VEOLIA WATER PROJECTS LIMITED

WATER RESOURCES MANAGEMENT PLAN

APPENDIX 3 - CLIMATE CHANGE METHODOLOGY

INTRODUCTION

Climate change will impact on the operation and resilience of the VWP Tidworth area of supply.

- Low ground water levels – consecutive dry years could result in low ground water levels that would impact on the deployable output of the sources and this could lead to drought

- High ground water levels – these will influence the flow of water through the nearby River Bourne and this could result in flood risk due to increased rainfall in the catchment basin

- Hot weather extreme events – these are likely to be more common and prolonged. This will influence peak demand on the water network

- Cold weather extreme events – variation in weather could well impact on leakage due to sudden thaws after prolonged freezing periods

The likely impact of such events is covered in Appendix 2 – Resilience. This appendix focuses on the method used to predict ground water levels.

Sudden variations in weather cannot be adequately modelled, but reference is made in Appendix 2 of recent sudden extreme events and the observed impact on the operation of the network.

1 DESCRIPTION

Climate change will influence the operation of VWP. One of the main considerations is ground water levels as these influence the availability of source water and if insufficient could lead to a drought.

The following is an extract from section 6 of the AECOM report 'Tidworth STW Infiltration modelling'. This project involved the prediction of ground water levels at Tidworth STW's, specifically the observation borehole using best practice principles when it comes to applying climate change scenarios.

The starting point for the analysis of climate change impacts is the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios in which four groups of emissions scenarios were considered in terms of their projected impact on climate change.

One scenario, known as SRESA1B, was used for subsequent climate modelling. This scenario assumes rapid economic growth, a moderate population increase and a balance between fossil and non-fossil fuels to meet energy needs.

The ‘modelling chain’ which stems from this scenario is shown in Figure 20. The Met Office Hadley Centre Regional Climate Model (HadRM3) was used to dynamically downscale Global Circulation Model (GCM) results as part of the climate change experiments carried out for the 2009 UK Climate Projections report (UKCP09).

The HadRM3-PPE experiment was designed to simulate the regional climate for the UK in the period 1950-2100 for the historical and medium (SRESA1B) emissions scenario. The model was run for the wider European area and the UK data extracted from it. The ‘Perturbed Physics Ensemble’ (PPE) consists of an 11-member ensemble, each member driven by the same historical and SRESA1B emissions, with one unperturbed member and 10 members with different perturbations to the atmospheric parameterisations (slight variations in, amongst other things, convective parameterisation and cloud microphysics).

The standard forcings include historical levels of greenhouse gases (including methane), sulphur (direct and first indirect forcing, sulphur chemistry without natural dimethyl sulphide and SO2 background emissions; anthropogenic SO2 emissions from surface and high level only) and tropospheric / stratospheric ozone.

Drawing on the results of HadRM3-PPE, the Future Flows and Groundwater Levels (FFGWL) project has applied a consistent methodology to the assessment of the impact of climate change on river flows and groundwater levels across England, Wales and Scotland using the 11-member PPE.

The HadRM3-PPE time series are provided at a 25-km grid spatial resolution and daily time temporal resolution. However, analyses of precipitation and temperature time series for the historical (pre-2000) period showed systematic differences from observations because their coarse spatial resolution does not allow for small-scale atmospheric processes to be adequately reproduced for the purpose of modelling river flow and groundwater levels. The HadRM3-PPE daily outputs were modified using a statistical technique so that their statistical properties match those of the observations for the same periods and a spatial downscaling was applied to incorporate the spatial heterogeneity observed in precipitation within each 25-km grid square.

Potential evapotranspiration at 5-km resolution was generated using the HadRM3-PPE climate time series, based on the FAO-56 Penman-Monteith method. Groundwater levels were simulated using R-Groundwater, a simple lumped catchment groundwater model developed to model groundwater level time series at observation boreholes by linking simple algorithms to simulate soil drainage, the transfer of water through the unsaturated zone and groundwater flow.

The RGroundwater model consists of three components (Figure 21): a soil moisture balance model producing a time-series of potential recharge (soil drainage), a simple transfer function representing the delay in the time of the arrival of recharge from the base of the soil to the water table, and a lumped catchment groundwater model based on a simple Darcian representation of flow out of a series of aquifer ‘outlets’.

FFGWL developed two unique datasets for Great Britain:

- Future Flows Climate (FF-HadRM3-PPE), an 11-member ensemble 1 km gridded projection time series (1950-2098) of precipitation and potential evapotranspiration for Great Britain.

- Future Flows Hydrology (FF-HydMod-PPE), an 11-member ensemble projection of daily river flow and monthly groundwater levels time series (1951-2098) for 282 rivers and 24 boreholes in Great Britain.

These datasets represent a nationally consistent ensemble of 11 plausible realisations (all equally likely) of 148 years of climate, river flow and groundwater regime, and enable the investigation of the role of climate variability on river flow and groundwater levels nationally and how this may change in the future. Considering all ensemble members together accounts for some climate change uncertainty.

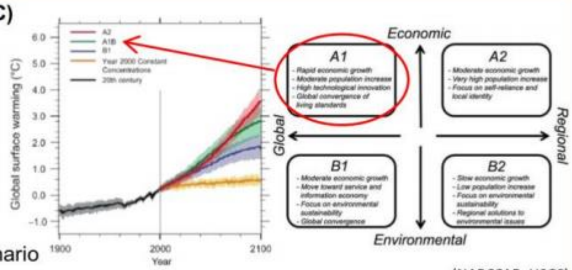
2. PROCESS DIAGRAM

Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES)

Four different groups of emissions scenarios considered

SRES A1B is based on rapid economic growth, moderate population increase and 'balanced' (B) energy sources (fossil intensive and non-fossil)

Considered a medium emissions/climate change scenario



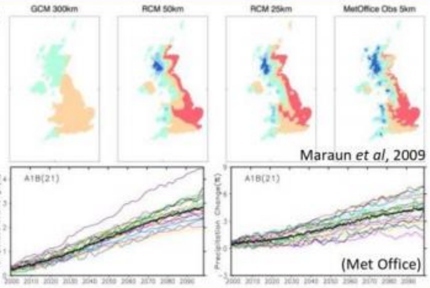
(NARCCAP; USGS)

Met Office Hadley Centre Regional Climate Model 3 (HadRCM3) 11-member Perturbed Physics Ensemble (PPE)

Based on SRES A1B (note: all members of the ensemble are distinct realisations derived from a single emissions scenario)

Downscaling from Global Climate Model (GCM) to Regional Climate Model (RCM)

Uses atmospheric perturbations to generate 10 simulations of climate from 1951-2099 (plus one unperturbed simulation)



Maraun *et al*, 2009

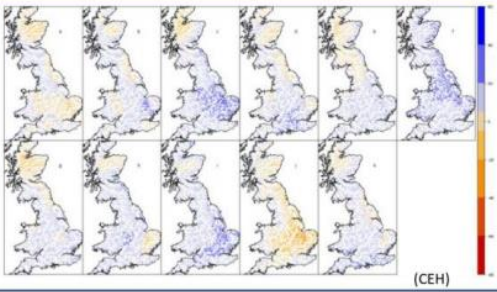
(Met Office)

BGS/CEH Future Flows and Groundwater Levels

Uses HadRCM3-PPE-UK based on SRES A1B with further downscaling of climate data to 1-km resolution

Catchment average Available Precipitation (AP) and Potential Evapotranspiration (PE) time series calculated from1951-2098 for each member of the ensemble for 283 river sites and 24 observation boreholes (OBHs)

Nationally consistent ensemble of 11 plausible realisations



(CEH)

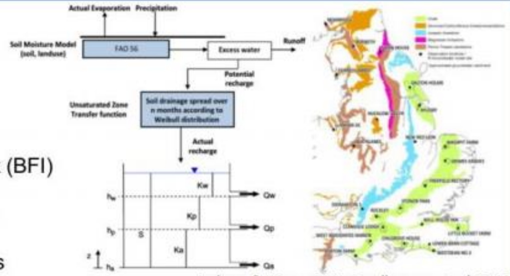
R-Groundwater model for 24 OBHs

AP and PE applied to a soil moisture model based on Food and Agriculture Organisation Irrigation and Drainage paper 56 (FAO56) to calculate 'excess water'

Runoff and potential recharge split based on Baseflow Index (BFI)

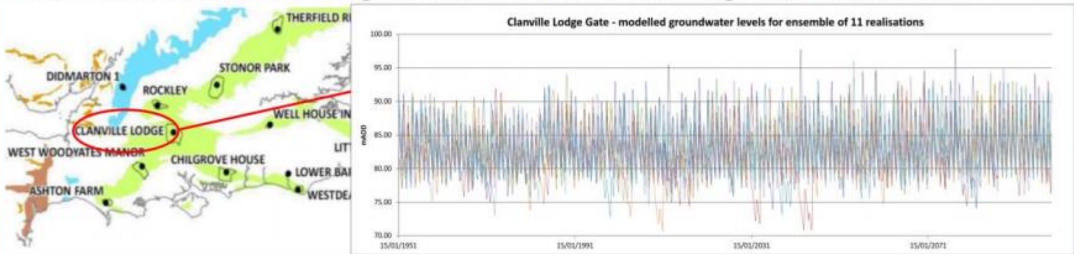
Unsaturated zone delay modelled using Weibull distribution

Groundwater represented by three-store model with outflows



Jackson & Wang, 2011; Prudhomme *et al*, 2013

Simulated 11-member ensemble of groundwater levels for Clanville Lodge Gate OBH, 1951-2098



3 CONCLUSIONS

The method outlined above aligns with best practice in terms of the selection of an appropriate climate change scenario which is then used to predict likely impact on the ground water table local to Tidworth.

Although the work completed by AECOM focused on the lagoon levels at Tidworth STW’s the results include a prediction of the Observation Borehole Level (OBH) which is used to monitor the availability of water at the boreholes.

The results can therefore be used to predict the probability of future events in terms of both high and low ground water events that in turn may result in drought or flood risk respectively.

4 RECOMMENDATIONS

Confirm that this methodology aligns with the Climate Change guidance of WRMP. This will be determined from feedback from DEFRA regarding the general WRMP submission. An assumption has been made that this will be reviewed during Quarter 3 of 2019.

VWP should therefore be ready to modify the scenario should this prove appropriate. However, given the scale of VWP activities and the involvement in the Salisbury Hydrology Group (refer to Appendix 3 – Resilience) it is assumed that this methodology is appropriate.

5 PLAN OF ACTION

			2019				2020				2121				2022				2023			
S/N	Element of Work	Pre S/N Req	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
12	Climate Change Methodology	-																				