCOMBE	System	0.09	0.11
		Turbidity	0.08	0.02
		Planned Outage	0.04	
		Pollution of Source	0.03	0.03
	SHELLBROOK	Power	0.03	0.03
		System	0.05	0.06
		Turbidity	0.01	0.01
		Planned Outage	0.00	
	WIER WOOD	Pollution of Source	0.00	0.00
		Power	0.00	0.00
		System	0.00	0.00
		Turbidity	0.00	0.00
		Planned Outage	0.04	
		Pollution of Source	0.06	0.00
		Power	0.00	0.00
		System	0.19	0.19
		Turbidity	0.01	0.01
		Planned Outage	0.04	
		Pollution of Source	0.03	0.03
		Power	0.05	0.03
		System	0.22	0.22
		Turbidity	0.05	0.22

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ3	ARLINGTON	Planned Outage	0.11	
		Pollution of Source	0.19	1.19
		Power	0.96	1.19
		System	0.96	1.19
	BIRLING FARM	Turbidity	0.19	1.19
		Planned Outage	0.02	
		Pollution of Source	0.01	0.06
		Power	0.01	0.06
	CORNISH	System	0.03	0.15
		Turbidity	0.00	0.02
		Planned Outage	0.03	
		Pollution of Source	0.01	0.02
	CROWHURST BRIDGE	Power	0.00	0.00
		System	0.02	0.02
		Turbidity	0.03	0.02
		Planned Outage	0.09	
	DEEP DEAN / FRISTON	Pollution of Source	0.04	0.04
		Power	0.04	0.04
		System	0.01	0.01
		Turbidity	0.04	0.04
	HAZARDS GREEN	Planned Outage	0.13	
		Pollution of Source	0.07	0.10
		Power	0.07	0.10
		System	0.29	0.37
	HOLYWELL	Turbidity	0.06	0.08
		Planned Outage	0.06	
		Pollution of Source	0.03	0.06
		Power	0.03	0.06
	POWDER MILL	System	0.32	0.64
		Turbidity	0.03	0.06
		Planned Outage	0.01	
		Pollution of Source	0.00	0.01
	SWEET WILLOW WOOD	Power	0.00	0.01
		System	0.00	0.00
		Turbidity	0.00	0.01
		Planned Outage	0.02	
	WALLERS HAVEN	Pollution of Source	0.01	0.02
		Power	0.01	0.02
		System	0.07	0.10
		Turbidity	0.01	0.02
	WATERWORKS ROAD	Planned Outage	0.02	
		Pollution of Source	0.02	0.01
		Power	0.02	0.01
		System	0.14	0.16
	WATERWORKS ROAD	Turbidity	0.01	0.01
		Planned Outage	0.06	
		Pollution of Source	0.06	
		Power	0.03	0.05
	WATERWORKS ROAD	System	0.07	0.05
		Turbidity	0.25	0.41
		Planned Outage	0.03	0.05

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ4	BEENHAMS	Planned Outage	0.03	
		Pollution of Source	0.02	0.04
		Power	0.02	0.04
		System	0.06	0.15
	BOXALLS LANE	Turbidity	0.00	0.01
		Planned Outage	0.10	
		Pollution of Source	0.06	0.06
		Power	0.06	0.06
	BRAY	System	0.03	0.03
		Turbidity	0.06	0.06
		Planned Outage	0.29	
		Pollution of Source	0.29	1.43
	BRAY GRAVELS	Power	0.29	1.43
		System	1.43	1.43
		Turbidity	0.05	0.03
		Planned Outage	0.15	
	COLLAGE AVENUE	Pollution of Source	0.07	0.07
		Power	0.07	0.07
		System	0.27	0.27
		Turbidity	0.01	0.01
	COOKHAM	Planned Outage	0.15	
		Pollution of Source	0.07	0.07
		Power	0.07	0.07
		System	0.04	0.04
	GREYWELL	Turbidity	0.07	0.07
		Planned Outage	0.06	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
	HURLEY	System	0.27	0.27
		Turbidity	0.01	0.01
		Planned Outage	0.21	
		Pollution of Source	0.09	0.11
	ITCHEL	Power	0.09	0.11
		System	0.41	0.46
		Turbidity	0.09	0.11
		Planned Outage	0.03	
	LASHAM	Pollution of Source	0.02	0.06
		Power	0.03	0.06
		System	0.11	0.41
		Turbidity	0.01	0.05
	WEST HAM	Planned Outage	0.12	
		Pollution of Source	0.05	0.06
		Power	0.05	0.06
		System	0.22	0.23
	WOODGARSTON	Turbidity	0.01	0.01
		Planned Outage	0.06	
		Pollution of Source	0.03	0.03
		Power	0.03	0.03
		System	0.01	0.01
		Turbidity	0.03	0.03
		Planned Outage	0.05	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
		System	0.24	0.26
		Turbidity	0.00	0.00

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ5	RUSHMOOR	Planned Outage	0.04	
		Planned Outage	0.02	
	BOURNE	Pollution of Source	0.01	0.02
		Power	0.01	0.02
		System	0.04	0.05
		Turbidity	0.00	0.00
	BRITTY HILL	Planned Outage	0.03	
		Pollution of Source	0.01	0.02
		Power	0.01	0.02
		System	0.01	0.01
		Turbidity	0.01	0.02
	EAST MEON	Planned Outage	0.01	
		Pollution of Source	0.00	0.00
		Power	0.00	0.00
		System	0.03	0.05
		Turbidity	0.00	0.00
	GREATHAM	Planned Outage	0.04	
		Pollution of Source	0.02	0.03
		Power	0.02	0.03
		System	0.08	0.11
		Turbidity	0.02	0.03
	HAWKLEY	Planned Outage	0.01	
		Pollution of Source	0.01	0.06
		Power	0.01	0.06
		System	0.04	0.41
		Turbidity	0.01	0.05
	HEADLEY PARK	Planned Outage	0.07	
		Pollution of Source	0.04	0.04
		Power	0.04	0.04
		System	0.13	0.14
		Turbidity	0.01	0.01
	HINDHEAD LONDON ROAD	Planned Outage	0.00	
		Pollution of Source	0.00	0.00
		Power	0.00	0.00
		System	0.00	0.00
		Turbidity	0.00	0.00
	OAKHANGER	Planned Outage	0.08	
		Pollution of Source	0.04	0.06
		Power	0.04	0.06
		System	0.38	0.51
		Turbidity	0.01	0.01
	SHEET	Planned Outage	0.04	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
		System	0.01	0.01
		Turbidity	0.02	0.02
	TILFORD MEADS	Planned Outage	0.07	
		Pollution of Source	0.04	0.04
		Power	0.04	0.04
		System	0.36	0.36
		Turbidity	0.01	0.01
	TILFORD WELEESLEY ROAD	Planned Outage	0.03	
		Pollution of Source	0.01	0.02
		Power	0.01	0.02
		System	0.05	0.08
		Turbidity	0.01	0.02
	WINDMILL HILL	Planned Outage	0.02	
		Pollution of Source	0.01	0.06
		Power	0.01	0.06
		System	0.07	0.41
		Turbidity	0.01	0.05

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ6	BOROUGH GREEN	Planned Outage	0.01	
		Pollution of Source	0.00	0.00
		Power	0.00	0.00
		System	0.04	0.04
	BOXLEY	Turbidity	0.00	0.00
		Planned Outage	0.02	
		Pollution of Source	0.02	0.01
		Power	0.02	0.01
	BURHAM SWA SITE	System	0.02	0.01
		Turbidity	0.02	0.01
		Planned Outage	0.07	
		Pollution of Source	0.07	0.03
	COSSINGTON	Power	0.07	0.03
		System	0.07	0.03
		Turbidity	0.07	0.03
		Planned Outage	0.01	
	FORSTAL	Pollution of Source	0.00	0.04
		Power	0.00	0.04
		System	0.00	0.04
		Turbidity	0.00	0.04
	HALLING CHALK	Planned Outage	0.07	
		Pollution of Source	0.03	0.04
		Power	0.03	0.04
		System	0.02	0.02
	HALLING GREENSAND	Turbidity	0.03	0.04
		Planned Outage	0.02	
		Pollution of Source	0.01	0.01
		Power	0.01	0.01
	HARTLEY	System	0.01	0.01
		Turbidity	0.01	0.01
		Planned Outage	0.02	
		Pollution of Source	0.01	0.01
	HOCKERS LANE	Power	0.01	0.01
		System	0.02	0.02
		Turbidity	0.00	0.00
		Planned Outage	0.09	
	MATTS HILL (SWS)	Pollution of Source	0.04	0.04
		Power	0.04	0.04
		System	0.05	0.05
		Turbidity	0.04	0.04
	PADDLEWORTH AND RYASH	Planned Outage	0.05	
		Pollution of Source	0.05	0.04
		Power	0.05	0.04
		System	0.05	0.04
	RIDLEY	Turbidity	0.05	0.04
		Planned Outage	0.02	
		Pollution of Source	0.01	0.02
		Power	0.01	0.02
	TROSLEY	System	0.01	0.02
		Turbidity	0.01	0.02
		Planned Outage	0.01	
		Pollution of Source	0.01	0.04
		Power	0.01	0.04
		System	0.01	0.09
		Turbidity	0.01	0.04
		Planned Outage	0.05	
		Pollution of Source	0.02	0.04
		Power	0.00	0.00
		System	0.01	0.01
		Turbidity	0.02	0.04

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ7	BEWL BRIDGE BH	Planned Outage	0.03	
		Pollution of Source	0.01	0.02
		Power	0.01	0.02
		System	0.01	0.02
		Turbidity	0.01	0.02
	BEWL BRIDGE SW	Planned Outage	0.07	
		Pollution of Source	0.07	0.04
		Power	0.07	0.04
		System	0.07	0.04
		Turbidity	0.07	0.04
	GOUDHURST	Planned Outage	0.06	
		Pollution of Source	0.03	0.04
		Power	0.03	0.04
		System	0.01	0.01
		Turbidity	0.03	0.04

Planned and Unplanned Outages for All Sources in Each Water Zone				
WIS Zone	Sourceworks Name	Category of Outage	Average Outage	Peak Outage
RZ8	BOUGHTON	Planned Outage	0.03	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
		System	0.00	0.00
	CHARING	Turbidity	0.02	0.02
		Planned Outage	0.03	
		Pollution of Source	0.02	0.02
		Power	0.02	0.02
	CHILHAM	System	0.00	0.00
		Turbidity	0.02	0.02
		Planned Outage	0.11	
		Pollution of Source	0.06	0.01
	FORD	Power	0.06	0.01
		System	0.06	0.01
		Turbidity	0.06	0.01
		Planned Outage	0.02	
	GODMERSHAM	Pollution of Source	0.01	0.01
		Power	0.01	0.01
		System	0.00	0.00
		Turbidity	0.01	0.01
	HOPLANDS FARM	Planned Outage	0.11	
		Pollution of Source	0.06	0.06
		Power	0.06	0.06
		System	0.06	0.06
	HOWFIELD	Turbidity	0.06	0.06
		Planned Outage	0.04	
		Pollution of Source	0.02	0.04
		Power	0.02	0.04
	KINGSTON	System	0.02	0.04
		Turbidity	0.02	0.04
		Planned Outage	0.11	
		Pollution of Source	0.06	0.06
	NEWNHAM	Power	0.06	0.06
		System	0.06	0.06
		Turbidity	0.06	0.06
		Planned Outage	0.08	
	OSPRINGE	Pollution of Source	0.05	0.05
		Power		0.05
		System	0.05	0.00
		Turbidity		0.05
	STOCKBURY	Planned Outage	0.05	
		Pollution of Source	0.03	0.05
		Power	0.03	0.05
		System	0.03	0.05
	THANINGTON	Turbidity	0.03	0.05
		Planned Outage	0.06	
		Pollution of Source	0.03	0.04
		Power	0.03	0.04
	WESTWELL / HENWOOD	System	0.03	0.04
		Turbidity	0.03	0.04
		Planned Outage	0.02	
		Pollution of Source	0.01	0.01
	WICHLING	Power	0.01	0.01
		System	0.01	0.01
		Turbidity	0.01	0.01
		Planned Outage	0.15	
	WINEYCOCK SHAW	Pollution of Source	0.08	0.10
		Power		0.10
		System	0.02	0.02
		Turbidity		0.10
	WINEYCOCK SHAW	Planned Outage	0.02	
		Pollution of Source	0.01	0.04
		Power	0.01	0.04
		System	0.01	0.04
	WINEYCOCK SHAW	Turbidity	0.01	0.04
		Planned Outage	0.04	
		Pollution of Source	0.03	0.05
		Power	0.03	0.05
	WINEYCOCK SHAW	System	0.03	0.05
		Turbidity	0.02	0.04
		Planned Outage	0.03	
		Pollution of Source	0.02	0.03
	WINEYCOCK SHAW	Power	0.02	0.03
		System	0.02	0.03
		Turbidity	0.01	0.02
		Planned Outage	0.03	

**Summary of Planned and Unplanned Outages for
Resource Zones 1 - 8**

Resource Zone 1

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.30	0.00
Pollution of Source	0.14	0.12
Power	0.27	0.13
System	0.66	0.48
Turbidity	0.43	0.12

Resource Zone 2

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.70	0.02
Pollution of Source	0.72	1.50
Power	1.19	1.50
System	1.95	2.70
Turbidity	0.30	0.45

Resource Zone 3

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.61	0.00
Pollution of Source	0.42	1.55
Power	1.22	1.54
System	2.09	3.06
Turbidity	0.41	1.50

Resource Zone 4

Category of Outage	Average Outage	Peak Outage
Planned Outage	1.41	0.00
Pollution of Source	0.82	2.05
Power	0.83	2.05
System	3.37	3.84
Turbidity	0.43	0.46

**Summary of Planned and Unplanned Outages for
Resource Zones 1 - 8**

Resource Zone 5

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.46	0.00
Pollution of Source	0.23	0.37
Power	0.23	0.37
System	1.21	2.14
Turbidity	0.11	0.22

Resource Zone 6

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.45	0.00
Pollution of Source	0.28	0.33
Power	0.26	0.30
System	0.31	0.39
Turbidity	0.28	0.33

Resource Zone 7

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.15	0.00
Pollution of Source	0.11	0.09
Power	0.11	0.09
System	0.08	0.06
Turbidity	0.11	0.09

Resource Zone 8

Category of Outage	Average Outage	Peak Outage
Planned Outage	0.79	0.00
Pollution of Source	0.44	0.51
Power	0.31	0.51
System	0.34	0.35
Turbidity	0.30	0.50

List of Unconstrained Options - including Options to reduce Outages					
S.No.	GIS ID	WRMP_Type	WRZ	Option_Reference_ID	Option_Name
1	GW-50	NGW	RZ4	SEW-NGW-RZ4-2142	RZ4 Confined Chalk - closing the gap
2	GW-55	NGW	RZ4	SEW-NGW-RZ4-2147	Boxalls Lane Chalk - Peak
3	GW-56	NGW	RZ5	SEW-NGW-RZ5-2148	Headley Park Closing Gap on Peak
4	GW-39	EGW	RZ5	SEW-EGW-RZ5-2131	Hawkley Closing the Gap
5	GW-60	NGW	RZ3	SEW-NGW-RZ3-2152	Re-licence Sedlescombe
6	GW-66	NGW	RZ3	SEW-NGW-RZ3-2158	Hastings groundwater - licences: Kent Street
7	GW-67	EGW	RZ2	SEW-EGW-RZ2-2159	Enhance sources at Balcombe
8	GW-68	EGW	RZ2	SEW-EGW-RZ2-2160	Stream augmentation at Balcombe
9	GW-110	EGW	RZ3	SEW-EGW-RZ3-2196	Hastings groundwater - licences: Cadborough
10	GW-117	EGW	RZ2	SEW-EGW-RZ2-2202	Increase actual to DO at Saddlescombe
11	GW-119	EGW	RZ4	SEW-EGW-RZ4-2210	White Waltham - third borehole
12	GW-123	NGW	RZ4	SEW-NGW-RZ4-2214	Oakley - new licence within Chalk
13	GW-124	NGW	RZ4	SEW-NGW-RZ4-2215	North Waltham - new licence within Chalk
14	GW-140	NGW	RZ1	SEW-NGW-RZ1-2229	Hartlake Wells; Resize and optimisation of pumps to close licence
15	GW-143	NGW	RZ4	SEW-NGW-RZ4-2232	Tongham bridging the licence gap
16	GW-144	NGW	RZ1	SEW-NGW-RZ1-2233	Tonbridge - New Wharf Rd PS – bridging the licence gap
17	GW-146	NGW	RZ3	SEW-NGW-RZ3-2235	Birling Farm treatment capacity to bridge the licence gap
18	GW-159	NGW	RZ7	SEW-NGW-RZ7-2246	Bowl Borehole 1 and 2 – upside raw water main – bridging the licence gap
19	GW-181	EGW	RZ8	SEW-EGW-RZ8-2263	Wichling, Newnham & WCS – bridging the licence gap
20	GW-189	NGW	RZ2	SEW-NGW-RZ2-2271	Pyecombe – wastewater discharge to ground – dilution – downstream groundwater abstraction

South East Water: Climate change studies to support the draft Water Resources Management Plan

Task 2: Impacts of climate change on Deployable Output - Summary Report

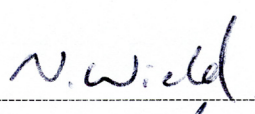
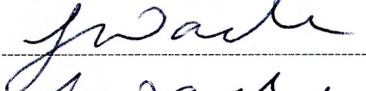
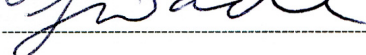


Document information

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Summary

South East Water: Climate change studies to support the draft Water Resources Management Plan

Task 2: Impacts of climate change on Deployable Outputs – Summary Report

Report EX 6845
August 2012

This report provides a summary of the impacts of climate on Deployable Outputs for South East Water's surface water and groundwater sources.

The approach adopted for this work made use of the previous analysis of the impacts on climate change for South East Water (HRW, 2007) and follows the Environment Agency's Draft Water Resources Planning Guidelines (EA, 2012).

The study made use of HYSIM rainfall-runoff models, water resources models and a number of new recharge and 'aquifer response function' models to link changes in climate to changes in recharge, groundwater levels, river flows and Deployable Outputs.

The detailed hydrological and groundwater modelling projects significant changes in seasonal rivers flows and small reductions in groundwater levels. For example:

- Large reduction on the Ouse of 5.13 MI/d projected for Barcombe WTW, for the mid scenario, and 14.17 MI/d for the minimum scenario. Additionally for the minimum scenario reductions of 1.93 MI/d and 1.11 MI/d at Poverty Bottom and Cockhaise Well groundwater sources contribute to the zones significant overall loss.
- Wallers Haven shows small reduction for the mid scenario of 0.89 MI/d but reductions of 2.95 MI/d for the minimum scenario.
- Within WRZ4 several groundwater sites show marked reductions for the minimum scenario, with Cookham showing the largest reduction of 1.91 MI/d.

In accordance with Environment Agency guidance the UK Climate Change Projections (UKCP09) were applied to these models to derive climate change losses for use of the supply line of the supply-demand balance and uncertainties related to climate change for inclusion in the Headroom assessment.

A high level overview of the results indicates that for South East Water:

- The total impact on DO across the company for the central or 'mid' scenario is projected to be minus 12.63 MI/d for DYAA scenario, which is marginally lower than in the previous plan; **this will be accounted for on the supply line in the supply-demand forecast.**
 - WRZ2 is projected to experience the greatest reductions in Average Deployable Output (DO) of -6.09 MI/d for the 'mid' scenario. The majority of the impact within WRZ2 is on the surface water with a large reduction shown at Barcombe Mills.
 - Lower impacts are projected for zones 1,4,5 and 7; in most cases groundwater is projected to be fairly robust to future changes in average monthly climate.
 - It should be noted that the projections do not consider the risks of an increase in the frequency of two or three dry winters and further work may be required to 'stress test' DO for three dry winters with climate change.
- The range of possible impacts is large, although less than in PR09, and **this will be accounted for in the company's assessment of headroom.**
 - Under the worst case and Peak Deployable Output scenario, the projected losses are minus 57.65 MI/d across South East Water's zones.

- Under the best case and Peak Deployable Output scenario the company could gain 6.83 Ml/d.

Table ES1. Draft impacts of climate change for each WRZ for the UKCP09 2030s Medium Emissions scenario

RZ		Peak (min)	Peak (mid)	Peak (max)	Ave (min)	Ave (mid)	Ave (max)
1	WRZ 1	-4.37	-0.05	0.00	-2.92	-0.04	0.00
2	WRZ 2	-17.46	-5.45	5.83	-17.68	-6.09	5.83
3	WRZ 3	-7.77	-1.30	1.00	-7.80	-1.64	1.00
4	WRZ 4	-9.15	-0.06	0.00	-9.09	-0.05	0.00
5	WRZ 5	-6.14	0.00	0.00	-5.11	-0.01	0.00
6	WRZ 6	-3.82	-0.65	0.00	-4.72	-1.92	0.00
7	WRZ 7	-3.21	0.00	0.00	-2.22	0.00	0.00
8	WRZ 8	-5.74	-0.98	0.00	-7.08	-2.88	0.00
Total		-57.65	-8.49	6.83	-56.62	-12.63	6.83
Total (PR09)		-92.16	-12.73	38.90	-87.89	-14.01	54.65
Differences		34.50	4.24	-32.07	31.27	1.38	-47.82

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Appendix

Ground water level changes

1 Introduction

This report forms a summary of the analysis of the impacts of climate change on deployable output completed by HR Wallingford to support the production of South East Water's Draft Water Resources Plan.

1.1 BACKGROUND

South East Water is divided into 8 water resources zone (Figure 1). Water is abstracted from surface water, both reservoirs and run-of-river schemes, and groundwater. Each resource's catchment and aquifer characteristics, source, treatment and licence conditions influence how Deployable Outputs respond to changes in climate. Climate will undoubtedly affect the water balance but in order to understand the impacts detailed modelling studies are required.



Figure 1.1 South East Water's Resource Zones

The Environment Agency's Water Resources Planning Guidelines for PR09 require companies to consider climate change impacts on surface and groundwater using hydrogeological, hydrological and water resources zone models (Environment Agency, 2012). This study used the latest UKCP09 climate change scenarios and followed the current guidance in order to present clear evidence of the impacts of climate change and updated the groundwater models used for the previous climate change impact assessment for PR09.

1.2 REPORT STRUCTURE

Section 2 provides some key points from the Environment Agency's Draft Water Resources Planning Guidelines (Environment Agency, 2012) and draft supplementary guidance on climate change that describe how the outputs of the study should be used in the company's Draft Water Resources Plan for PR14.

The subsequent Sections 3 to 10 provide a summary of the losses for each water resources zone. Section 11 provides some overall conclusions for the Draft and Final Water Resources Plans.

1.3 METHODS AND ASSUMPTIONS

The climate change impacts assessment was based on the UK Climate Projections 2009 (UKCP09) using the Medium Emissions scenario for the 2030s (2020 to 2039 time period). Although there is some evidence that greenhouse gas emissions are following the High Emissions scenario the range of impacts projected in the 2030s are very similar using either the Medium or High scenario.

The UKCP09 projections provide detailed data on the possible changes in annual, seasonal and monthly climate for thirty year time slices. These are applied to an historical climate to model potential impacts. South East Water's models typically include a long time period of daily climate data, for example from 1920 to 2012, to capture the impacts of important historical droughts like 1921/21, 1944 and 1976. The climate projections are then applied to these data to assess future impacts. No further work was completed on the risks of three dry winters, which may increase the impacts on groundwater DO.

The approach adopted built on the modelling completed for the last plan, which was most detailed in water resources zones 1 to 5. To provide an assessment of the impact of climate change for WRZs 6-8, the average DO impact for zones 1-3 were applied, where sources show an impact and have the same underlying geology, to zones 6, 7 and 8. It is therefore assumed that the impacts each geology type in zones 1, 2 and 3 will be representative of zones 6, 7 and 8, due to the same underlying geology and the zones being in the same geographical location.

The assessment of groundwater impacts is particularly complex as projected changes in water levels must be converted to DO impacts using site specific data that describes the links between "rest water level" and various constraints and source outputs. It has been assumed that the constraints on all sources as identified in PR09 have remained constant through to this assessment carried out for PR14. It has been assumed that these constraints correctly reflect the sources. Some source DOs may be reviewed between draft and final plans.

2 *Water resources planning guidance*

The previous climate impacts methodology was based on using the UKWIR06 scenarios and running three climate change scenarios, 'mid', 'wet' and 'dry', through water resources systems models. There are several new requirements under the EA WRPG:

1. The need to complete basic or intermediate vulnerability assessments (VA), which help to classify zones as Low, Medium or High vulnerability to climate change.
2. The use of the outcome of the VA to determine the level of detail for climate change modelling, with Low Vulnerability zones requiring fewer runs and the use of simple approaches and Medium/High Vulnerability zone requiring a larger number of runs and the application of more complex methods.

The key points from the Environment Agency draft supplementary guidance on climate change are as follows:

1. A water company should assess the effects of climate change on resource zone deployable output by assessing the implications of climate change on river flows and groundwater recharge. A water company should also assess the

- impact of climate change on any future supply options through its options appraisal process.
2. The methods a water company uses to assess the effect of climate change on deployable output should be proportionate to the risks presented by climate change to each water resource zone. A water company should undertake an initial vulnerability assessment in order to determine how vulnerable a water resource zone is to the effects of climate change. The outcome of this assessment will help identify the appropriate level of climate change assessment.
 3. To best assess the potential implications for water resources, water companies should use catchment or groundwater models when ever possible. Scenarios describing future changes in rainfall and potential evaporation should be used to perturb the historic records used to drive these models. Where such hydrological models do not exist, companies should use *flow* or *recharge factors* to perturb historical river flow or recharge series. The level of detailed required, depending on the zone's vulnerability, is described in figure 3.1 of the Water Resource Planning Guidelines (EA, 2012).
 4. Companies will need to maintain a clear and transparent audit trail so as to be able to present an evidence-based case for the amount (or not) of modelling work undertaken to assess the vulnerability to changes in future climate. This will include the reasons why hydrological modelling is not thought appropriate, given the results of the strategic assessment using flow factors.

There are four stages to estimate the impacts on Deployable Outputs:

- Calculate river flows and/or groundwater recharge/levels for a water resource zone in the 2030s, under the number of climate projections appropriate to the level of assessment being carried out;
- Calculate deployable output for the water resource zone in the 2030s under each climate projection being assessed;
- Scale the impacts of climate change by determining the change in deployable output for each year of the planning period and input these figures into the water resources planning tables;
- Determine the uncertainty associated with climate change for inclusion in target headroom.

The interpolation of climate change impacts is based on the following approach:

- i. A water company should scale the change in deployable output calculated for the 2030, for each year of the planning period.
- ii. The water company should determine the scaled change to base year deployable output by using Equation 1 to extrapolate from 2030/31¹ onwards. In the equation *Year* is the year of interest².

¹ Equation 1 should be used for 2029/30 also to get smooth transition between time periods

² This formula is based on the fact that the scenarios represent changes by the 2030's (2035) relative to 1961-1990 (1975). Note that in these equations 'Year' is the first year of the financial year – for example, results for 2012 should be entered in planning tables against the year annotated "2012-13".

$$\text{Scale factor} = \frac{\text{Year} - 1975}{2035 - 1975} \quad \text{Equation 1}$$

- iii. To avoid a step change in 2012/13 between baseline deployable output and the underlying trend, a water company should interpolate linearly between 2013/14 and 2029/30. This can be done by scaling the change in deployable output using Equation 2:

$$\text{Scale factor} = \frac{\text{Year} - 2012}{2031 - 2012} \quad \text{Equation 2}$$

The scaled change in deployable output across the planning period as a result of best estimate of climate change impacts should be recorded in the water resources planning tables.

2.1 VULNERABILITY ASSESSMENT AND LEVEL OF DETAIL ADOPTED FOR CLIMATE CHANGE IMPACTS ASSESSMENT

The vulnerability assessment for South East Water's supply areas indicated that zones 1-5 were high, zones 6 and 8 medium, and zone 7 low; as shown in Figure 2.1.

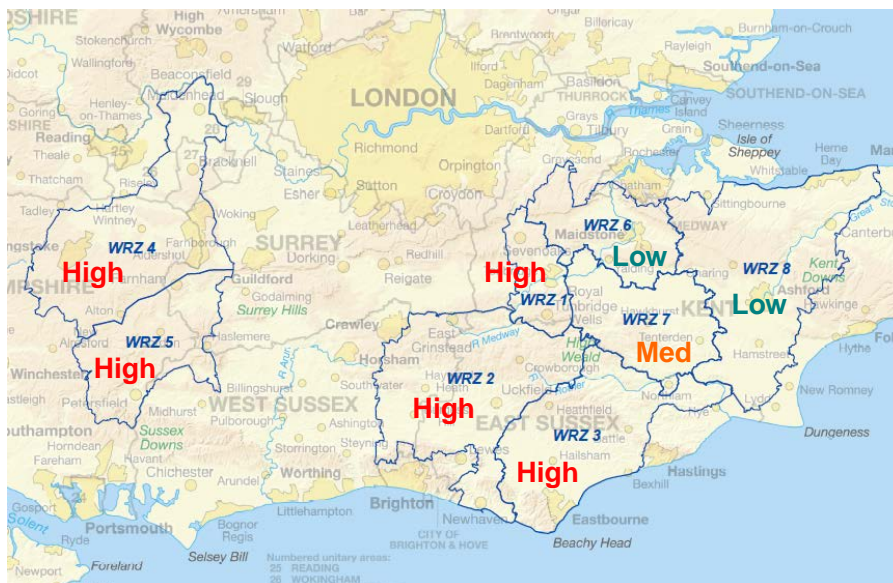


Figure 2.1 South East Water's resource zones and their vulnerability to climate change

This was based primarily on previous assessment and what was reported in the company's 2009 plan. Since then the south east of England has suffered a groundwater drought and there is further work ongoing to improve the assessment of these sources to future droughts. Therefore this vulnerability assessment may be updated in 2013.

South East Water completed a detailed assessment of climate change for all zones that were medium or high vulnerability. This included:

- Reviewing the latest research including the UK Government's Future Flows project³;

³ <http://www.bgs.ac.uk/research/groundwater/change/FutureFlows/home.html>

- Using South East Water HYSIM rainfall-runoff models and a set of 17 groundwater models;
- Applying one hundred UKCP09 projections to the relevant hydrological or groundwater models;
- Selecting 20 of these projections for application to water resources systems models for WRZ 2 and 3, which were projected to have the greatest impacts.

3 WRZ1

WRZ1 is groundwater dominated and supplies the area of Sevenoaks and Tonbridge. The climate change losses for the WRZ 1 Zone are summarised in Table 3.1.

Table 3.1 Climate change losses/gains in the Medway Resource Zone

RZ	Site Name	Type of site	DO change (Ml/d)					
			Peak			Average		
			min	mid	max	min	mid	max
1	Cramptons Rd	GW	-2.59	-0.05	0.00	-1.62	-0.04	0.00
1	Oak Lane	GW	-0.02	0.01	0.00	-0.02	0.01	0.00
1	Kemsing	GW	0.00	0.00	0.00	0.00	0.00	0.00
1	Saints Hill	GW	-0.53	0.00	0.00	-0.44	0.00	0.00
1	Hartlake	GW	-1.03	0.00	0.00	-0.67	0.00	0.00
1	Pembury (TW)	springs	0.00	0.00	0.00	0.00	0.00	0.00
1	Pembury (Ash)	GW	0.00	0.00	0.00	0.00	0.00	0.00
1	Tonbridge (Gravels)	GW	-0.11	-0.01	0.00	-0.10	-0.01	0.00
1	Tonbridge (Ash)	GW	-0.08	0.00	0.00	-0.07	0.00	0.00
1	Total		-4.37	-0.05	0.00	-2.92	-0.04	0.00

The overall losses from the 'mid' scenario in this resource zone are small for the 'mid' scenario. However, losses are more significant under the 'max' scenario, due in large part to the Cramptons Road source.

Key points:

- Cramptons Road: The large reductions in deployable output in the 'min' scenario are due to a predicted reduction in water level of 0.61m;
- Hartlake: The reduction in DO at Hartlake is a result of the lowered drought curve becoming constrained by the estimated pump cut off of Borehole C at 12.5 m AOD;
- Compared to PR09, there is a small reduction in the impact on DO for the 'mid' scenario for the zone.

4 WRZ2

WRZ2 has groundwater and surface water sources and supplies the area of Tunbridge Wells and Horsham. The climate change losses for the WRZ 2 Zone are summarised in Table 4.1.

Table 4.1 Climate change losses/gains in WRZ2

RZ	Site Name	Type of site	DO change (MI/d)					
			Peak			Average		
			min	mid	max	min	mid	max
2	Eridge	GW	0.00	0.00	0.00	-0.24	0.00	0.00
2	Saddlescombe	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Clayton	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Coombe Down	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Whitelands	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Forest Row	GW	-0.12	0.00	0.00	-0.08	0.00	0.00
2	Groombridge	GW	0.00	0.00	0.00	-0.03	0.00	0.00
2	Hempstead	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Coggins Mill/Sharnden	GW	-0.14	0.00	0.00	-0.12	0.00	0.00
2	Cowish	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Poverty Bottom	GW	-1.45	-0.32	0.00	-1.93	-0.96	0.00
2	Offham Springs	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Cockhaise Well (Holywell Cockhaise)	GW	-1.58	0.00	0.00	-1.11	0.00	0.00
2	Rathfinny	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Hackenden	GW	0.00	0.00	0.00	0.00	0.00	0.00
2	Barcombe WTW	SW	-14.17	-5.13	5.83	-14.17	-5.13	5.83
2	Shell Brook WTW	SW	0.00	0.00	0.00	0.00	0.00	0.00
2	(Weir Wood Reservoir)	SW	0.00	0.00	0.00	0.00	0.00	0.00
2	Total		-17.46	-5.45	5.83	-17.68	-6.09	5.83

Water resource zone two shows the highest losses across South East Water's zones. This zone incurs approximately 95% of losses due to the reduction in DO at Barcombe Mills run of river abstraction, which is directly related to the behaviour of Ardingly reservoir under the climate change scenarios.

Poverty Bottom is the only groundwater source showing any reductions in DO under the climate change 'mid' scenario. Cockhaise Well, Forest Row and Coggins Mill/Shamden do show losses under the 'min' scenario.

Key points:

- Barcombe: Significant reductions in yield observed under the 'mid' and 'min' scenarios due to reduced performance of Ardingly reservoir.
- Poverty Bottom: The reductions in DO at Poverty Bottom in the 'min' scenario are a result of the lowered drought curve becoming constrained by the top of the adit in Borehole 1 at -1 m AOD.
- WRZ two shows only a small reduction in DO losses compared to PR09 for all scenarios.

5 WRZ3

WRZ3 has groundwater and surface water sources and supplies the area of Eastbourne and Hastings. The climate change losses for the WRZ 3 Zone are summarised in Table 5.1.

Table 5.1 Climate change losses/gains in the WRZ3

RZ	Site Name	Type of site	DO change (Ml/d)					
			Peak			Average		
			min	mid	max	min	mid	max
3	Powder Mill (BH1)	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Powder Mill (Telham Ln)	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Sedlescombe	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Friston	GW	-0.99	-0.12	0.00	-0.58	0.02	0.00
3	Deep Dean	GW	-0.56	-0.07	0.00	-0.33	-0.04	0.00
3	Crowhurst Bridge	GW	-0.20	-0.02	0.00	-0.97	-0.55	0.00
3	Powder Mill (Twr Fm)	GW	-0.04	0.00	0.00	-0.02	0.00	0.00
3	Turzes Farm	GW	0.00	0.00	0.00	-0.04	0.00	0.00
3	Stonegate	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Birling Farm	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Sweet Willow Rd	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Hazards Green	GW	0.00	0.00	0.00	0.00	0.00	0.00
3	Holywell (E.Bourne)	GW	-0.09	0.00	0.00	-0.04	0.00	0.00
3	Cornish	GW	-1.31	-0.01	0.00	-0.89	0.00	0.00
3	Water Works Rd	GW	0.00	0.00	0.00	-0.36	0.00	0.00
3	Filching	GW	-0.02	0.00	0.00	-0.01	0.00	0.00
3	River Rother at Crowhurst Br	SW	-0.52	0.00	0.00	-0.52	0.00	0.00
3	Darwell Reservoir	SW	0.00	0.00	0.00	0.00	0.00	0.00
3	Wallers Haven	SW	-2.95	-0.89	-0.16	-2.95	-0.89	-0.16
3	Arlington	SW	-1.09	-0.17	1.16	-1.09	-0.17	1.16
3	Total		-7.77	-1.30	1.00	-7.80	-1.64	1.00

This Resource Zone suffers the second highest reduction in DO due predominantly surface water losses for the 'mid' scenario. For the 'min' scenario the cumulative impact of many groundwater sources, and three surface water sources, results in a large DO loss projected.

Key points:

- Friston: The reductions in DO at Friston are a result of the lowered drought curve becoming constrained by the pump depth at Friston No.1 Borehole at -0.5 m AOD.
- Wallers Haven: The Wallers Haven run of river abstraction is subject to significant losses under the 'min' scenario, and noticeable losses under the 'mid' scenario. This is due to a reduction in flows under the climate change scenarios partially compensated for by a groundwater augmentation scheme.
- Arlington. This reservoir is less affected than Ardingly, although under the 'min' scenario noticeable losses are incurred.

- Cornish. Cornish show next to no reductions in DO for the 'mid' scenario, but for the 'min' scenario significant reductions are seen.
- WRZ3 shows DO losses of approximately a third those values reported for PR09 for the Mid and 'min' scenario.

6 WRZ4

WRZ4 is predominately groundwater and supplies the area of Basingstoke, Camberley and Maidenhead. The climate change losses for the WRZ 4 Zone are summarised in Table 6.1.

Table 6.1 Climate change losses/gains in the WRZ4

RZ	Site Name	Type of site	DO change (MI/d)					
			Peak			Average		
			min	mid	max	min	mid	max
4	Cookham	GW	-2.09	0.01	0.00	-1.91	0.01	0.00
4	Greywell	GW	-1.62	0.18	0.00	-1.62	0.18	0.00
4	Boxhalls Lane Chalk	GW	-1.20	0.00	0.00	-0.17	0.00	0.00
4	Boxhalls Lane LGS	GW	0.00	0.00	0.00	0.00	0.00	0.00
4	Tongham	GW	0.00	0.00	0.00	-0.21	0.00	0.00
4	Itchel	GW	0.00	0.00	0.00	0.00	0.00	0.00
4	Lasham	GW	-0.87	0.00	0.00	-1.49	0.00	0.00
4	Cliddesden	GW	-0.02	0.00	0.00	-0.01	0.00	0.00
4	West Ham PS	GW	-0.12	0.00	0.00	-0.30	-0.03	0.00
4	West Ham Park	GW	-0.62	-0.18	0.00	-0.45	-0.10	0.00
4	Bray Gravels	GW	-0.04	-0.02	0.00	-0.08	-0.03	0.00
4	College Avenue	GW	-0.14	0.00	0.00	-0.92	-0.03	0.00
4	Woodgarston	GW	-1.10	0.00	0.00	-1.10	0.00	0.00
4	Beenhams Heath	GW	-0.64	-0.03	0.00	-0.37	-0.02	0.00
4	Hurley	GW	-0.69	-0.03	0.00	-0.46	-0.03	0.00
4	Bray South	SW	0.00	0.00	0.00	0.00	0.00	0.00
4	Total		-9.15	-0.06	0.00	-9.09	-0.05	0.00

Water resource zone 4 shows a minimal impact on DO for the 'mid' scenario, but a large impact for the 'min' scenario due the cumulative effects of small impacts across all sites.

Key points:

- Cookham & Greywell: For the 'mid' scenario there is a small increase in DO. In the 'min' scenario the medium reductions in DO at Cookham and Greywell are a result of a potential reduction to the abstraction licence proportional to the predicted reduction in aquifer recharge.
- Lasham: The reductions in DO are a result of the lowered drought curve becoming constrained by the estimated pump cut off in Borehole 4 at 50.2 m AOD.
- The DO losses for WRZ4 are less than those reported for PR09.

7 WRZ5

WRZ5 is groundwater dominated and supplies the area of Farnham. The climate change losses for the WRZ 5 Zone are summarised in Table 7.1.

Table 7.1 Climate change losses/gains in WRZ5

RZ	Site Name	Type of site	DO change (M/d)					
			Peak			Average		
			min	mid	max	min	mid	max
5	Tilford Meads	GW	-1.80	0.00	0.00	-1.80	0.00	0.00
5	Tilford WR	GW	-0.99	0.00	0.00	-0.99	0.00	0.00
5	Rushmoor	GW	0.00	0.00	0.00	0.00	0.00	0.00
5	Hawkley	GW	0.00	0.00	0.00	0.00	0.00	0.00
5	Sheet	GW	0.00	0.00	0.00	0.00	0.00	0.00
5	Oakshot	GW	0.00	0.00	0.00	0.00	0.00	0.00
5	Greatham	GW	0.00	0.00	0.00	0.00	0.00	0.00
5	Hindhead LDN Rd	GW	-0.02	0.00	0.00	-0.02	0.00	0.00
5	Hindhead Tower Rd	GW	0.00	0.00	0.00	-0.19	0.00	0.00
5	Windmill Hill, Alton	GW	-0.24	0.00	0.00	-0.26	0.00	0.00
5	Oakhanger	GW	-0.90	0.00	0.00	-1.08	-0.01	0.00
5	Britty Hill	GW	-0.68	0.00	0.00	0.00	0.00	0.00
5	Headley park	GW	-1.40	0.00	0.00	-0.66	0.00	0.00
5	The Bourne	GW	0.00	0.00	0.00	-0.03	0.00	0.00
5	East Meon	GW	-0.11	0.00	0.00	-0.09	0.00	0.00
5	Total		-6.14	0.00	0.00	-5.11	-0.01	0.00

Water resource zone 5 DO is solely source from groundwater supplies. Virtually no impacts were projected for the 'mid' scenario however, large impact were seen for the 'min' scenario: with the largest reduction seen at Tilford Meads, Tilford WR and Oakhanger. Reductions at other sources for the 'min' scenario add up to have a large net impact on total DO losses.

Key points:

- Tilford Meads, Tilford WR & Oakhanger: The reductions in DO at Tilford Meads, Tilford WR and Oakhanger in the 'min' scenario are a result of a potential reduction to the abstraction licence proportional to the predicted reduction in aquifer recharge.
- Headley Park: The reductions in DO at Headley Park are a result of the lowered drought curve becoming constrained by the estimated pump cut off in Borehole 1 at 21.14 m AOD.
- There are minimal changes seen in DO impact compared to the assessment undertaken for PR09.

8 WRZ6

WRZ6 is predominately groundwater dominated and supplies the area of Snodland. The climate change losses for the WRZ 6 Zone are summarised in Table 8.1.

Table 8.1 Climate change losses/gains in WRZ6

RZ6	Site Name	Type of site	DO change (MI/d)					
			Peak			Average		
			min	mid	max	min	mid	max
6	Hartley Chalk	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
6	Ridley	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
6	Hartley Greensand	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Borough Green	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Nepicar Lane	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Trosley	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Ryarsh	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Paddlesworth	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Halling Chalk (Inc No.7)	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Halling Greensand - BH6	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Forstal site (Well and BHs 1-4 (only) total combined)	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Cossington Greensand	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Boxley Greensand (No1&No.2 (Boarley BH))	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Cossington Springs (Chalk)	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
6	Boxley Well Source (Chalk)	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
6	Boxley Springs	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Thurnham	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Hockers Lane (Harple Lane)	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Harrietsham	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Burham WTW	SW	0.00	0.00	0.00	0.00	0.00	0.00
6	Matts Hill (Belmont)	GW	0.00	0.00	0.00	0.00	0.00	0.00
6	Pitfield Booster	T	0.00	0.00	0.00	0.00	0.00	0.00
6	Tunbury Ave (SWS)	T	0.00	0.00	0.00	0.00	0.00	0.00
6	Total		-3.82	-0.65	0.00	-4.72	-1.92	0.00

Water resource zone 6 is predominately comprised of groundwater sources. The impact on DO has been assumed to be representative for the same geology found within the same geographical area; therefore the reductions shown for the chalk sources are an average of the DO reduction in the chalk sources within water resources zones 1-3.

Key points:

- Hartley Chalk, Ridley, Cossington Springs and Boxley Well all show small impacts for the mid estimate, but which accumulate into a noticeable impact on DO for climate change for the zone. These locations show a medium impact for the 'min' scenario which results in a large impact for the zone.

9 WRZ7

WRZ7 has groundwater and surface water sources and supplies the area of Maidstone. The climate change losses for the WRZ 7 Zone are summarised in Table 9.1.

Table 9.1 Climate change losses/gains in WRZ7

RZ7	Site Name	Type of site	DO change (Ml/d)					
			Peak			Average		
			min	mid	max	min	mid	max
7	Goudhurst Sourceworks (excluding Lamberhurst)	GW	-1.07	0.00	0.00	-0.74	0.00	0.00
7	Lamberhurst Sourceworks	GW	-1.07	0.00	0.00	-0.74	0.00	0.00
7	Maytham Farm	GW	0.00	0.00	0.00	0.00	0.00	0.00
7	Bewl Bridge BHs	GW	-1.07	0.00	0.00	-0.74	0.00	0.00
7	Bewl Bridge SW	SW	0.00	0.00	0.00	0.00	0.00	0.00
7	Total		-3.21	0.00	0.00	-2.22	0.00	0.00

As for WRZ6 the impact on DO has been assumed to be representative for the same geology found within the geographical area. For this zone the underlying geology is Ashdown Beds, and therefore the reductions shown are an average of the DO reduction in the Ashdown sources within water resources zones 1-3.

Key points:

- Goldhurst Sourceworks, Lamberhurst Sourceworks and Bewl Bridge Boreholes are situated on Ashdown bed geology and therefore are shown to have the same impacts. No change is seen for the 'mid' scenario. For the 'min' scenario, the sites show small reduction, which accumulate into large losses for the zone.

10 WRZ8

WRZ8 is predominately groundwater and supplies the area of Canterbury and Ashford. The climate change losses for the WRZ 8 Zone are summarised in Table 10.1.

Table 10.1 Climate change losses/gains in WRZ8

RZ8	Site Name	Type of site	DO change (MI/d) (change in DO to use in plan)					
			Peak			Average		
			min	mid	max	min	mid	max
8	Chilham	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Godmersham	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Charing	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Westwell	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Henwood	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Kingston	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Thannington	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Howfield	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Hoplands Farm	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Ford	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Wichling	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Wineycock Shaw	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Newnham	GW	-0.96	-0.16	0.00	-1.18	-0.48	0.00
8	Ospringe	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Boughton	GW	0.00	0.00	0.00	0.00	0.00	0.00
8	Stockbury (via Bottom Pond)	SW	0.00	0.00	0.00	0.00	0.00	0.00
8	To Veolia SE (Folkestone & Dover)	T	0.00	0.00	0.00	0.00	0.00	0.00
8	Total		-5.74	-0.98	0.00	-7.08	-2.88	0.00

Losses with WRZ8 solely occur on chalk geology therefore the impact on DO has been assumed to be representative for the chalk geology found within the geographical area. The reductions shown are an average of the DO reduction in the chalk sources within water resource zones 1-3.

Key points:

- Chilham, Goldmersham, Kingston, Wichling, Wineycock Shaw and Newnham show small reductions which accumulate to show a large reductions across WRZ8, for the 'mid' scenario.
- The same sites show mediums impacts for the 'min' scenario which add up to a significant total impact for the zone.

11 Conclusions

This section outlines the changes to DO at a Water Resource Zone and company wide level. Table 11.1 gives the changes in DO experienced over each resource zone.

- The 'min' scenario shows significant impacts over all resource zones, although zone 7 is substantially less affected than the others in terms of MI DO loss.
- The 'mid' scenario gives significant reductions in zone 2 and to a lesser extent zone 8. Zones 1, 4, 5 and 7 are relatively unaffected by climate change for the 'mid' scenario.
- The 'max' scenario shows significant increases in DO only in zones 2 and 3.

Table 11.1 Summary of climate change losses/gains for 2035 for each Water Resources Zone (WRZ)

RZ		Peak (min)	Peak (mid)	Peak (max)	Ave (min)	Ave (mid)	Ave (max)
1	WRZ 1	-4.37	-0.05	0.00	-2.92	-0.04	0.00
2	WRZ 2	-17.46	-5.45	5.83	-17.68	-6.09	5.83
3	WRZ 3	-7.77	-1.30	1.00	-7.80	-1.64	1.00
4	WRZ 4	-9.15	-0.06	0.00	-9.09	-0.05	0.00
5	WRZ 5	-6.14	0.00	0.00	-5.11	-0.01	0.00
6	WRZ 6	-3.82	-0.65	0.00	-4.72	-1.92	0.00
7	WRZ 7	-3.21	0.00	0.00	-2.22	0.00	0.00
8	WRZ 8	-5.74	-0.98	0.00	-7.08	-2.88	0.00
Total		-57.65	-8.49	6.83	-56.62	-12.63	6.83

Following the EA's Draft Water Resource Planning Guidelines and using updated UKCP09 climatetology, the projected impacts on zones 1-8 are lower than those reported for PR09. This is in part due to this assessment using UKCP09 climate change projections, resulting in different DO changes.

12 *References*

Draft Water Resource Planning Guidelines; The technical methods and instructions, Environment Agency, 2012.

Analysis on the impacts on climate change; Task 2: Impacts of climate change on deployable output – Summary report, H R Wallingford, 2007, Report EX5640.

Appendix Ground water level changes

Table A.1 Changes in groundwater level for modelled sources.

RZ	Model type	Site Name	WRMP 2009 Assessment based on the UKWIR06 scenarios (6 model runs)			WRMP 2014 Assessment based on the UKCP09 projections (100 model runs)			Change in GW level WRMP - UKCP09		
			Water level change (m)			Water level change (m)					
			Min	Mid	Max	Min	Mid	Max	Min	Mid	Max
WRZ1	GR2	Saints Hill	-0.40	0.00	0.40	-0.19	-0.05	0.13	0.21	-0.05	-0.27
WRZ1	GR2	Hartlake	-1.30	0.00	1.30	-0.87	-0.11	0.77	0.43	-0.11	-0.53
WRZ1	GR1	Lower Wield Farm				-1.88	-0.18	1.38			
WRZ1	GR2	Crampons Road	-2.50	-0.40	2.10	-0.61	0.19	1.28	1.89	0.59	-0.82
		WRZ1 average	-1.40	-0.13	1.27	-0.89	-0.03	0.89	0.85	0.15	-0.54
WRZ2	GR2	Houndean Bottom				-4.86	-1.51	1.13	-4.86	-1.51	1.13
WRZ2	GR2	Cowish	-0.20	0.00	0.30	-1.20	0.12	-0.29	-1.00	0.12	-0.59
WRZ2	GR2	Groomsbridge (including Eridge)	-0.20	0.00	0.20	-0.11	-0.01	0.09	0.09	-0.01	-0.11
WRZ2	GR2	Poverty Bottom	-1.50	-0.30	1.40	-1.45	-0.48	0.88	0.05	-0.18	-0.52
WRZ2	GR2	Rathfinney	-2.80	0.50	2.90	-1.80	-0.49	1.22	1.00	-0.99	-1.68
WRZ2	GR2	Lower Barn Cottage (Future Flows Model)				-0.13	0.09	0.24			
		WRZ2 average (HRW models only)	-1.18	0.05	1.20	-1.14	-0.21	0.47	0.04	-0.26	-0.73
WRZ3	GR2	Crowhurst bridge (GW supply only)	-1.50	-0.30	1.20	-0.76	-0.15	0.59	0.74	0.15	-0.61
WRZ3	GR2	Eastbourne group	-0.70	-0.30	0.30	-0.23	-0.03	0.22	0.47	0.27	-0.08
WRZ3	GR2	Wigdens bottom (Cornish)	-2.30	-0.40	1.90	-0.88	-0.05	1.00	1.42	0.35	-0.90
WRZ3	GR2	Cross In Hand Knaves				-0.79	-0.37	-0.04			
WRZ3	GR2	West Dean BH 3				-0.41	-0.14	0.07			
WRZ3	GR2	West Dean (Future Flows Model)				-0.05	0.04	0.13			
		Average (HRW models only)	-1.50	-0.33	1.13	-0.61	-0.15	0.37	0.88	0.26	-0.53
WRZ4	GR2	Beenhams Heath	-4.70	-2.40	3.40	-2.16	-0.15	2.08	2.54	2.25	-1.32
WRZ4	GR2	Boxhalls lane	-2.00	0.00	2.50	-0.86	-0.07	0.85	1.14	-0.07	-1.65
WRZ4	GR2	Bray	-0.20	-0.20	0.10	-0.08	-0.03	0.06	0.12	0.17	-0.04
WRZ4	GR2	Lasham	-2.60	0.00	2.60	-1.31	0.02	1.78	1.29	0.02	-0.82
WRZ4	GR2	Westham Park	-1.90	-0.80	1.00	-0.85	-0.16	0.81	1.05	0.64	-0.19
WRZ4	GR2	Westham PS	-1.60	-0.70	1.00	-0.95	-0.09	0.93	0.65	0.61	-0.07
WRZ4	GR2	Woodgarston	-2.40	0.35	2.90	-1.88	-0.18	1.38	0.52	-0.53	-1.52
WRZ4	GR1	Stonor Park				-13.40	-5.27	2.59			
WRZ4	GR1	Stonor Park (Future Flows Model)				-1.96	-0.94	0.89			
		Average (HRW models only)	-2.20	-0.54	1.93	-2.69	-0.74	1.31	1.04	0.44	-0.80
WRZ5	GR2	Bourne	-1.20	0.10	1.30	-1.07	0.04	1.31	0.13	-0.06	0.01
WRZ5	GR2	Britty hill	-1.00	-0.10	0.80	-0.75	-0.03	0.77	0.25	0.07	-0.03
WRZ5	GR2	Collage avenue	-1.70	-0.30	1.10	-1.29	-0.60	0.27	0.41	-0.30	-0.83
WRZ5	GR2	Headley park	-0.50	0.00	0.50	-0.56	-0.09	0.54	-0.06	-0.09	0.04
WRZ5	GR2	Windmill hill	-1.50	0.40	1.70	-0.98	-0.04	1.17	0.52	-0.44	-0.53
WRZ5	GR1	Folly Cottage				-1.29	-0.60	0.27			
		Average	-1.18	0.02	1.08	-0.99	-0.22	0.72	0.25	-0.16	-0.27
WRZ6	GR1	Elphicks Farm				0.06	5.02	11.71			
WRZ6	GR1	Ryarth BH2				-3.27	-1.43	0.62			
		Average				-1.60	1.79	6.17			
WRZ8	GR1	Charing				-1.65	-0.69	0.07			
WRZ8	GR1	Dane Court Farm				-1.28	0.08	1.65			
WRZ8	GR1	Duckpit Farm				-3.40	0.44	5.81			
WRZ8	GR2	Little Bucket Farm (Future Flows Model)				-3.40	-1.48	5.81			
		Average (including FF model)				-2.43	-0.41	3.33			

FLOW FACTORS

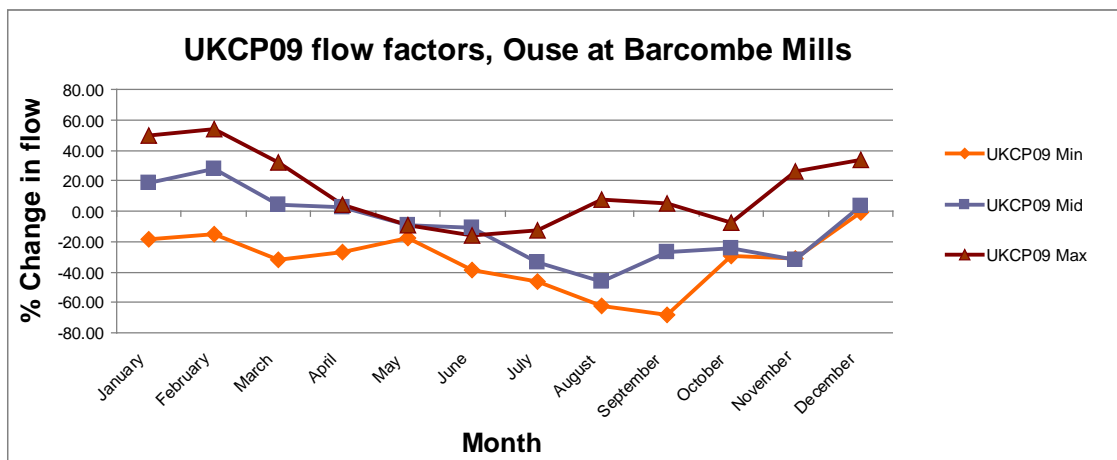


Figure A1 Projected changes in flows at Barcombe Mills indicating reduction in flows in May June, July and October for all scenarios

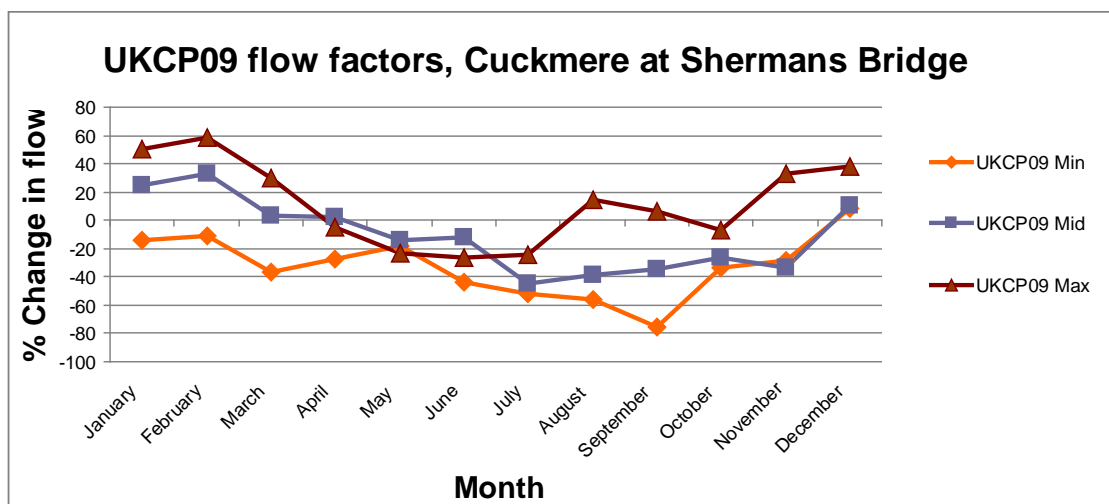


Figure A2 Projected changes in flows at Shermans Bridge indicating reduction in flows in May June, July and October for all scenarios



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Appendix 3E: Level of Service

Background

The WRMP Guideline states: - ‘A company should consider a change in levels of service as a means of managing supply and demand.’

The guideline further says ‘as a minimum the water company should assess baseline deployable output (without climate change) for the following levels of service scenarios. We recommend that companies display this in a table that can be easily understood by its customers and regulators showing

Three planning scenarios are described.

1. No restriction
2. Water company planned LoS
3. Reference LoS.

When we tested customers’ views on future challenges that may impact on the reliability of their water supplies, there was hostility – particularly towards hosepipe bans which were just being introduced when the research took place – and the blame was levelled at water companies. The research showed that fixing more leaks, investing in infrastructure and reducing the frequency of hosepipe bans are all water companies’ problems as customers consider they already pay enough to have these issues addressed.

However, during the willingness to pay research, customers told us that they accept hosepipe bans are a necessity, and they support maintaining the current level of services which is, on average, one hosepipe ban every 10 years.

Having established our customers’ priorities we wanted to explore with them their views on both current and future levels of service. Customers were presented with a choice of varying levels of service. The results showed that customers are not willing to pay significantly more to change the current levels of service. Overall 86% of customers (including 84% of low income households) supported our plan which included maintaining our current levels of service.

Deployable output assessments have been calculated based on a 1:50 year return period in our WRMP and are consistent with our levels of service and the reference levels of service. Our research shows customers support our existing levels of service and we do not propose to change these during the plan. We will continue to update our deployable outputs to ensure that they are consistent with levels of service supported by our customers. By ensuring our preferred plan is resilient we can be confident that our preferred plan options will maintain existing levels of service. Calculating groundwater yields for different return periods is complex. In addition to the 1:50 year return period we have also calculated the yields for groundwater sources using a 1:100 year scenario, and we have used this 1:100 year event as our no restrictions scenario.

Shared resources and bulk transfers are calculated by the donor company and may have different levels of service so are not presented in the table below.

		Deployable Output		
		DYAA	DYCP	Comment
Customer Level of Service	No restrictions	615.3	719.1	85% of our water supply is from aquifers and although some of our area is covered by regional models, other parts are not covered. We cannot therefore accurately model a no-restrictions deployable output. The figures for the No Restrictions scenario represents the deployable outputs in a 1:100 year event
	Water company level of service	622.7	727.2	These Water Company and Reference levels of service are the same for South East Water.
	Reference levels of service	622.7	727.2	The deployable outputs are those reported elsewhere in our plan.

Our sensitivity analysis, reported in Appendix 9, shows that using a 1:100 year return period brings schemes forward, typically by one to two years.