Project:	PR19 Framework Trading Resources	**To:**	Cambridge Water
Subject:	Climate Change Assessment Review	**From:**	Jo Withington Jo Parker
Date:	18 Aug 2017	**cc:**	James Tradewell

1. Introduction

We have undertaken a review of the 'WRMP Appendix A16 CWC Climate Change Technical Note_Final_27 Mar 2013' (Mott MacDonald, 2013) to ensure that it is consistent with the updated Environment Agency (EA) WRMP guidance on 'Estimating the impacts of climate change on water supply' (EA, 2017).

This review found that the WRMP14 vulnerability analysis was broadly in line with the guidance from the EA water resources planning guidelines (2012) but was not presented at a Resource Zone (RZ) scale. We have revisited the basic vulnerability assessment using the data produced for the 2013 climate change vulnerability assessment (Mott MacDonald, 2013). The review of the WRMP14 assessment also revealed that the deployable output (DO) assessment was presented to 2050s. The more recent EA Guidelines (2016 and revised guidelines 2017) stipulate that this should be done to the 2080s. Therefore, to align with the guidelines we have undertaken the analysis with the updated time horizon of the 2080s. Table summarises our review of the previous WRMP14 climate change vulnerability analysis (Mott MacDonald, 2013) for its alignment with EA water resources planning guidance (2017).

Additionally, we have provided a wider vulnerability context based on information from a range of sources including Drought plan (2012), WRMP (2016), Source vulnerability update (2016).

Table 1 Summary of WRMP14 climate change vulnerability analysis

Guideline item	WRMP14	Compliance with EA Guidelines	Changes made for WRMP19	Considerations for further work
Vulnerability assessment	Magnitude versus sensitivity plot of deployable output (DO) presented at the source scale.	Guidelines state that a magnitude versus sensitivity plot of RZ vulnerability should be presented.	Analysis presented at the RZ scale to comply with EA guidelines. Additionally, as Cambridge Water (CWC) only has one RZ the analysis is also presented at a source level to help CWC understand their vulnerability in more detail.	For the climate sensitive sources the WRMP14 analysis was undertaken using a mixture of peak and annual average DO baselines. This makes it difficult to normalise the range of impact over the total RZ DO (see footnote 1).
Identifying the most appropriate level of climate change assessment	Tier 3 was undertaken on medium and high vulnerability sources.	The guidelines state that medium vulnerability zones only require a tier 2 analysis. Therefore, the previous analysis adopted a more conservative approach.	RZ categorised as low which the guidelines suggest requires tier 1 impact assessment. As the WRMP14 analysis went beyond this and adopted a tier 3 approach we haven't reduced this to a tier 1 approach.	
Calculate deployable outputs for the 2080s	Previous analysis was done to 2050s.	Guidance requires analysis to be done to 2080s.	Analysis done to 2080s.	

2. Basic Vulnerability Assessment

Cambridge Water consists of one RZ, supplied by 28 groundwater sources. These 28 groundwater sources mainly abstract from the chalk strata to the south and east of Cambridge. The underground chalk strata is generally a robust water storage aquifer, recharged by rainfall mostly during the winter months each year (CCA Report, 2016).

In line with the most recent guidance (EA, 2017) we have undertaken a basic vulnerability assessment using information on the change in source Deployable Output (DO) from previous climate change assessments as detailed in section 3.3.3 of the 2012 technical methods (EA, 2012).

The data used was produced by Mott MacDonald for WRMP14 and is presented in the Appendix. Mott MacDonald were commissioned to undertake an assessment of the impact of climate change on Cambridge Water's groundwater sources and determine the likely change to Deployable Output (DO) as a result (Mott MacDonald, 2013). From this analysis, eight sources were constrained by factors other than licences and taken forward for further climate change assessment (Mott MacDonald, 2013). These eight sources are also those that demonstrate the most vulnerability during low groundwater level (drought) conditions, as defined in the SRO studies for each of the PWS sources (Mott MacDonald, 2012).

Table 2 summarises the 28 sources within the Cambridge Water area and the 8 sources which have been taken forward into the climate change vulnerability assessment.

Another source has been added to the assessment since 2013, HOPW, and has been considered in this WRMP19 assessment. Atkins has undertaken a review of the source reliable output analysis (SRO) provided by Cambridge Water. This review concluded that HOPW is constrained by its annual and daily licence conditions (ref, 2017) and therefore has not been considered as vulnerable to climate change in this assessment.

Table 2 Cambridge Water's Groundwater Sources and summary of screening process (Mott MacDonald, 2013)

Constrained by licence	Potential vulnerability (included in CCVA)	Not included in Mott MacDonald (2013) assessment[1]
APPW	DUPW	LBPW
BAPW	DGPW	SIPW
BRPW	FD36PW	
CRPW2	GCPW	
DAPW	GWPW	
EUPW	MEPW	
FD12PW	WEPW	
FOPW	WCPW	
FUPW		
HEPW		
HGPW		
HOPW2		
KIPW2		
LIPW		
LOPW		
MGPW2		
RIPW		
SAPW2		

The vulnerability classification of the RZ has been determined by its position on a magnitude versus sensitivity plot, provided in the EA water resources planning guidelines (2012), Table 3. The plot shows

[1] These sources do not feature in current DO.

change in deployable output (DO) for the 'mid' climate change scenario against the uncertainty range. The RZ is classified as low climate vulnerability.

The magnitude versus sensitivity plot for the Cambridge Water RZ is shown in Figure 1. A second magnitude versus sensitivity plot broken down by source is provided in Figure 2. Although three sources fall into the high and medium vulnerability category, overall the vulnerability of the RZ to climate change is categorised as **low**.

Table 3 Vulnerability scoring matrix

Uncertainty range (% change wet to dry)	Mid scenario (% reduction in DO)		
	<5%	>5%	>10%
<5%	Low	Medium	High
6 – 10%	Medium	Medium	High
11 – 15%	Medium	High	High
>15%	High	High	High

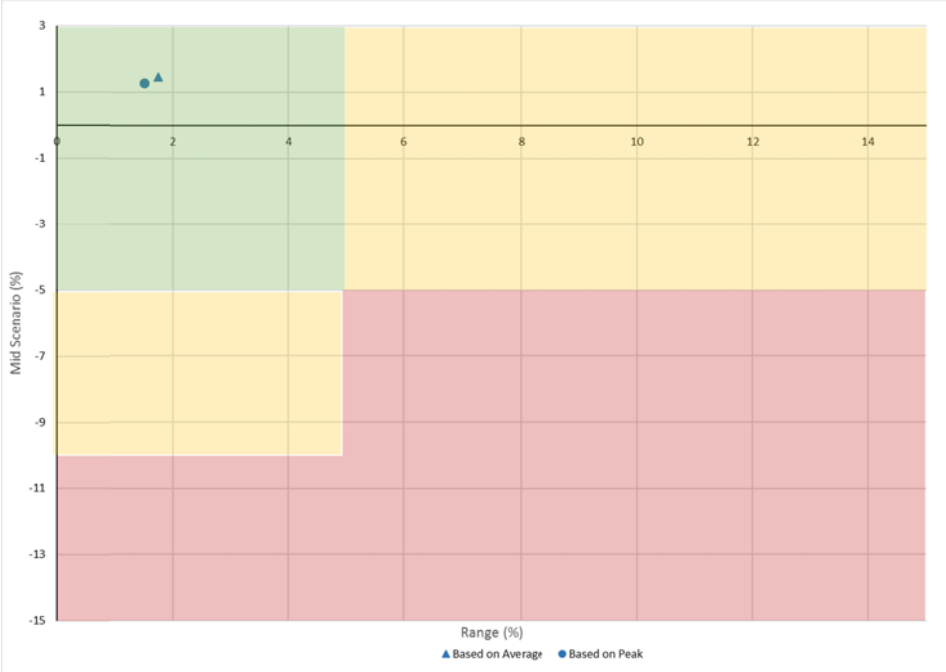

Figure 1 Magnitude versus sensitivity plot for the Cambridge RZ, calculated two different ways[2]

[2] In each case the uncertainty range was calculated as the difference between the high emissions 90th percentile calculated DO, and the mid scenario was taken as the medium emissions 50th percentile. The previous assessment (March 2013), looked at the impact of climate change on DO at a combination of peak and average demand conditions, which therefore had to be taken into consideration when calculating the percentage impact on the total RZ DO. The 'Based on Average' point used a calculation that took the respective baseline DO in correspondence to the conditions used in the climate change DO assessment, but those sources not considered in the DO assessment were allocated average DO values, the 'Based on Peak' used the peak values for these sources.

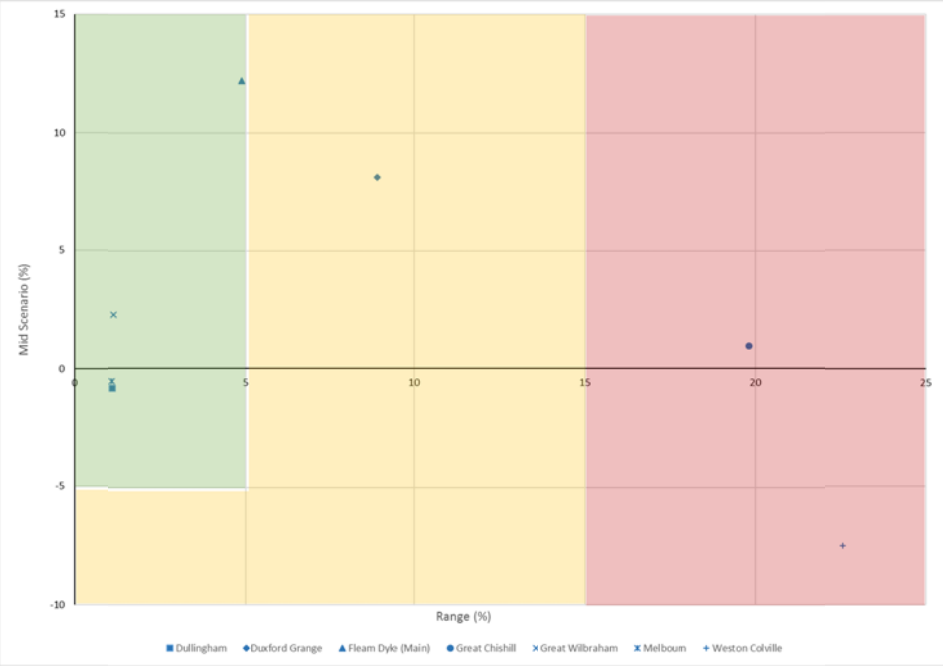

Figure 2 Magnitude versus sensitivity plot for the Cambridge RZ, for sources identified as vulnerable to climate change

3. Vulnerability Context

The EA Guidelines for WRMP16 suggest that companies should also provide a summary of other information available to determine RZ vulnerability. Using various sources, we have developed the summary presented in Table 4 below. Table 5 shows the supply-demand balance for Cambridge Water RZ. The resource zone is in surplus throughout the forecast period suggesting that there is likely to be some spare resource that could be used to adapt to any reductions in groundwater from climate change.

Table 4 Summary of RZ vulnerability

Descriptor	Summary information	Information Source
Critical Drought Years	The most severe drought affecting Cambridge Water, since the company has been collecting rainfall records is the drought of the 1920's, which comprised of three successive dry winters. The worst drought in the across the East Anglian region is also understood to be the 1933-34 drought.	Draft Drought Plan (2017) Source Vulnerability, Mott MacDonald (2016) Cole and Marsh (2006)
Supply Demand Balance	No supply demand deficit expected in the WRMP14 tables by 2039-40, see Table 5.	WRMP14 (2014)
Security of Supply	For 2015/16 the Security of Supply Index was reported as 100%, based on the WRMP14 headroom of 16.94 and planning surplus of 12.94 Ml/d.	WRMP14 Annual Review (2016)
Critical climate variables	The supply in the RZ is entirely comprised of groundwater sources, and is therefore vulnerable to dry winters affecting groundwater recharge, especially successive	Draft Drought Plan (2017)

Descriptor	Summary information	Information Source
	dry winters.	
Adaptive Capacity	Currently average daily available deployable output exceeds average day demands by around 28 Ml/d, and peak deployable output exceeds peak demand by over 30 Ml/d.	Draft Drought Plan (2017)
Sensitivity	Although 8 sources in the 2013 report were considered as vulnerable to climate change, a source vulnerability update (2016) identified another 4 sources that were vulnerable to the worst historic drought using ground water level hindcasting. Climate change could exacerbate any of these effects resulting in a greater number of sources being vulnerable to climate change.	Source Vulnerability, Mott MacDonald (2016)
Vulnerability classification	Overall classification as low.	WRMP14 (2014) Mott MacDonald (2013)

Table 5 Supply demand balance for the Cambridge Water RZ as assessed under the WRMP14.

	2016-17	2021-22	2039-40
Supply Demand Balance (Ml/d)	11.95	10.60	5.54

4. Further Recommendations

The updated methodology includes a tiered approach to estimate the impact of climate change on river flows based on the basic vulnerability classification of each RZ (EA, 2017). The Cambridge Water RZ is considered to have a low vulnerability to climate change impacts, and so under the updated methodology, Tier 1 analysis is required (i.e. use future flows hydrology monthly change factors as outlined in the WRMP19 supplementary information on estimating the impacts of climate change on water supply, EA, 2017). A simple approach to assessing the impact of climate change on groundwater in this RZ could be undertaken however this analysis has gone beyond this to comply with Tier 3 (UKCP09 / water company own approach). This baseline vulnerability analysis has been undertaken in line with the EA guidelines, and using the best available data from Cambridge Water. To improve the analysis Cambridge Water may consider discussing with the EA the necessity to carry out the below additional tasks:

- The calculation of the impact of climate change on DO using a consistent baseline, either average or peak DO, across all sources deemed as vulnerable to climate change.
- Given the projected increase in drought severity with climate change Cambridge Water could consider undertaking a DO impact review of the additional sources identified as vulnerable to three dry winters in the source vulnerability assessment, 2016[3].

[3] DUPW, DAPW, DGPW, EUPW, FD36PW, FUPW, GCPW, GWPW, HEPW, KIPW2, MGPW2, WEPW and WCPW.

5. References

Cole and Marsh (2006), Major droughts in England and Wales from 1800 and evidence of impact. Environment Agency Science Report: SC040068/SR – Part 1

CCA Report (2016), South Staffs Water / Cambridge Water, Climate Change Adaptation, Update Report.

Draft Drought Plan (2017), Draft Drought Management Plan, February 2017, Cambridge Water Company.

EA (2012), Water resources planning guideline - The technical methods and instructions (available at: http://webarchive.nationalarchives.gov.uk/20130206062158/http:/a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/lit_6932_56bc01.pdf)

EA (2013), Climate change approaches in water resources planning – Overview of new methods (available at: https://www.gov.uk/government/publications/climate-change-approaches-in-waterresources-planning-new-methods)

EA (2016), Evidence Report, Estimating impacts of climate change on water supply.

EA (2017), WRMP19 supplementary information (revised April 2017) – Estimating the impacts of climate change on water supply.

Mott MacDonald (2012), Severe Drought Study: Impacts on Groundwater Potential Yield. Report 295635/EVT/IWRM/3/A

Mott MacDonald (2013), Technical Report, Climate Change Impacts on Deployable Outputs.

Mott MacDonald (2016), Mott MacDonald, 2016, Climate Change and Source Vulnerability, Drought Plan Support.

WRMP14 (2014), Cambridge Water, Water Resources Management Plan 2014 Cambridge Region.

WRMP14 Annual Review (2016), Cambridge Water, Water Resources Management Plan Annual Review, 2016 (available at: http://www.cambridge-water.co.uk/customers/water-resources-management-plan).

Appendix

Mott MacDonald (2013) results of climate change assessment on DO. These results have been used in the climate change vulnerability assessment presented in Section 2 of this report.

Source			DUPW (Average Demand)		DGPW (Peak Demand)		FD36PW) (Average Demand)		FD36PW (Peak Demand)		GCPW (Average & Peak Demand)		GWPW (Peak Demand)		MEPW (Peak Demand)		WEPW (Average & Peak Demand)		WCPW (Average & Peak Demand)	
Observed Minimum GWL (mAOD)			9.85		20.18		8.84		8.84		25.32		8.84		20.85		5.83		11.38	
Year of Observed Minimum			1992		1992		1992		1992		1997		1992		1997		1992		1992	
Existing Average/Peak DO (Ml/d)			3.60		3.95		12.30		12.70		1.06		8.65		9.15		11.39 (Av & Peak)		2.92 (Av & Peak)	
Emission Scenario	Projection Period	Simulation Results Percentile	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)	Minimum Modelled GWL (mAOD)	Climate Changed DO (Ml/d)
Low Emissions	2030	10th Percentile	10.41	3.6	20.93	4.15	10.70	13.4	10.26	13.4	22.75	0.95	8.83	8.65	20.67	8.90	10.60		14.54	3.16
		50th Percentile	9.64	3.58	20.42	4.05	10.56	13.2	10.12	13.3	25.59	1.07	8.76	8.65	20.87	9.00	8.94		10.85	2.92
		90th Percentile	8.91	3.56	19.56	3.8	10.08	13.1	9.64	13.1	28.82	1.17	8.53	8.55	21.03	9.00	6.18		6.92	2.55
	2060	10th Percentile	10.26	3.6	21.11	4.2	10.93	13.4	10.49	13.5	22.45	0.95	8.89	8.65	20.78	8.90	11.20	Average = 11.39 (Annual licence) Peak = 15.91 (Daily licence)	14.46	3.16
		50th Percentile	9.48	3.57	21.02	4.2	10.88	13.4	10.44	13.5	25.67	1.07	9.23	8.75	21.12	9.05	10.23		9.59	2.80
		90th Percentile	8.49	3.55	20.90	4.2	10.81	13.3	10.37	13.4	29.79	1.21	9.63	8.9	21.56	9.15	8.99		3.46	2.20
	2080	10th Percentile	10.20	3.6	21.08	4.2	10.91	13.3	10.47	13.5	22.37	0.95	8.89	8.65	20.77	8.90	11.14		14.45	3.16
		50th Percentile	9.36	3.57	21.01	4.2	10.92	13.3	10.48	13.5	25.89	1.07	9.26	8.75	21.16	9.05	10.23		9.18	2.80
		90th Percentile	9.62	3.57	20.22	3.95	9.62	12.7	9.18	13.1	28.31	1.16	9.11	8.75	21.10	9.00	6.63		6.26	2.50
Medium Emissions	2030	10th Percentile	10.37	3.6	20.97	4.15	10.66	13.2	10.22	13.4	22.36	0.95	9.00	8.7	20.61	8.90	10.85		14.66	3.24
		50th Percentile	9.79	3.58	20.27	3.95	10.16	13.1	9.72	13.25	24.58	1.03	8.89	8.65	20.67	8.90	8.63		11.70	2.92
		90th Percentile	8.99	3.55	19.47	3.8	9.70	12.8	9.26	13.1	27.47	1.13	8.69	8.55	20.81	8.90	6.09	Average = 11.39 (Annual licence) Peak = 15.91 (Daily licence)	8.08	2.70
	2060	10th Percentile	10.22	3.6	21.17	4.27	10.96	13.4	10.52	13.5	22.29	0.94	8.92	8.65	20.79	8.90	11.31		14.39	3.16
		50th Percentile	9.48	3.57	21.10	4.26	10.90	13.4	10.46	13.5	25.76	1.07	9.27	8.75	21.15	9.05	10.22		8.95	2.75
		90th Percentile	8.18	3.52	21.15	4.27	11.17	13.8	10.73	13.55	30.25	1.24	9.83	8.95	21.74	9.20	9.71		2.23	2.10
	2080	10th Percentile	10.20	3.6	21.40	4.27	11.08	13.8	10.64	13.55	22.14	0.92	9.09	8.75	20.83	9.00	11.84		14.16	3.15

Source			DUPW (Average Demand)		DGPW (Peak Demand)		FD36PW) (Average Demand)		FD36PW (Peak Demand)		GCPW (Average & Peak Demand)		GWPW (Peak Demand)		MEPW (Peak Demand)		WEPW (Average & Peak Demand)		WCPW (Average & Peak Demand)	
		50th Percentile	9.22	3.57	21.41	4.27	11.22	13.8	10.78	13.55	26.01	1.07	9.52	8.85	21.29	9.10	11.17		8.44	2.70
		90th Percentile	9.10	3.57	20.77	4.1	10.16	13.3	9.72	13.25	29.08	1.18	9.59	8.9	21.39	9.10	8.05		4.28	2.30
High Emissions	2030	10th Percentile	10.35	3.6	20.45	4.05	10.68	13.6	10.24	13.4	22.61	0.96	8.90	8.65	**20.65**	8.90	10.73		14.67	3.20
		50th Percentile	9.82	3.57	19.79	3.86	10.17	13.3	9.73	13.25	24.78	1.03	8.88	8.65	20.68	8.90	8.61		11.58	2.92
		90th Percentile	8.99	3.57	**18.96**	**3.6**	9.63	13.1	9.19	13.1	27.62	1.13	**8.86**	8.65	20.78	8.90	**6.10**		7.69	2.65
	2060	10th Percentile	10.26	3.6	20.61	4.1	10.93	13.6	10.49	13.5	22.44	0.95	8.89	8.65	20.78	8.90	11.20	Average = 11.39 (Annual licence) Peak = 15.91 (Daily licence)	14.47	3.16
		50th Percentile	9.48	3.57	20.51	4.05	10.88	13.6	10.44	13.5	25.66	1.07	9.23	8.75	21.12	9.05	10.23		9.60	2.85
		90th Percentile	**8.49**	3.55	20.40	4.04	10.81	13.6	10.37	13.4	29.79	1.21	9.63	8.9	21.56	9.15	8.99		**3.46**	2.30
	2080	10th Percentile	10.20	3.6	20.58	4.06	10.91	13.7	10.47	13.5	**22.37**	0.95	8.89	8.65	20.77	8.90	11.14		14.45	3.20
		50th Percentile	9.36	3.56	20.51	4.06	10.92	13.7	10.48	13.5	25.89	1.07	9.25	8.75	21.16	9.05	10.22		9.19	2.80
		90th Percentile	9.62	3.56	19.71	3.85	**9.62**	12.7	**9.18**	13.1	28.31	1.16	9.11	8.75	21.10	9.00	6.62		6.26	2.50