**METADATA: DEPOSIT OF FILES IN RESEARCH DATA LEEDS**

Philip Rees, Stephen Clark, Rizwan Nawaz

Household Forecasts for the Planning of Long-Term Domestic Water Demand: Application to London and the Thames Valley

*Population, Space and Place, PSP-18-0065.R1*

This document provides a description of the data and code used to forecast households and domestic water demand in London and the Thames Valley, for a set of Water Resource Zones (Thames Water Utilities Ltd.).

**1. INFORMATION ABOUT THE DATA DEPOSIT**

Dataset title: **Household Forecasts for the Planning of Long-Term Domestic Water Demand: Application to London and the Thames Valley**

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**Roles**

Philip Rees is the contact author for the journal paper submission and the principal investigator for the project on future water demand and is the depositor of the dataset. He worked on Phases 1, 2 and 3 of the project. Stephen Clark is a post-doctoral research fellow, who worked on Phase 1 of the project, responsible for the computation of the population and household forecasts. Rizwan Nawaz worked as a post-doctoral research fellow on Phases 1 and 2 of the project, focussing on water demand modelling and future scenario development.

**Project title**

Long-Term Population and Property Forecasts for Thames Water

**Funder (s)**

Thames Water Utilities Limited (TWUL)

Engineering and Physical Sciences Research Council (EPSRC)

Economic and Social Research Council (ESRC)

**Grant number (s)**

TWUL: Collaborative Research Agreement with the University of Leeds for the project *Long-Term Population and Property Forecasts for Thames Water*, 1 June 2016 to 30 September 2017 (Principal Investigator, Professor Philip Rees).

EPSRC: Grant EP/I029346/1 (Dr. Rizwan Nawaz, Post-Doctoral Research Fellow).

ESRC: Grant ES/L013878/1 (NewETHPOP) (Principal Investigator, Professor Philip Rees).

**Academic subject**

Geography

**Institutional division**

Faculty of Environment

**2 DATASET DESCRIPTIONS**

Fig. M1 below sets out the overall framework for projecting water demand, equivalent to Figure 1 in the Population, Space and Place paper.

**Fig. M1. The framework for forecasting domestic water demand**

Notes: DCLG = Department of Communities and Local Government

PCC = Per Capita Consumption, PHC = Per Household Consumption (both in litres per day)

BaU = Business as Usual, LG = Light Green, DG = Dark Green



**Data and Code for the cleaning and aggregation of records**

See the Metadata associated with Nawaz et al. (2019), https://doi.org/10.5518/376.

**Data and Code for the analysis of the determinants of domestic annual average daily water demand**

See the Metadata associated with Nawaz et al. (2019), https://doi.org/10.5518/376.

**Data and Code for the analysis and projection of domestic annual average daily water demand**

The green modules in Fig. M1 input data on factors that help households to save water from the *Literature* into a diffusion model that implements water saving under the BaU, LG & DG *Scenarios* and produces Projected PCCs (Per Capita Consumption). PCCs are linked to and converted to Projected PHCs (Per Household Consumption) by household type.

The file used to forecast water demand from 2011 to 2101 for Thames Water region is: *Water Demand Projections Final-R2.xlsx* (EXCEL Workbook). The dark red module at the bottom of Fig.M1 holds the intermediate and final forecasts of domestic water demand. Into this file have been copied the Projected PHCs and PCCs, data from TWUL on the rollout of metering programme, and forecasts of households for Thames Water’s six water resource zones, classified by occupancy (persons per household), property type (detached, semi-detached, terraced, flats), ethnicity grouping of the head of household (South Asian, Other Asian). Through a series of documented workbook sheets and a set of assumptions, these inputs are converted into future water demand for water resource zones under three scenarios.

**Data and Code for the projection of local authority populations**

The methods and data for projecting local authority populations from 2011 to 2061 are described in Rees et al. (2016). The population projections data are available via <http://www.ethpop.org> or the UK Data Archive via Catalogue entry URL <https://discover.ukdataservice.ac.uk/catalogue/?sn=852508&type=Data%20catalogue>

SN (Study Number): 852508. The Mid-projection (L2Mid) was used for the local authority demographic projections. For the Thames Water project, the code was revised to improve the projected population outcomes for 2061 to 2101, using average mortality rates for ages 90+ to avoid a small number of negative populations and to adjust the populations at risk to match the occurrence-exposure rates used in all demographic components. The zip archive file, *L2MidPop2011-2101*, contains forecast populations by ethnicity, age and sex for 389 Local Authority Districts in the UK, at ten-year intervals, 2011, 2021, … , 2101. These forecasts populations underpin the household forecasts described in Rees et al. (2019).

**Data and Code for the projection of local authority households**

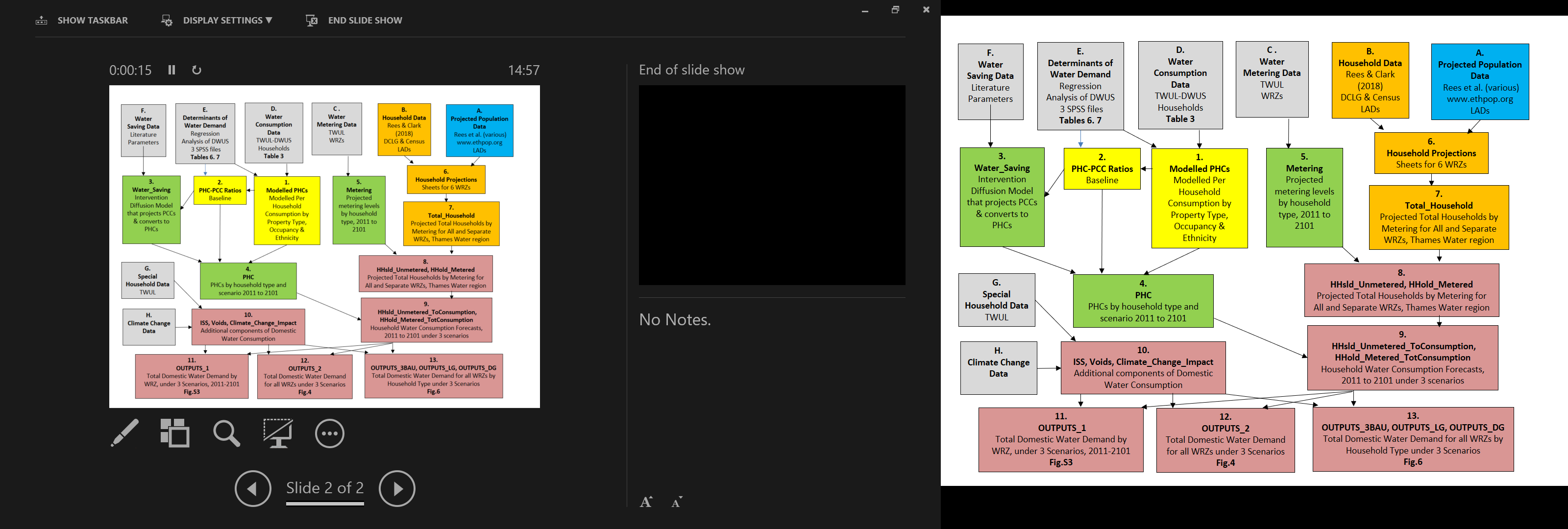
Fig.M1 orange modules implement the household forecasts. The methods and data for projecting households from 2011 to 2101 are described in Rees, Clark and Nawaz (2019). The data, models, or code generated or used during the study to forecast populations and households from 2011 to 2101 are available from the first author ([p.h.rees@leeds.ac.uk](mailto:p.h.rees@leeds.ac.uk)) or second author ([s.d.clark@leeds.ac.uk](mailto:s.d.clark@leeds.ac.uk)) by request. Files include input component assumption data and R code for preparing forecasts.

**3 DESCRIPTION OF THE WATER DEMAND WORKBOOK**

**Flow chart of the organization of the Water Demand Final workbook**

Fig. M2 is a flow chart showing the links between sheets in the Water Demand Final Projections workbook. The grey boxes contain External Data & Computations, available by request from the authors. The orange boxes contain Household Data & Computations and the Yellow Boxes contain Water Demand Data & Computations. Users can check our computations by using the flow charts to follow the computations. They can also replace input data or parameters in the workbook to produce alternative projections for the Thames Water region, or they can adapt the workbook to produce different water demand projections for other utilities or other geographies.

**Fig.M2. Flow Chart of Computations in the Water Demand Final.xlsx Workbook**



A through H = External Data Sets

1 through 13 = Sets of Sheets in the Workbook. Sets may contain just one sheet or several with similar structures (e.g. for different Water Resource Zones).

**A Projected Population Data**

Source(s): See [www.ethpop.org](http://www.ethpop.org) for data set and publications

Inputs: ETHPOP Mid-Population Projections, UK LADs, 2011-2061

Outputs: Extension of projections from 2061 to 2101, Extraction of Projected Populations for LADs in Thames Water Region

**B Household Data**

Source(s): See Rees, Clark and Nawaz (2019)

Inputs: ETHPOP populations, DCLG household formation rates, 2011 Census Microdata

Outputs: Projected Households by Occupancy, Property Type & Ethnicity for LADs in Thames Water Region, aggregated to WRZs, 2011-2011

**C Water Metering Data**

Source(s): Thames Water data on metering programme

Inputs: Percent Metered for Households by property type and WRZ

Outputs: Percent Metered 2011 to 2030, constant from 2031

**D Water Consumption Data**

Source(s): Thames Water and Artesia Consultants, see Data Availability statement

Inputs: Thames Water Domestic Water User Survey, daily records, 2006 to 2015

Outputs: Daily records cleaned and summed as Annual Average PHC

**E Determinants of Water Demand**

Source(s): Thames Water’s Domestic Water User Survey

Inputs: DWUS data in TW\_InputData.sav, code in TW\_Model.sps

Outputs: TW\_Output.spv, Table 3 in JWRPM paper, Regression model results and predicted PHCs

**F Water Saving Data**

Source(s): Journal Papers and Water Utility Reports, 1990 to 2017

Inputs: Summaries of literature on impacts of water saving interventions

Outputs: Change parameters for Water Saving Model

**G Special Household Data**

Source(s): Report to Thames Water by Edge Analytics (2016), using mainly 2011 Census data

Inputs: Data on Clandestine & Hidden Populations, Voids

Outputs: Numbers of Special Households & Voids

**H Climate Change Data**

Source(s): HR Wallingford (2012), based on analysis of climate record and domestic water demand

Inputs: Percent change in domestic water demand due to climate change

Outputs: Percent change per year calibrated for 2011 to 2035, extrapolated to 2101

**1.Modelled PHC**

Source(s): TW\_Output.spv

Inputs: Regression equations plus determinant variables

Outputs: Modelled Per Household Consumption by Property Type, Occupancy, Ethnicity & Water Resource Zone

**2.PHC-PCC Ratios**

Source(s): C:\Users\Philip\Documents\WORK\Research\Projects\Thames Water\Domestic Water Consumption\Phase 2\Drivers\Scenarios for Water Consumption PR Design.xslx

Inputs: Modelled PHCs from TW\_Output.spv, Household estimates based on 2011 Census microdata and local data, described in Rees, Clark & Nawaz (2019).

Outputs: For the baseline 2006-2015 period the ratios of modelled PHCs for household categories to the weighted average PCC associated with the modelled PHCs.

**3.Water\_Saving**

Source(s): E.Water Saving Data,PHC/PCC Ratios derived from TW\_Output.spv

Inputs: Water PCC savings parameters from intervention, Percent take-up at limit, Start year, End year

Outputs: Intervention Diffusion Model that projects PCCs & converts to PHCs

**4.PHC**

Source(s): 2 Inputs

Inputs: Projected Per Household Consumption by Scenario

Outputs: PHCs by household type and scenario 2011 to 2101

**5.Metering**

Source(s): C.Water Metering Data

Inputs: Water metering take-up planned by Thames Water

Outputs: Projected metering levels by household type, 2011 to 2101

**6.Household Projections by WRZ (6 Sheets)**

Source(s): Detailed in Rees, Clark and Nawaz (2019), HRP = Household Representative Person, DCLG = Department of Communities and Local Government

Inputs: Projected population by age for LADs, sex and ethnicity, household formation rates by age of sex of HRP for LADs (from DCLG 2014-based projections), Household type propensity by occupancy, property type and ethnicity of HRP for LADs by age and sex of HRPs

Outputs: Projected household by type and WRZ, 2011 to 2101 in sheets 6.HHold\_GUILDFORD, 6.HHold\_HENLEY, 6.HHold\_KENNET\_VALLEY, 6.HHold\_LONDON, 6.HHold\_SLOUGH-WYCOMBE-AYLESBURY, 6.HHold\_SWOX.

**7.Total\_Household**

Inputs: 6.Household Projections by WRZ

Outputs: Projected Total Households for All and Separate WRZs, Thames Water region

**8.HHsld\_Unmetered, HHold\_Metered**

Inputs: 5.Metering, 7.Total\_Household

Outputs: Projected Total Households by Metering for All and Separate WRZs, Thames Water region

**9.Hhsld\_Unmetered\_Consumption, Hhold\_Metered\_Consumption**

Inputs: 4.PHC, 8.Hhsld\_Unmetered, Hhold\_Metered

Outputs: Household Water Consumption Forecasts, 2011 to 2101 under 3 scenarios

**10.ISS, Voids, Climate\_Change\_Impacts**

Source(s): F.Special Household Data, G.Climate Change Data

Inputs: Numbers of Special Households & Voids, Climate Change percent change per year calibrated for 2011 to 2035, extrapolated to 2101

Outputs: These additional components of Domestic Water Consumption

**11.OUTPUTS\_1**

Inputs: 9.Hhsld\_Unmetered\_Consumption, Hhold\_Metered\_Consumption, 10.ISS, Voids, Climate\_Change\_Impacts

Outputs: Projections of Total Domestic Water Demand by WRZ under 3 Scenarios

**12 OUTPUTS\_2**

Inputs: 9.Hhsld\_Unmetered\_Consumption, Hhold\_Metered\_Consumption, 10.ISS, Voids, Climate\_Change\_Impacts

Outputs: Total Domestic Water Demand for all WRZs under 3 Scenarios

**13 OUTPUTS\_3BAU, OUTPUTS\_LG, OUTPUTS\_DG**

Inputs: 9.Hhsld\_Unmetered\_Consumption, Hhold\_Metered\_Consumption, 10.ISS, Voids, Climate\_Change\_Impacts

Outputs: Total Domestic Water Demand for all WRZs by Household Type under 3 Scenarios

**14 Figure**

Inputs: 11.OUTPUTS\_1

Outputs: Graph of Total Domestic Water Consumption by Scenario

**15 Figure**

Inputs: 12.OUTPUTS\_2

Outputs: Graph of Total Domestic Water Consumption by Property Type, Occupancy & Ethnicity

**16 Fig.6 in Paper**

Inputs: 13.OUTPUTS3\_BAU, OUTPUTS3\_LG, OUTPUTS3\_DG

Outputs: Graph of Total Domestic Water Consumption by WRZ

**References**

Nawaz, R., Rees, P., Clark, S. Mitchell, G., McDonald, A., Kalamandeen, M. Lambert, C. & Henderson, R. (2019) Long-Term Projections of Domestic Water Demand: A Case Study of London and the Thames Valley. *Journal of Water Resource Planning & Management*, 2019, 145(11): 05019017. DOI: 10.1061/(ASCE)WR.1943-5452.0001088

Rees, P., Wohland, P., Norman P., Lomax, N. and Clark, S. (2016). Population projections by ethnicity: challenges and solutions. Chapter 18, 383-408 in Swanson, D. (ed.) *The Frontiers of Applied Demography*. Springer, Switzerland

Rees, P., Clark, S. & Nawaz, R. (2019) Household Forecasts for the Planning of Long-Term Domestic Water Demand: Application to London and the Thames Valley. *Population, Space and Place, PSP-18-0065.R1*