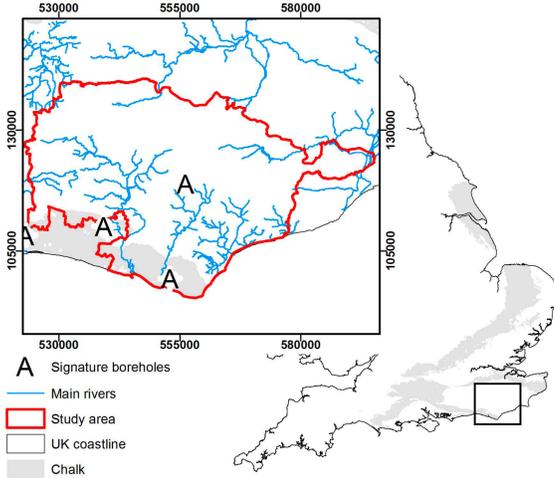


Study area



~ 50% groundwater supply
~40% surface water supply
~ 10% transfer imports
No regional groundwater model available

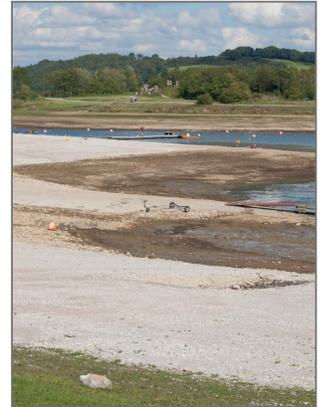
Model represents:

38 groundwater sources
3 reservoirs
8 water treatment works
3 transfer imports

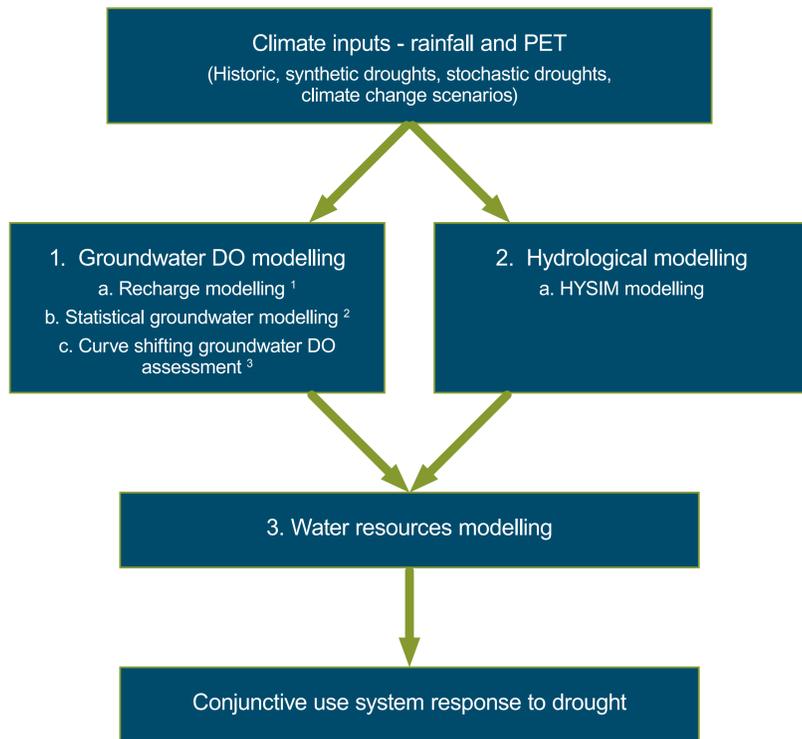


Background

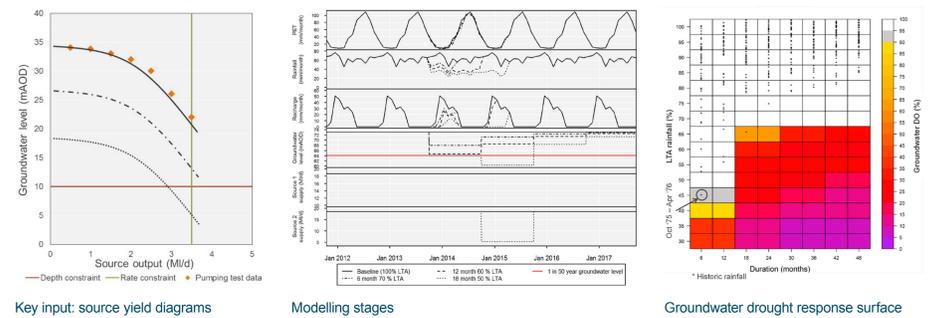
- > Traditionally water resource systems in the UK are assessed based on their performance during the worst historic drought
- > Current guidance suggests UK water companies need to plan system resilience to foreseeable future events and historic events
- > The uncertainty surrounding the predictions of groundwater supply during periods of low groundwater levels poses a challenge to water resource managers



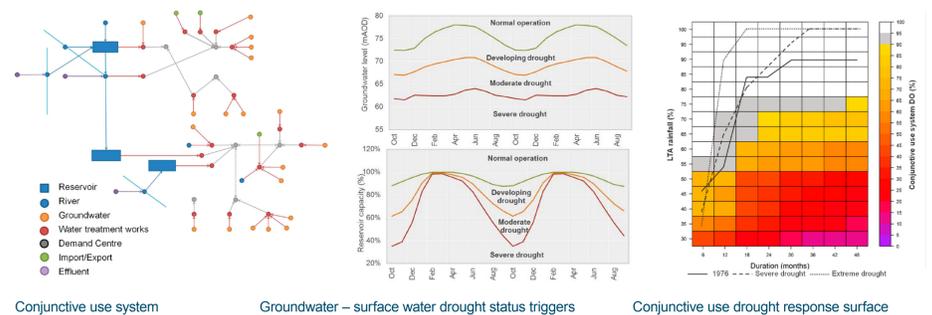
Methodology



Step 1: Groundwater DO modelling



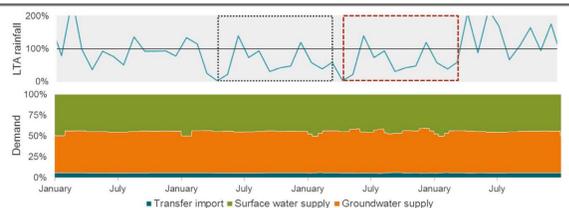
Step 3: Water resources modelling



System behaviour during droughts beyond the historic record

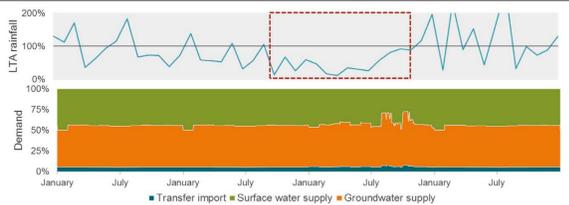
Third dry winter

- > April 2011 to March 2012 repeated
- > Demand fulfilled
- > Increased supply from groundwater sources



'Severe' drought

- > Stochastic drought, 13 months below LTA
- > Demand fulfilled
- > Groundwater supply maximised
- > Surface water supply reduced



References

- Allen et al., 1998, FAO Irrigation and Drainage Paper No.56
- Bloomfield et al., 2003, WEJ 17:86
- UKWIR, 2014, Handbook of source yield methodologies

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Conclusions

- > Methodology to systematically test conjunctive use system to drought successfully developed
- > Operational practice of balancing resources better reflected through conjunctive use modelling of groundwater and surface water
- > Generic approach. Applicable to a wide range of supply systems, as well as varying hydrological, geological, and hydrogeological settings
- > Groundwater supply represented as a function of the current understanding of source configuration, operation, and relationship to groundwater level fluctuations at an observation borehole
- > Selection of relevant metrics is key, and requires early input from water resource managers
- > Drought response surfaces successfully used to:
 - Provide high level view of individual source and conjunctive use system resilience to drought
 - Screen sources where further investigation required
 - Test role of infrastructure constraints on drought resilience

Future work

- > Physical representation of groundwater processes
- > Improved representation of pumping borehole groundwater levels
- > Improved representation of gravel sources

Use in UK water resources planning

- > Consideration of droughts beyond the historic record
- > Stochastic droughts used to identify 'Design', 'Severe', and 'Extreme' droughts reported in WRMP 2019 DO planning tables
- > Climate change factors (UKCP09 derived) used to assess range and likelihood of potential impacts on DO to 2080s
- > Reservoir curves optimised using a genetic algorithm to reflect conjunctive use
- > Conjunctive use modelling used to assess potential options and their interaction with existing sources and parallel options