



UK Groundwater Forum

Raising awareness of groundwater

Groundwater

“Out of sight, out of mind?”

RAISING AWARENESS OF GROUNDWATER

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2. Groundwater in the environment
3. Making use of groundwater
4. Groundwater resource management
5. Groundwater contamination & protection

What is Groundwater?

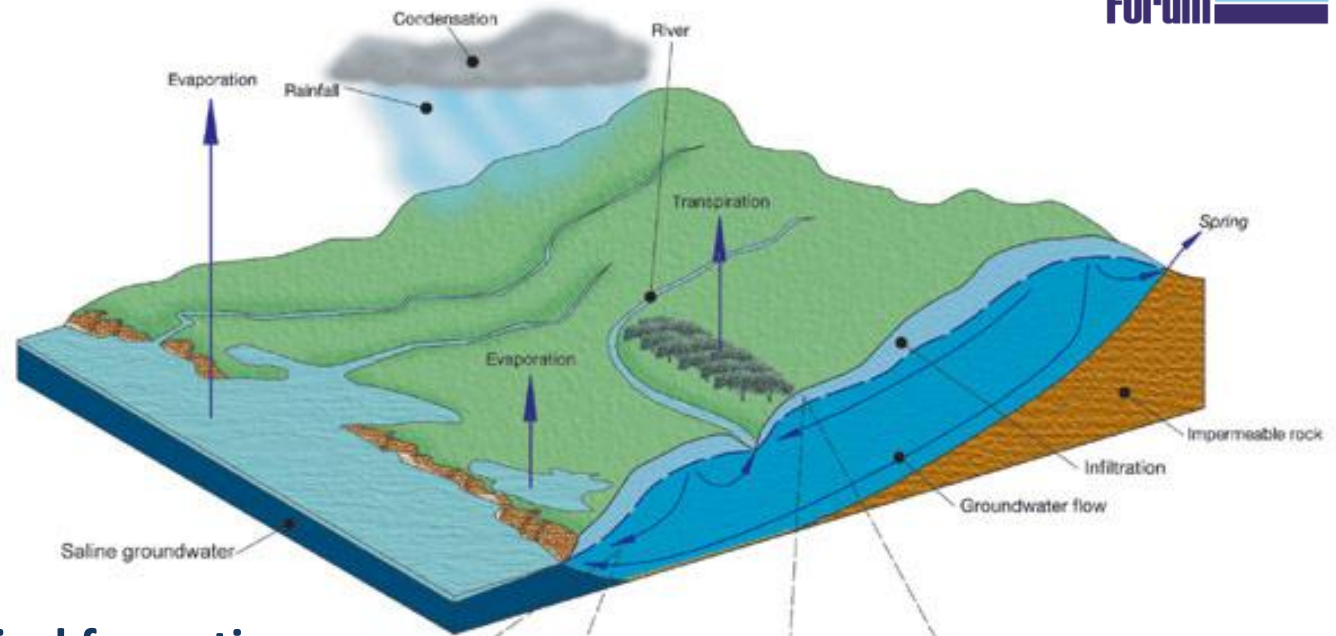


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Groundwater Basics & its Use

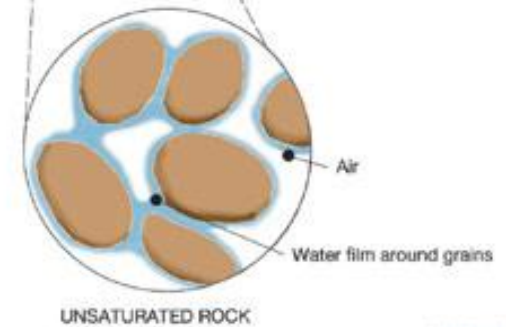
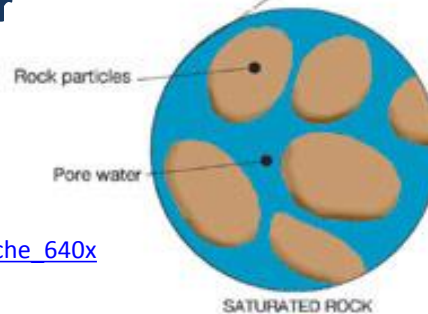
1. Groundwater in the water cycle
2. The World's water
3. Principal aquifers of the World & groundwater use
4. Groundwater in the UK

The Water Cycle



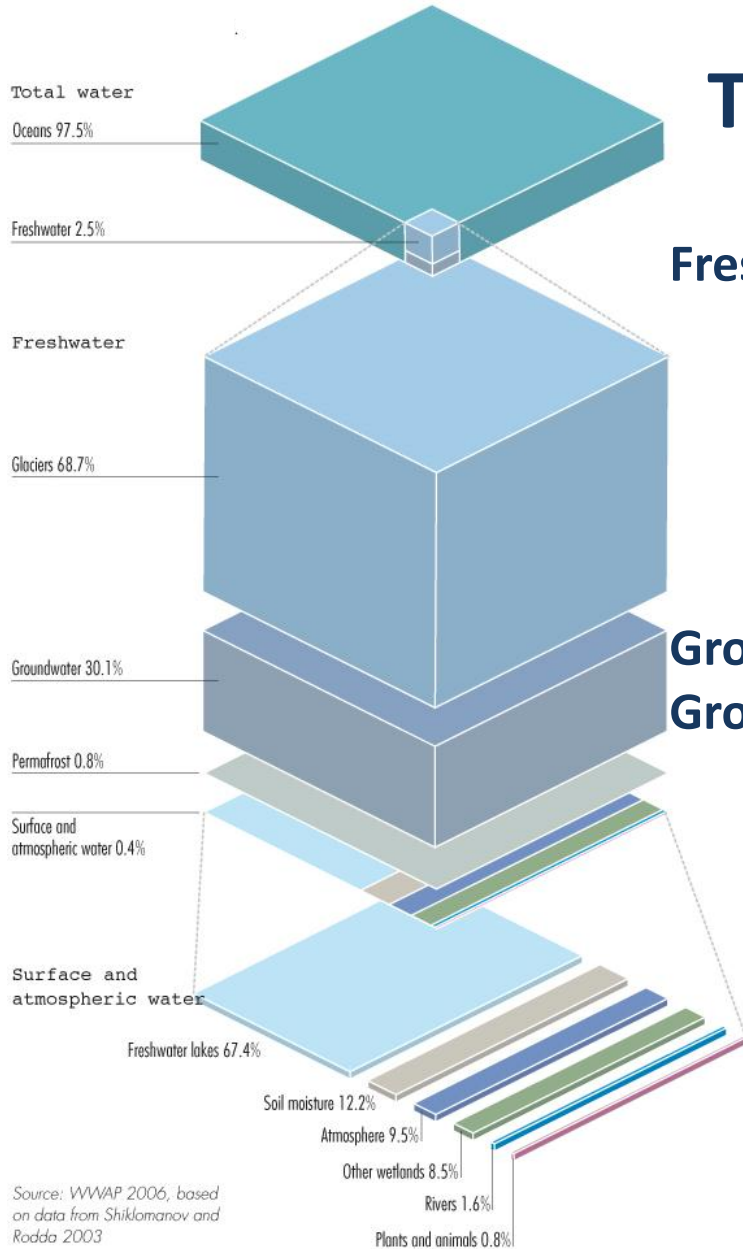
Aquifer

An underground geological formation that transmits & contains appreciable quantities of groundwater



http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf048.jpg

The World's Water



Freshwater = 2.5% of all water: 35,000,000 billion m³

Groundwater = 30% of freshwater: 10,500,000 billion m³

Groundwater = 96% of available freshwater

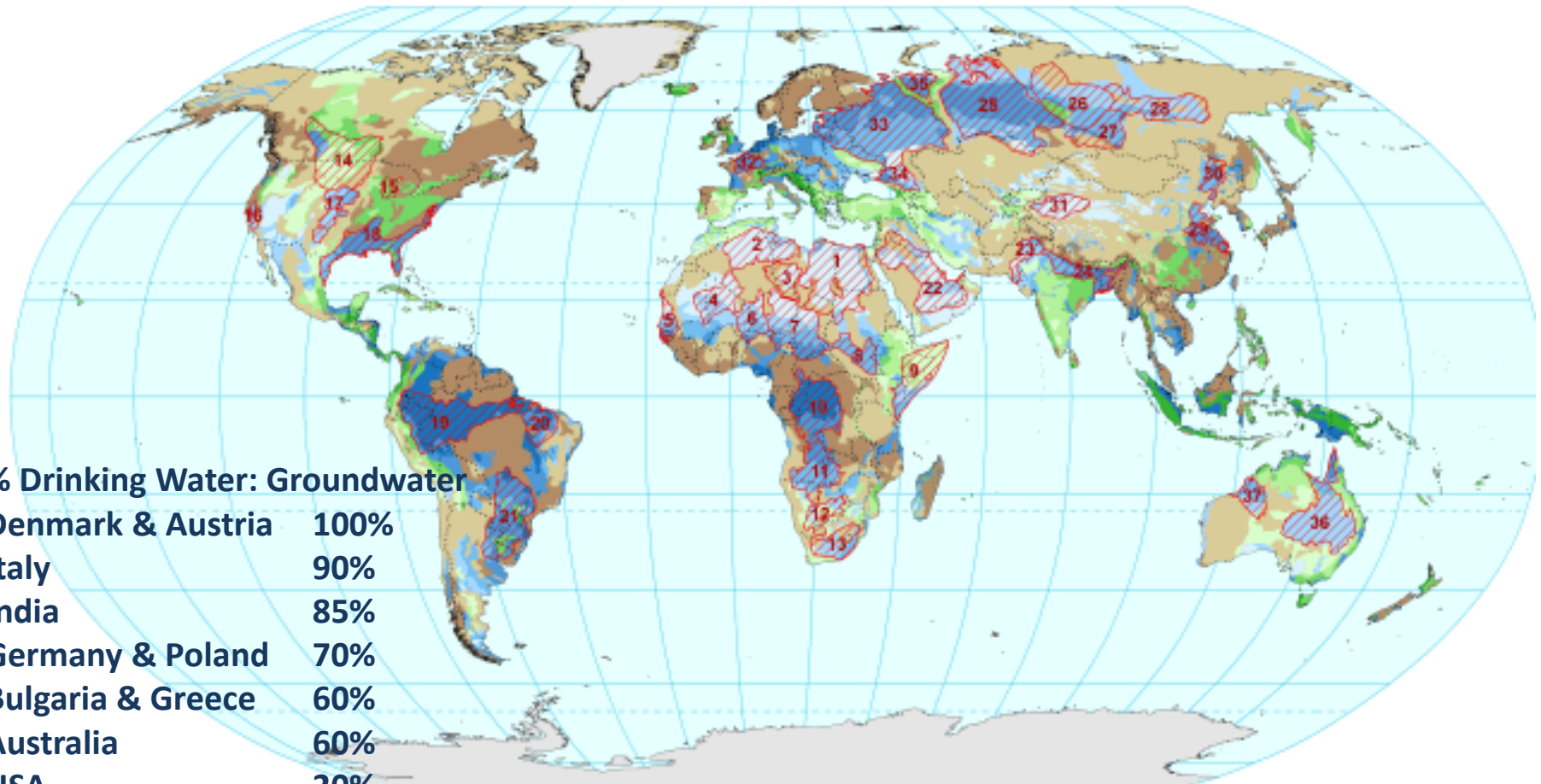
Groundwater:

**The World's most extracted
raw material**

600-700 billion m³/year

Source: WWAP 2006, based on data from Shiklomanov and Rodda 2003

Principal Aquifers of the World



WHYMAP & Margat 2008

http://www.whymap.org/whymap/EN/Downloads/Global_maps/whymap_largeaquifers.pdf?_blob=publicationFile&v=3

Principal UK Aquifers & Groundwater Use

Principal UK aquifers:

- Cretaceous Chalk
- Jurassic Limestones
- Permo-Triassic Sandstones

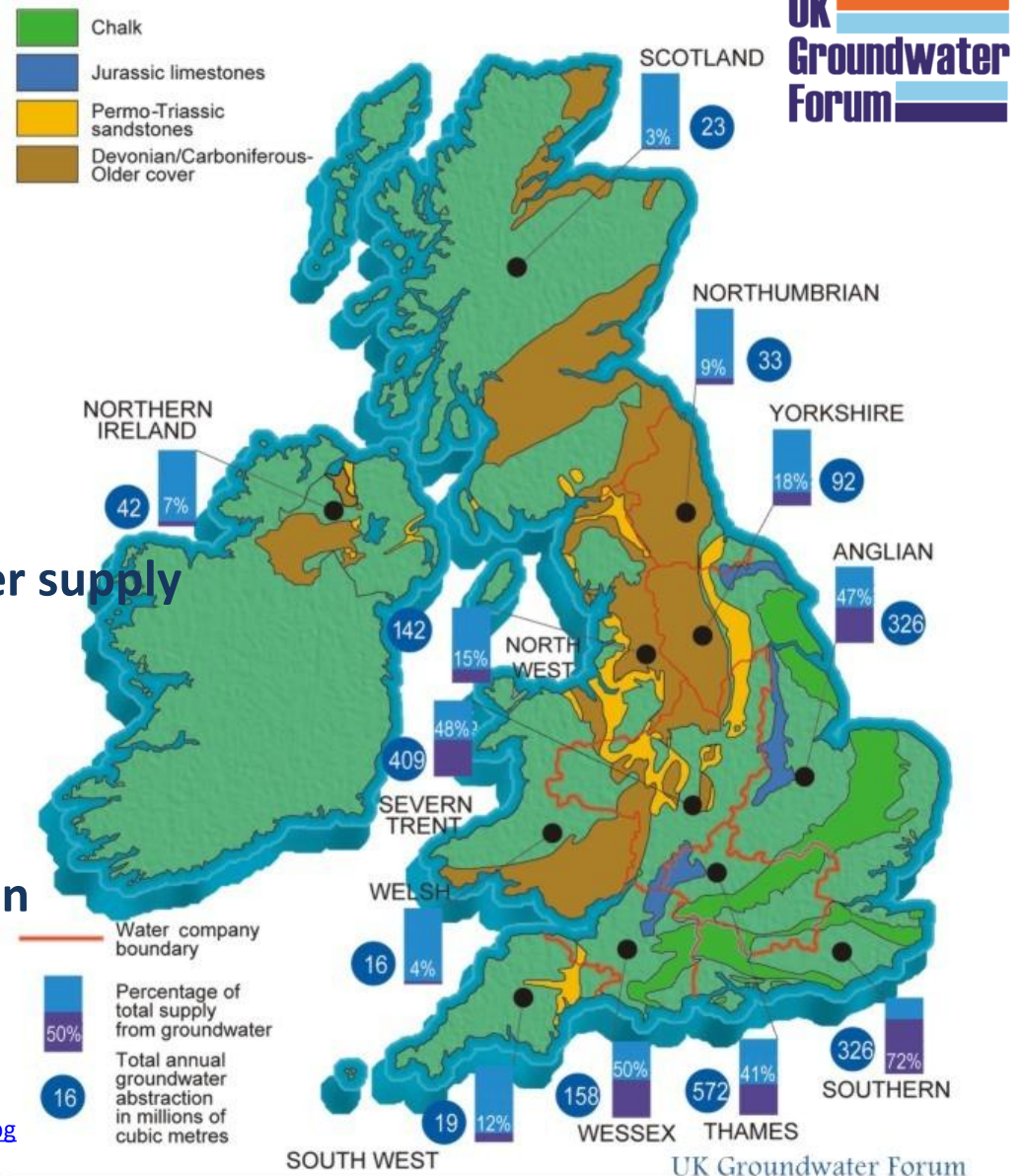
Groundwater provides ~35% of water supply

Regionally variable:

- 3% in Scotland
- 72% in South East England

Recent peak groundwater abstraction
2.3 billion m³ in 2003

http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf005.jpg



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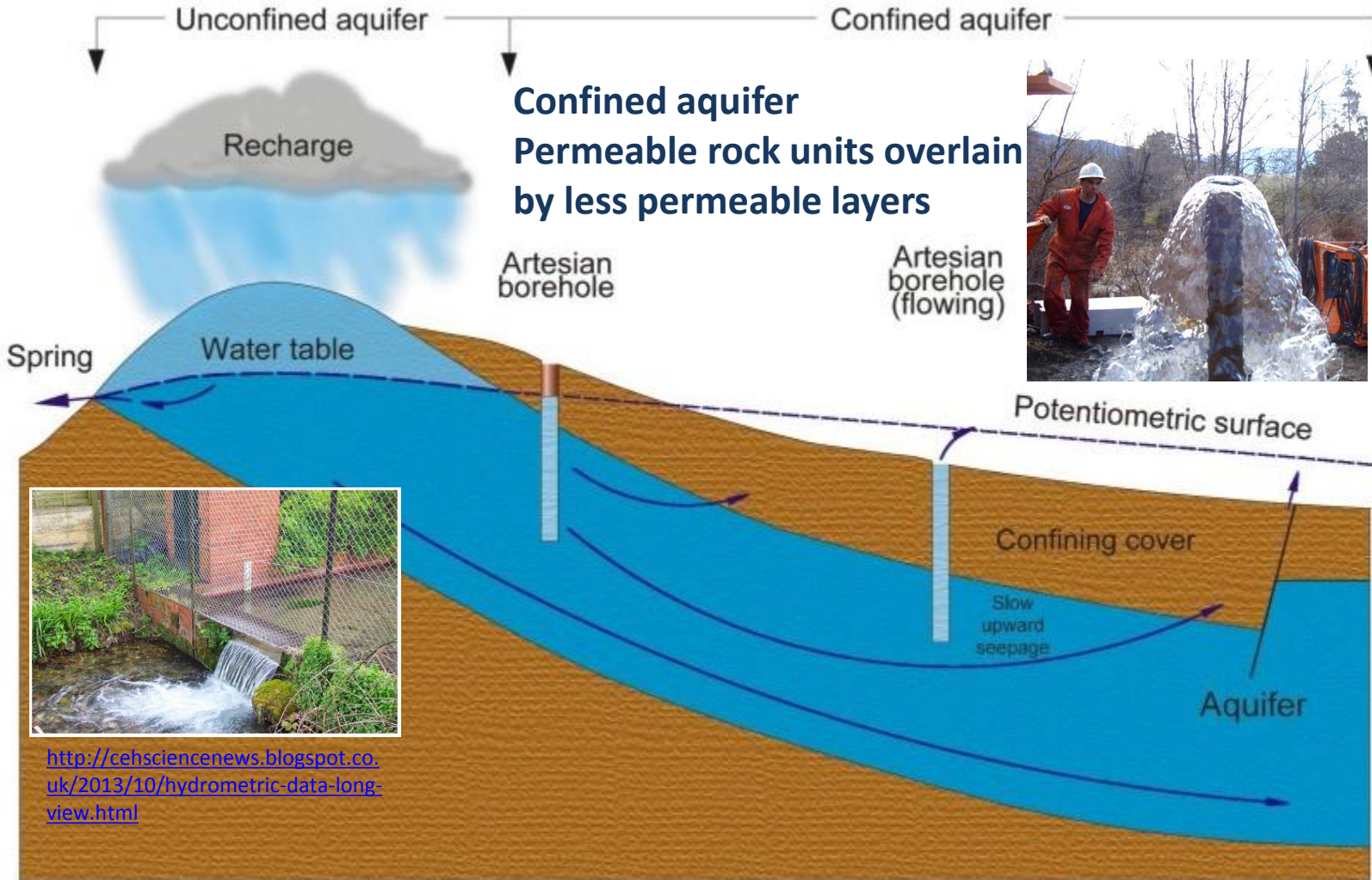
Uses of Groundwater

1. Drinking & domestic use
2. Farming, e.g. irrigation, cattle watering, fish farming
3. Construction, e.g. concrete, cement
4. Food & drinks manufacturing
5. Heating & cooling buildings
6. Industry, e.g. hydrocarbons, fracking
7. Mining, e.g. minerals processing

Groundwater in the Environment

1. Where can we see groundwater?
2. Wetlands & groundwater
3. Why do rivers flow when it's not raining?
4. The emergence of groundwater: a natural hazard
5. The ups & downs of groundwater

Unconfined & Confined Aquifers



<http://www.ahwelldrilling.ca/well-drilling/artesian-wells/>



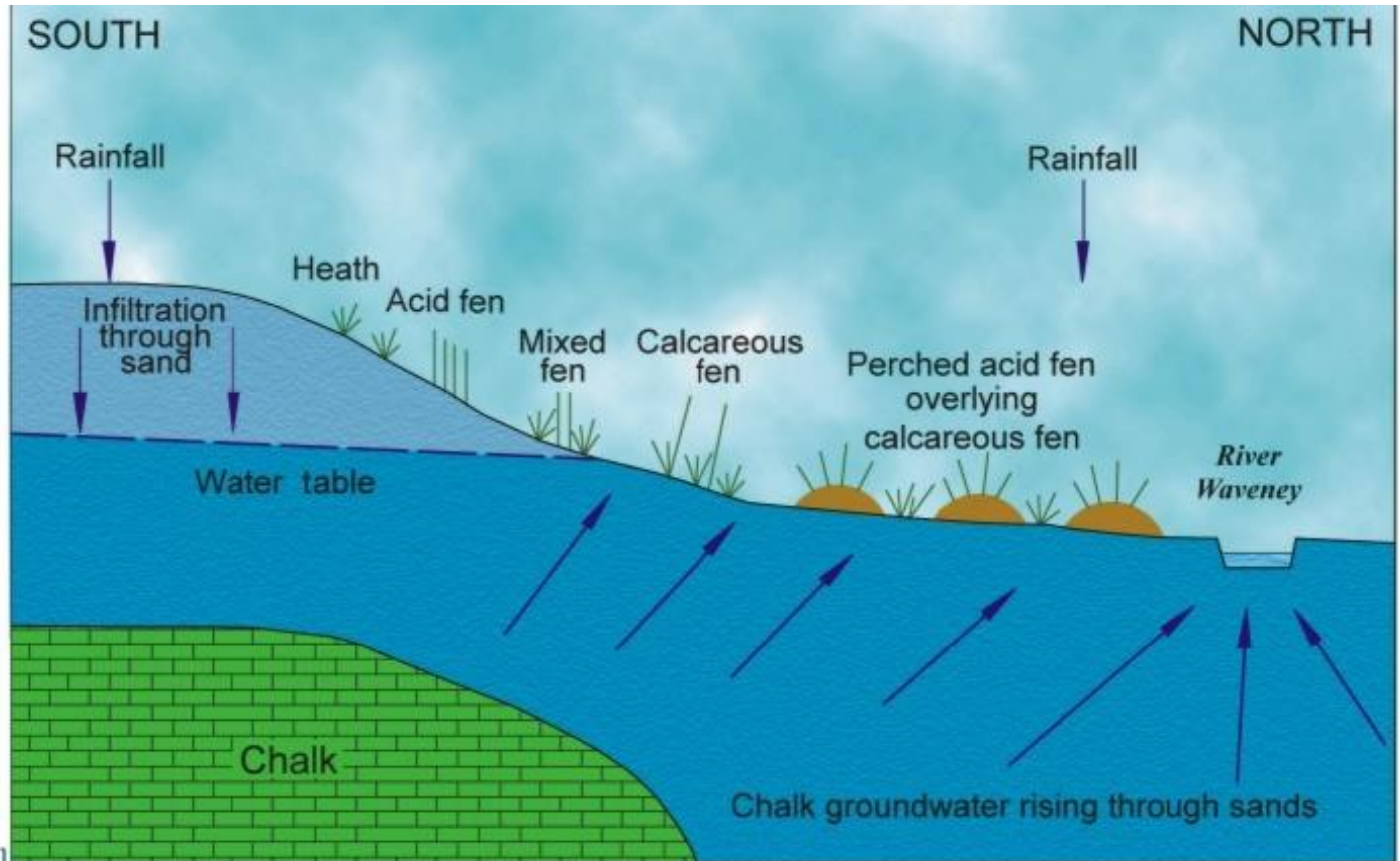
<http://cehsciencenews.blogspot.co.uk/2013/10/hydrometric-data-long-view.html>

http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf011.jpg

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Wetlands & Groundwater

Redgrave & Lopham Fen



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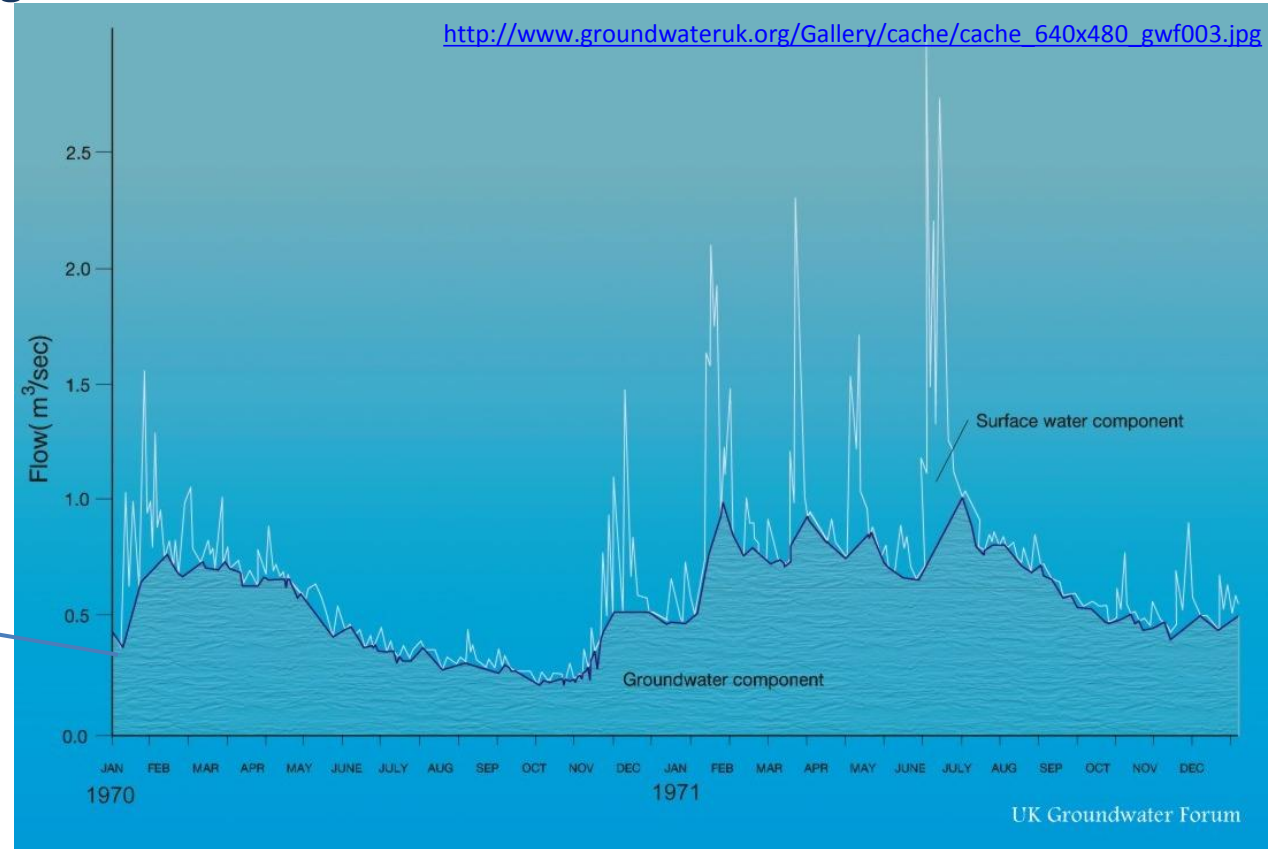
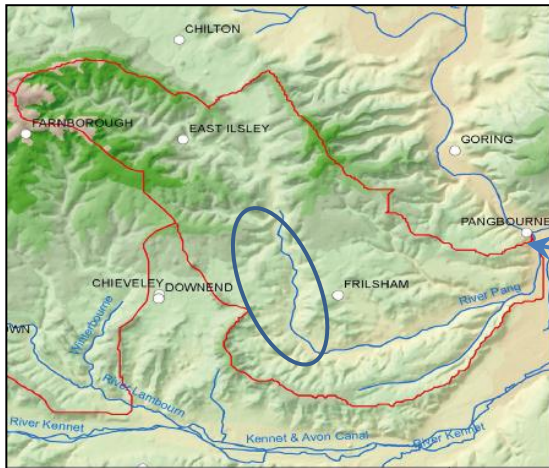
http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf028.jpg

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Groundwater as River Baseflow

River Pang

- Groundwater fed river in a Chalk catchment
- >90% of flow can be groundwater



Groundwater as River Baseflow

River Pang – this is groundwater



Where's the groundwater gone?



<http://www.thetimes.co.uk/tto/weather/article3618227.ece>

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Groundwater Flooding – The Other Extreme



<http://www.bgs.ac.uk/research/groundwater/flooding/groundwaterHomesFAQ.htm>

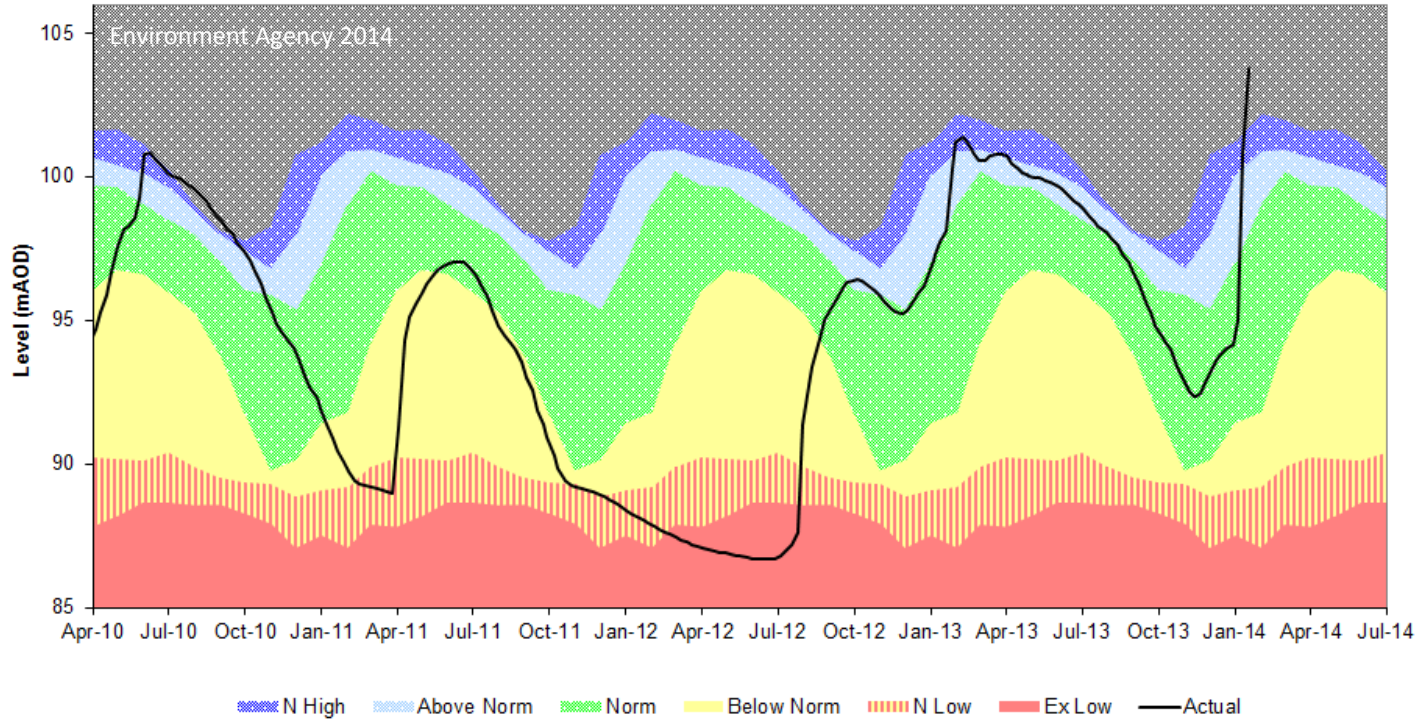


http://www.bgs.ac.uk/news/events/FTLEseminar/docs/posters/AHughes_Integrated_modelling.pdf

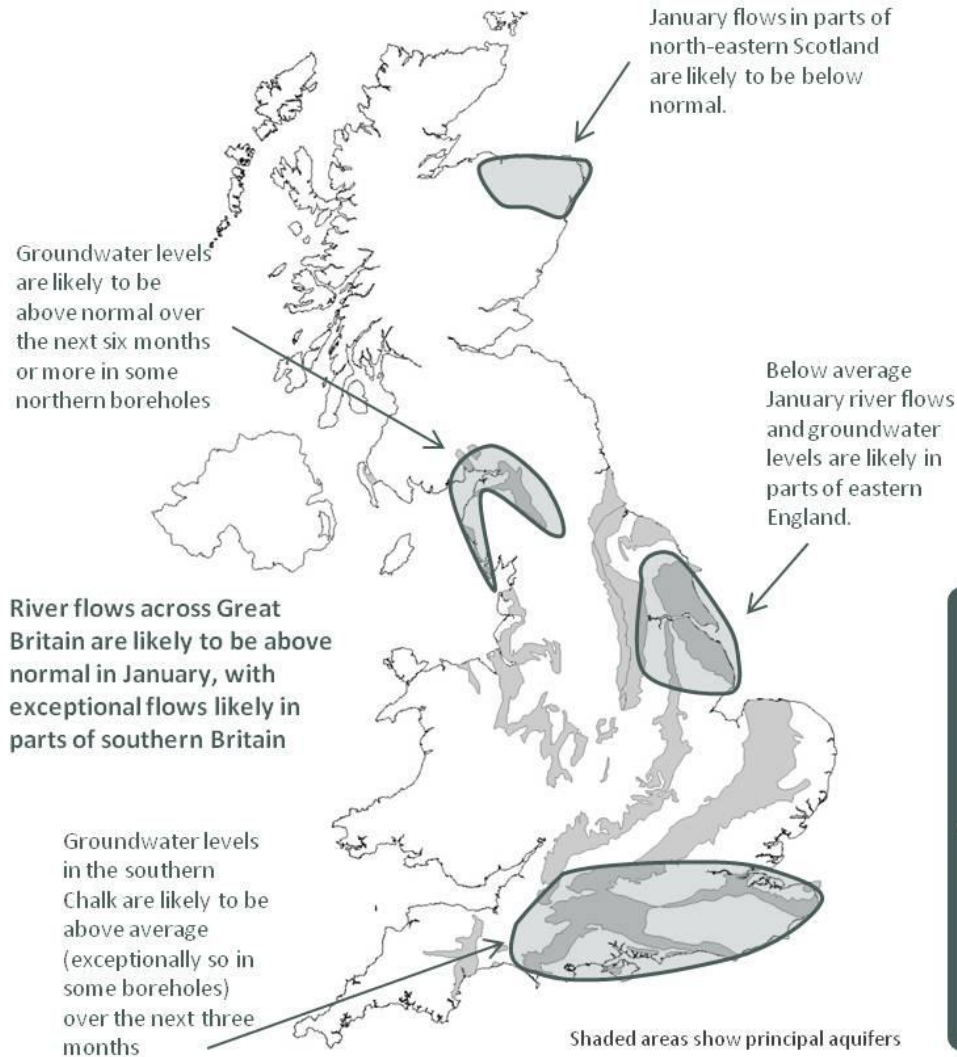
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The Ups & Downs of Groundwater

WELL HOUSE INN OBSERVATION BOREHOLE NORTH DOWNS SOUTH LONDON CHALK



Groundwater Forecasting



January 2014

Future of forecasting from:

Centre for Ecology & Hydrology

British Geological Survey

Met Office

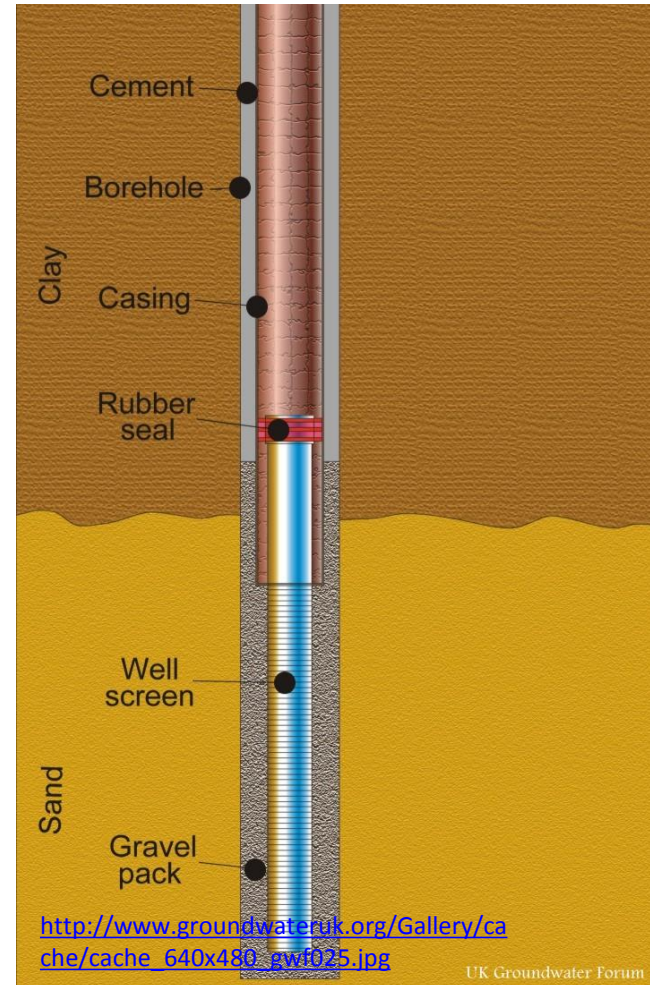
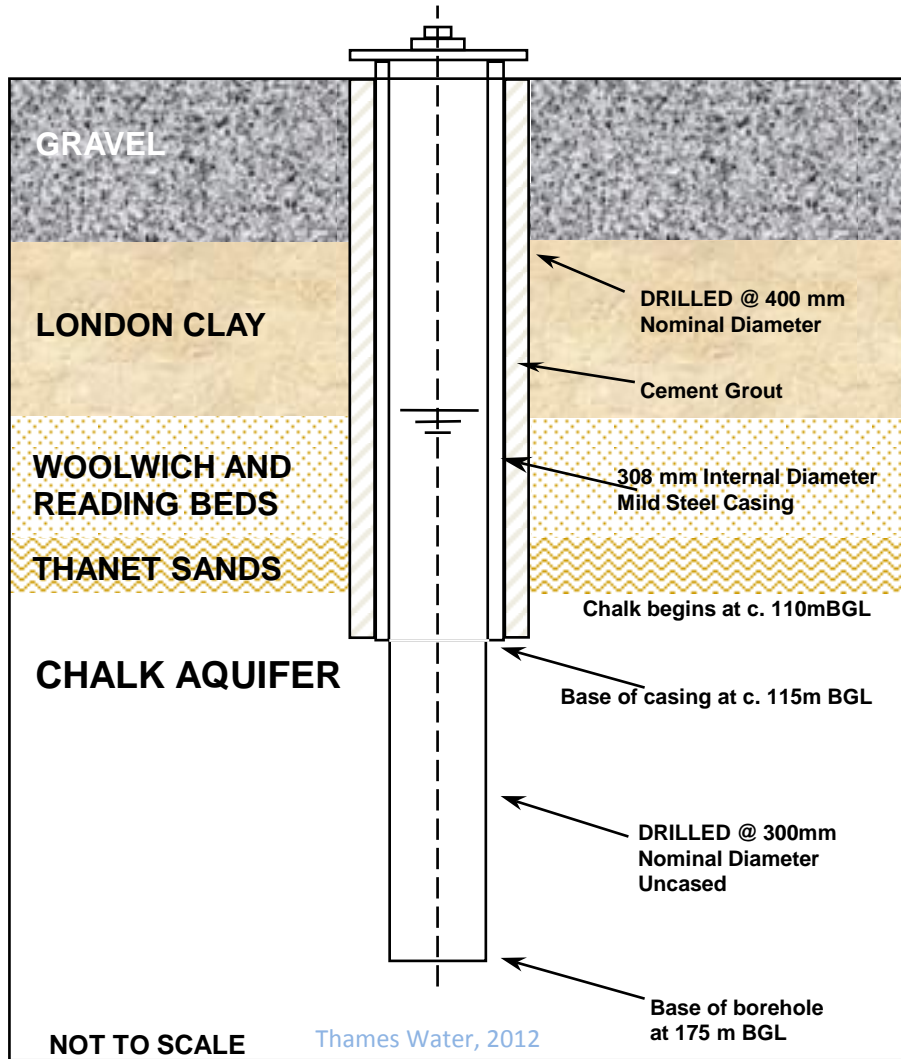
Environmental regulators

www.hydoutuk.net

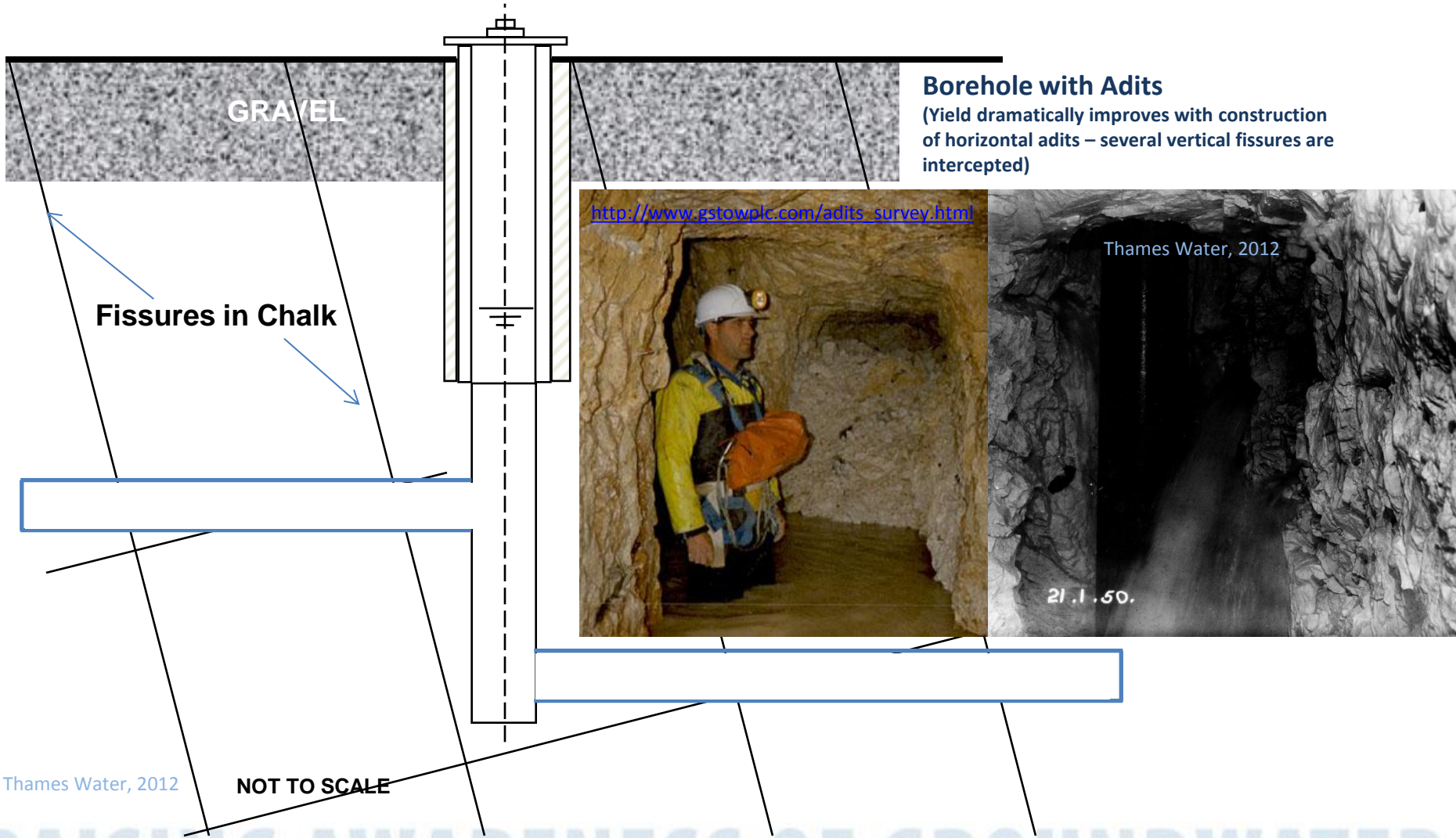
Making Use of Groundwater

1. Abstraction boreholes
2. Wells with adits
3. Construction & operation

Abstraction Boreholes



Abstraction Wells

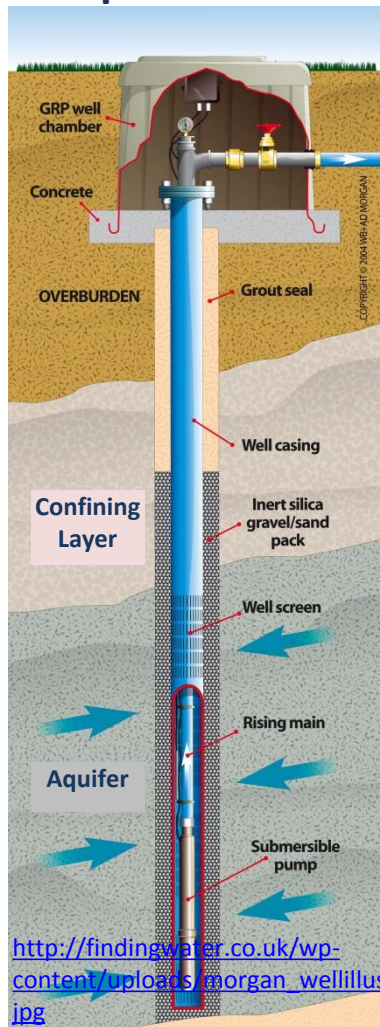


Borehole Construction & Operation

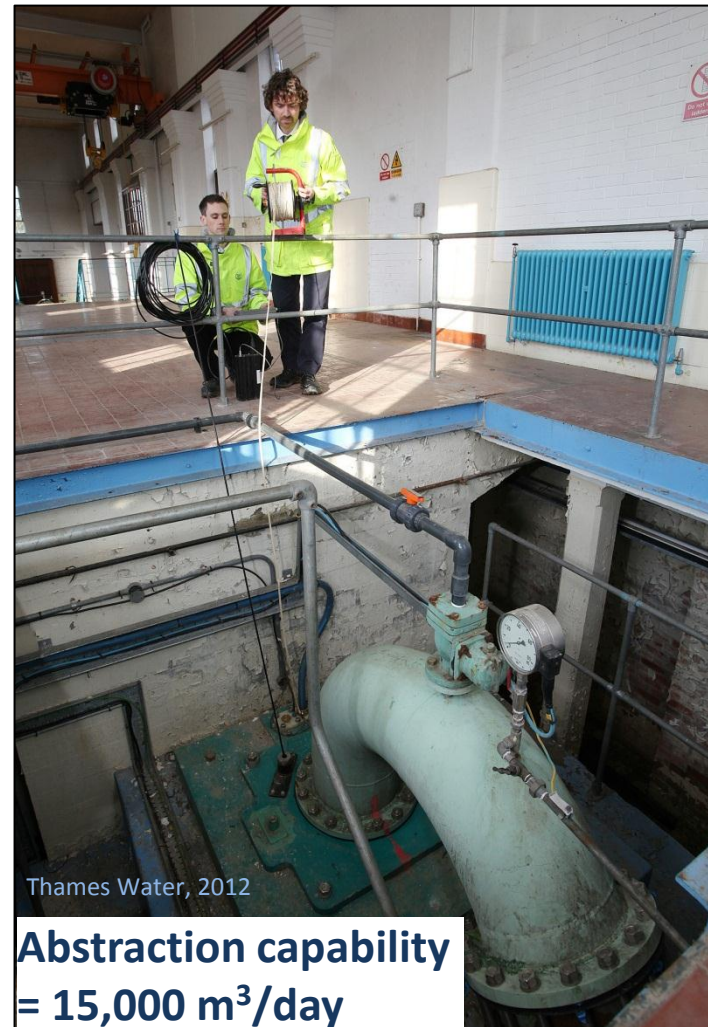
Drilling



Pump Installation



Headworks

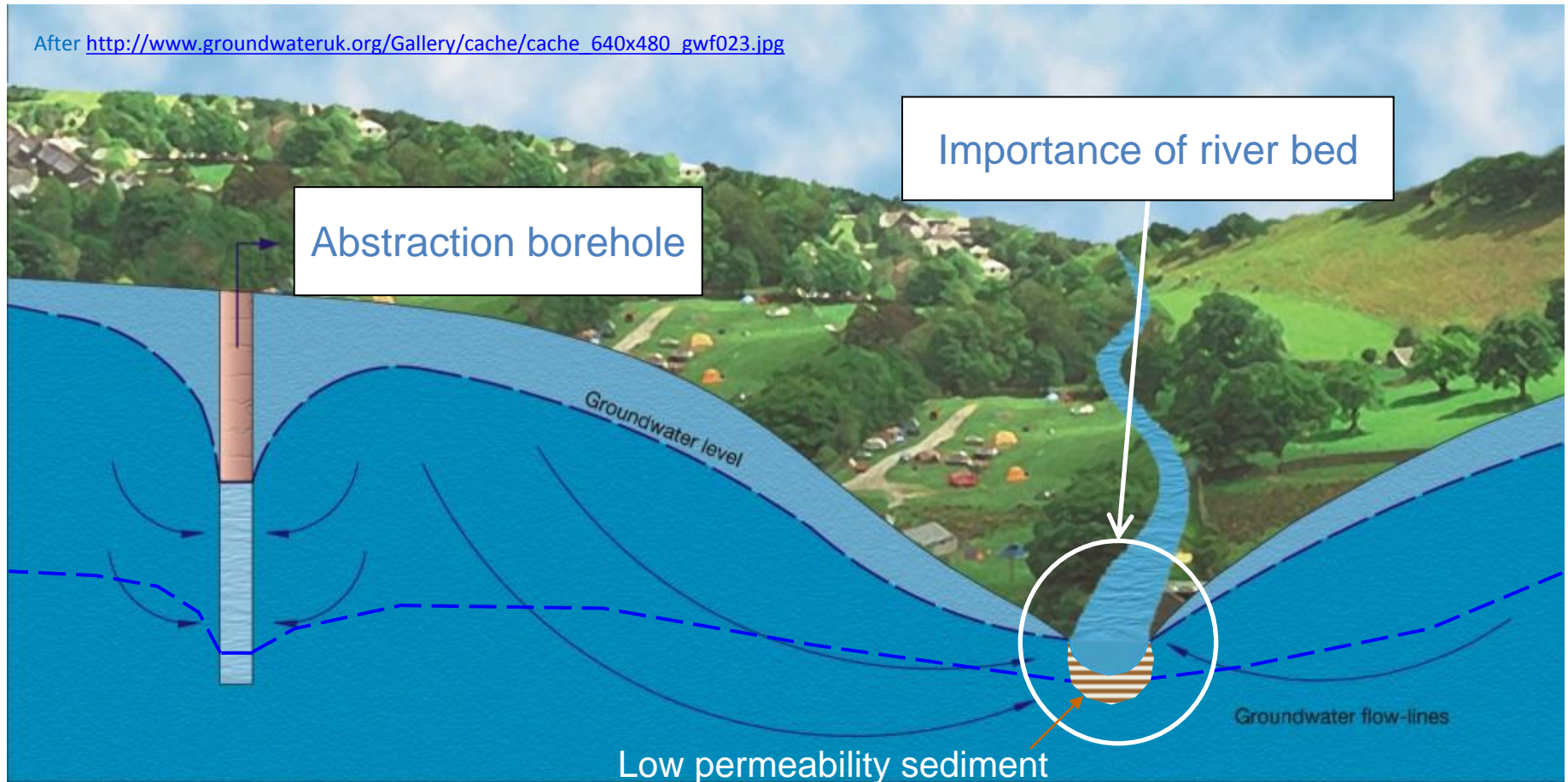


Groundwater Resource Management

1. Groundwater abstraction & rivers
2. Regulation of abstraction
3. Water Framework Directive
4. Resource management options

Groundwater Abstraction & Rivers

After http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf023.jpg



Regulation of Abstraction

- **Regulations ensure that water resources are managed and used effectively to meet the needs of people & the natural environment**
 - Range from 500 m³/day to 105,000 m³/day**
 - 1,000 m³/day can supply about 6,500 people**
- **Most UK groundwater abstractions are authorised by licences issued by environmental regulators:**
 - Environment Agency**
 - Natural Resources Wales**
 - Scottish Environment Protection Agency**
 - Northern Ireland Environment Agency**

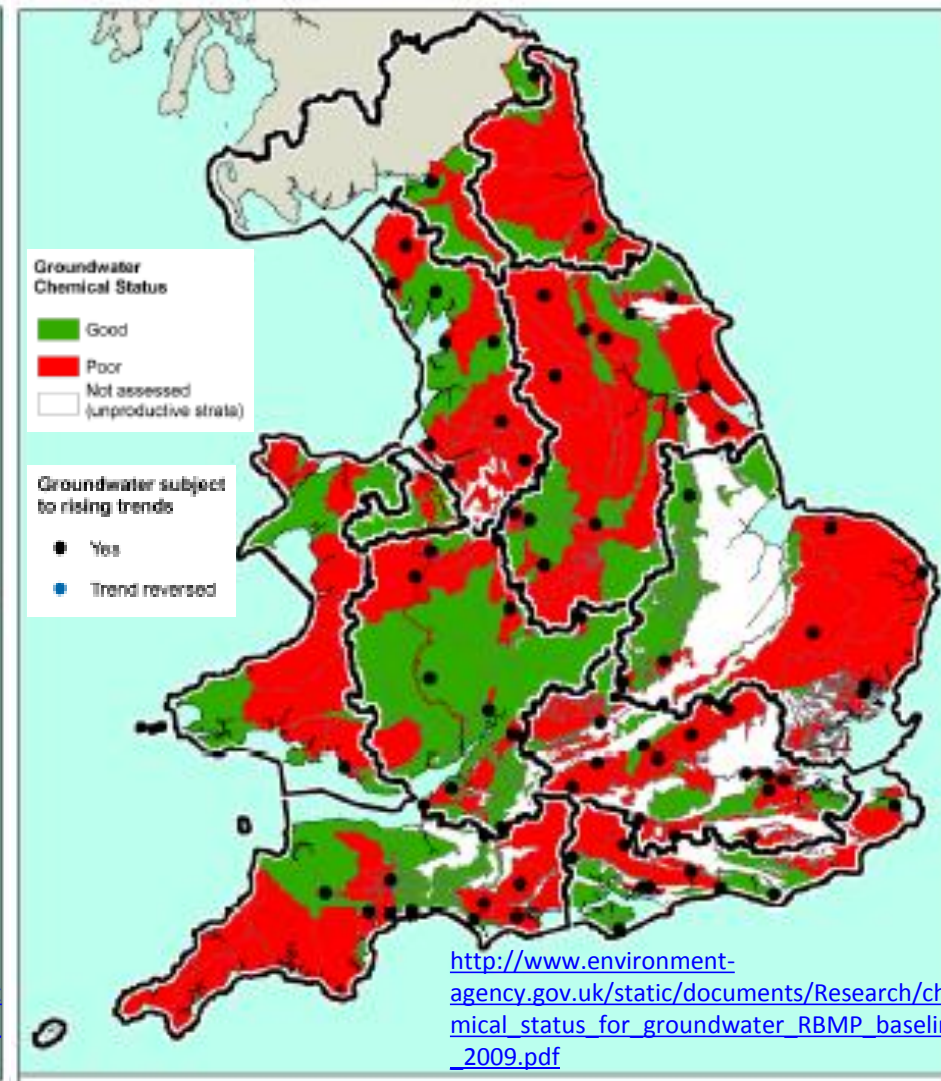
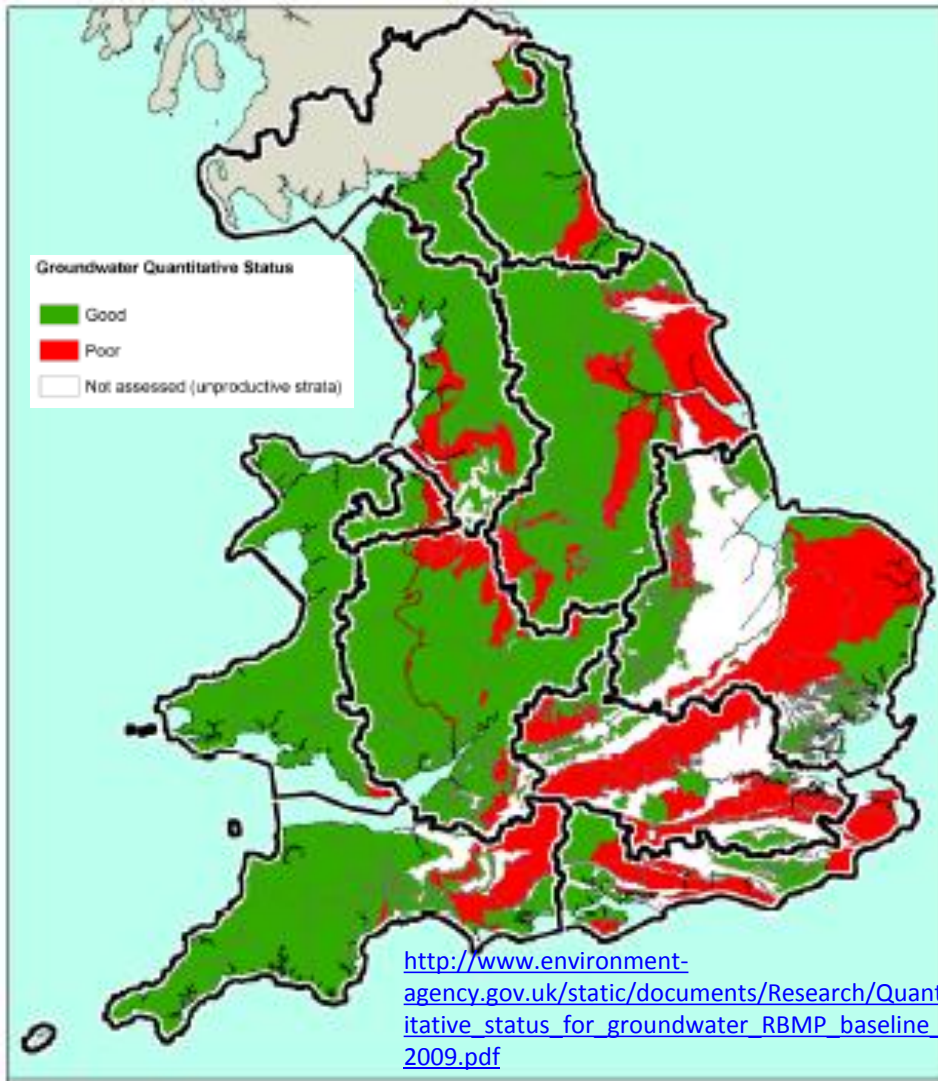
Regulation of Abstraction

- **Abstraction licences be paid for by the abstractors and prescribe:**
 - Borehole, well location & design**
 - What the abstracted water can be used for**
 - Hourly, daily & annual volumes that can be pumped**

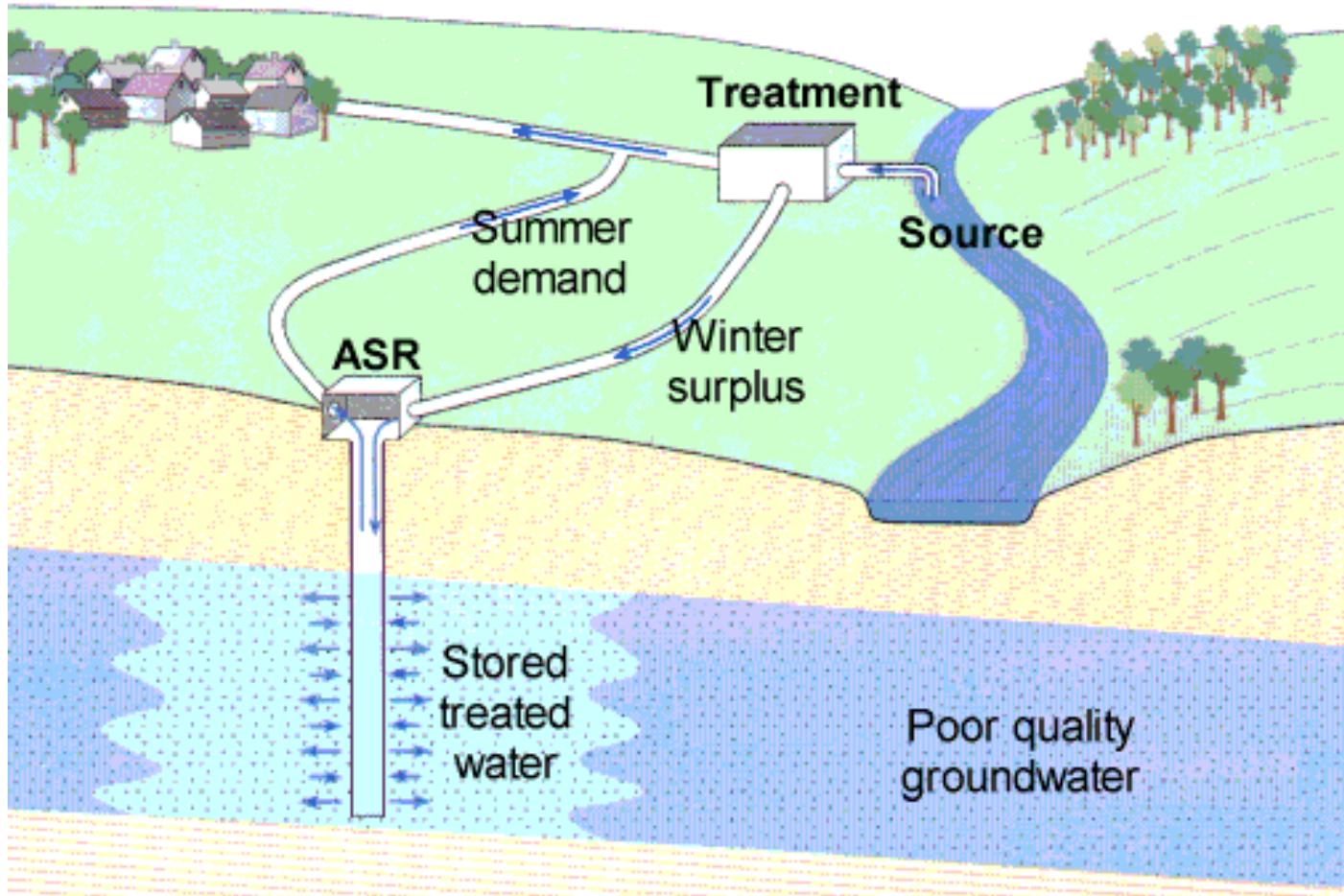
Some licences have conditions that restrict volumes when river flows are low

New licences are time limited, i.e. an expiry date is defined
- **Groundwater abstraction exempt from licensing if <20 m³/day in England & Wales, and low risk in Scotland**
- **Water resource management units, based on hydrologically defined catchments are used to manage abstraction, assessing whether water resources are available or over-abstracted**

Water Framework Directive 2015 status



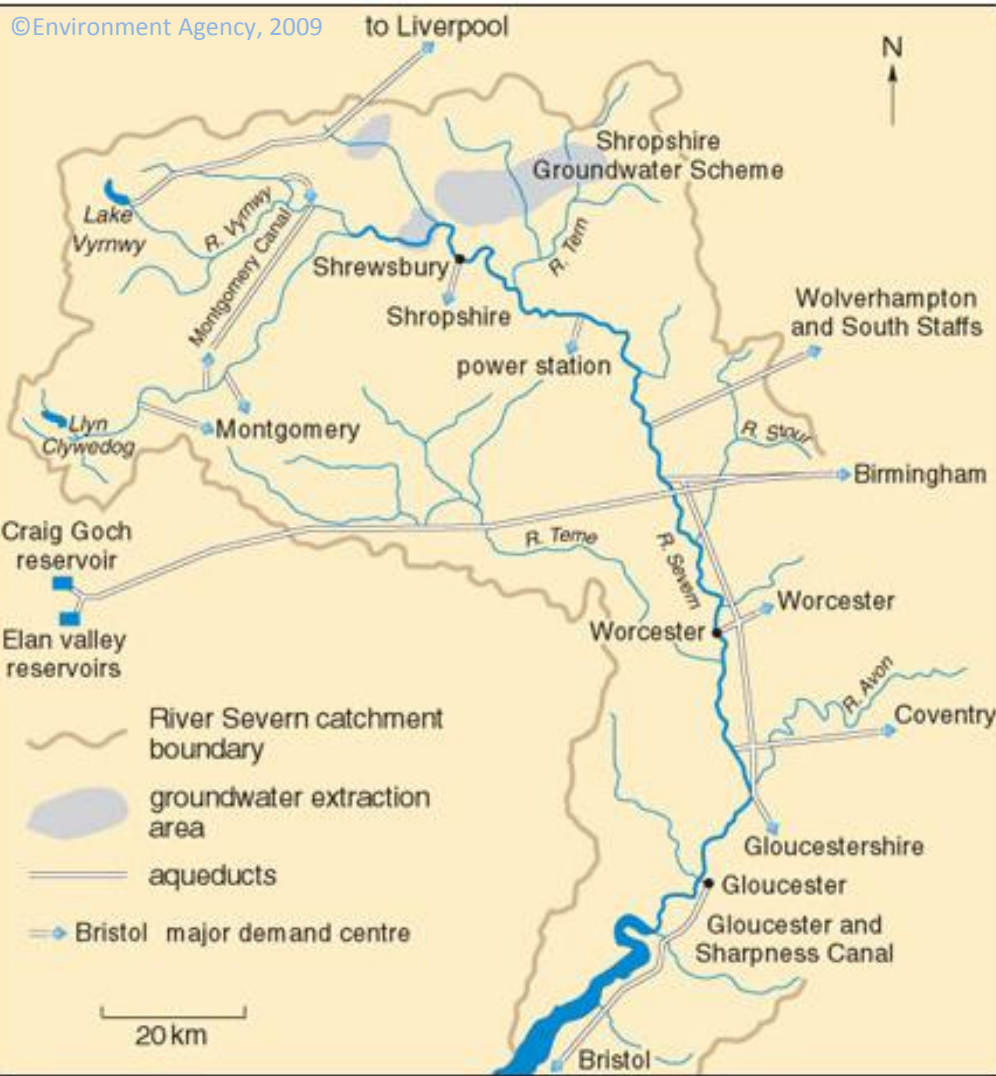
Aquifer Storage & Recovery (ASR)



©British Geological Survey, 1998

River Augmentation

©Environment Agency, 2009



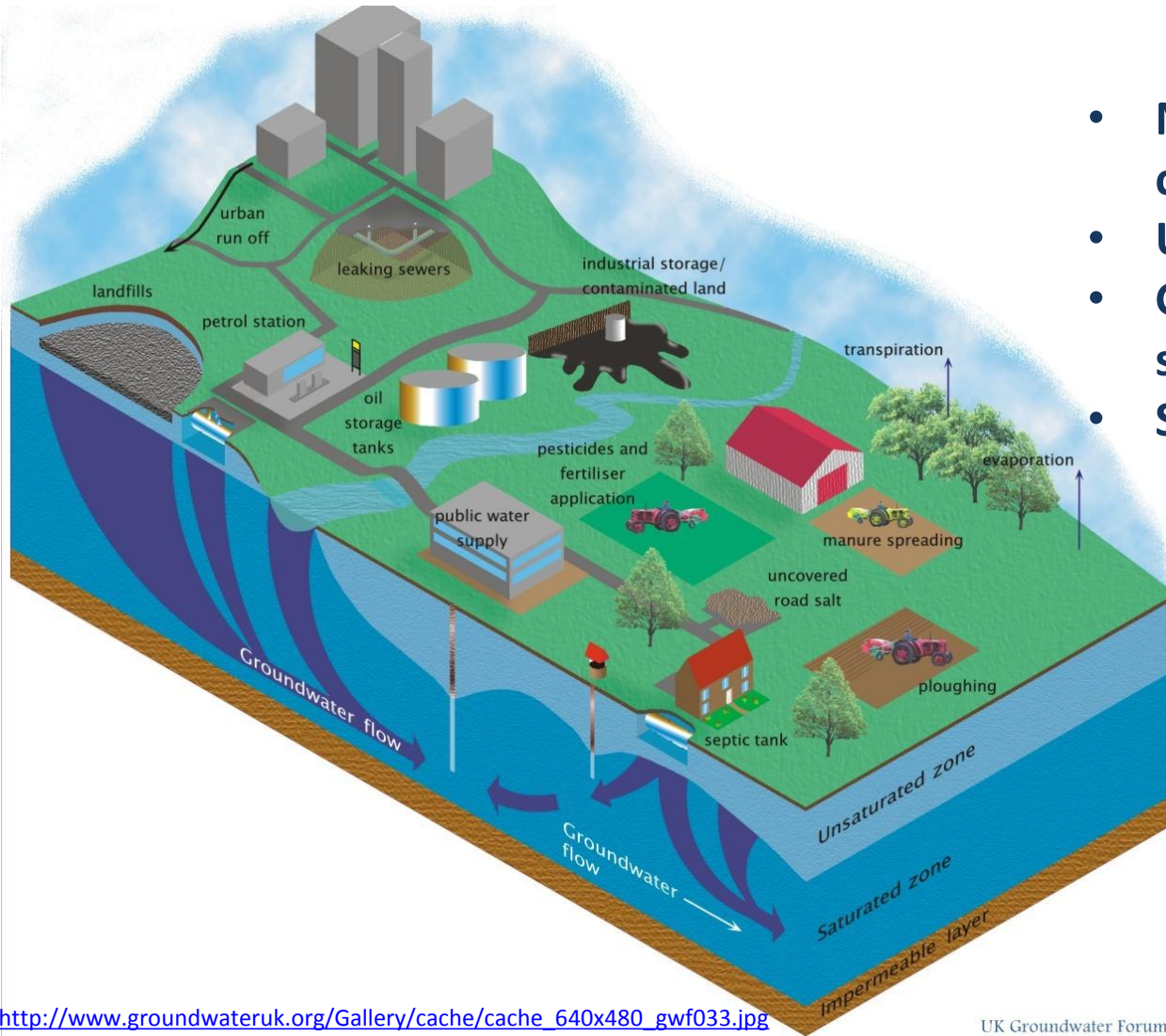
Shropshire Groundwater Scheme

- Permo-Triassic Sandstone aquifer
- 81 abstraction boreholes
- 225,000 m³/day
- Pumped into River Severn
- Augments low flows
- Supports pumping from River Severn for water supply

Groundwater Contamination & Protection

1. Contamination hazards
2. Abstraction source protection
3. Where to safely locate potentially polluting activities
4. Example of bromate contamination

Groundwater Contamination Hazards



- Numerous sources of contamination
- Urban & rural
- Groundwater & water supply sources at risk
- Source-Pathway-Receptor

http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf033.jpg

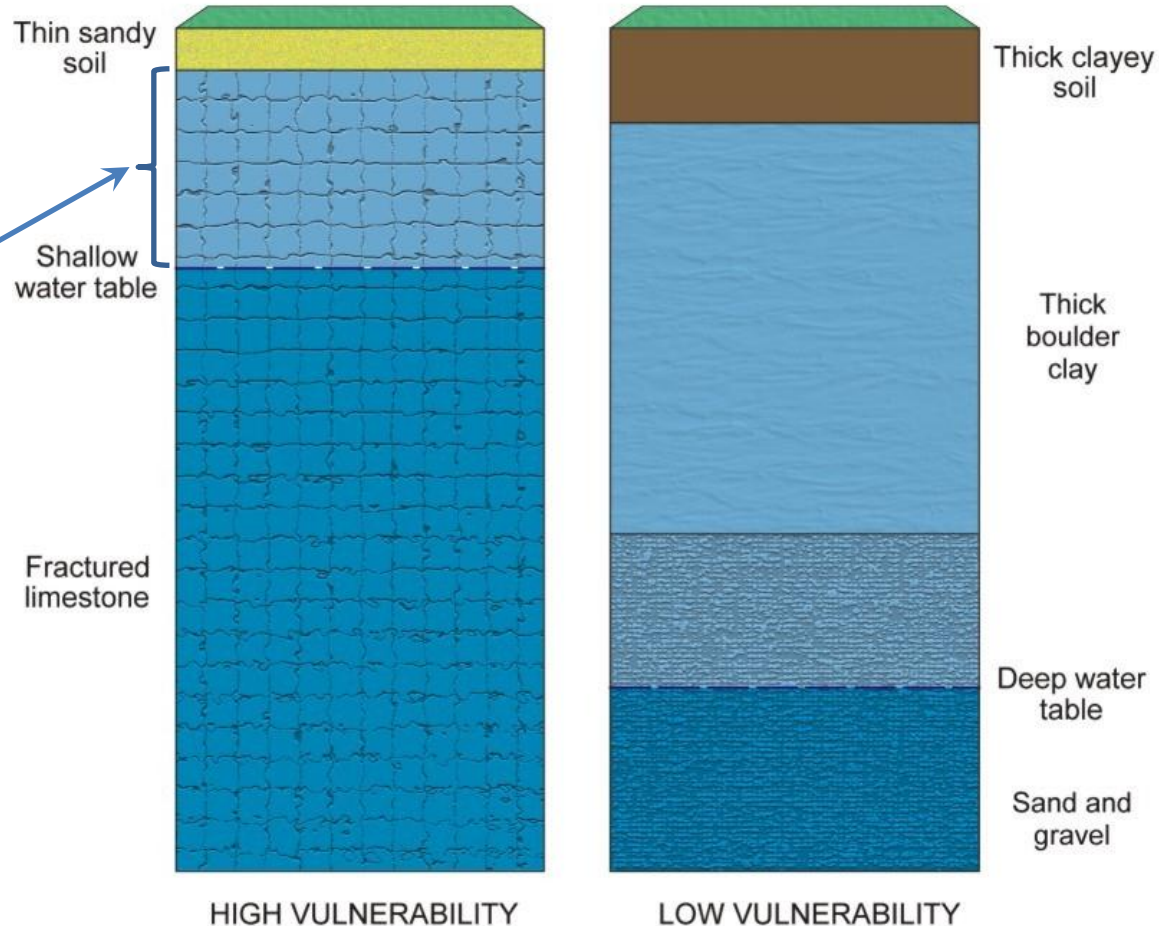
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Groundwater Vulnerability

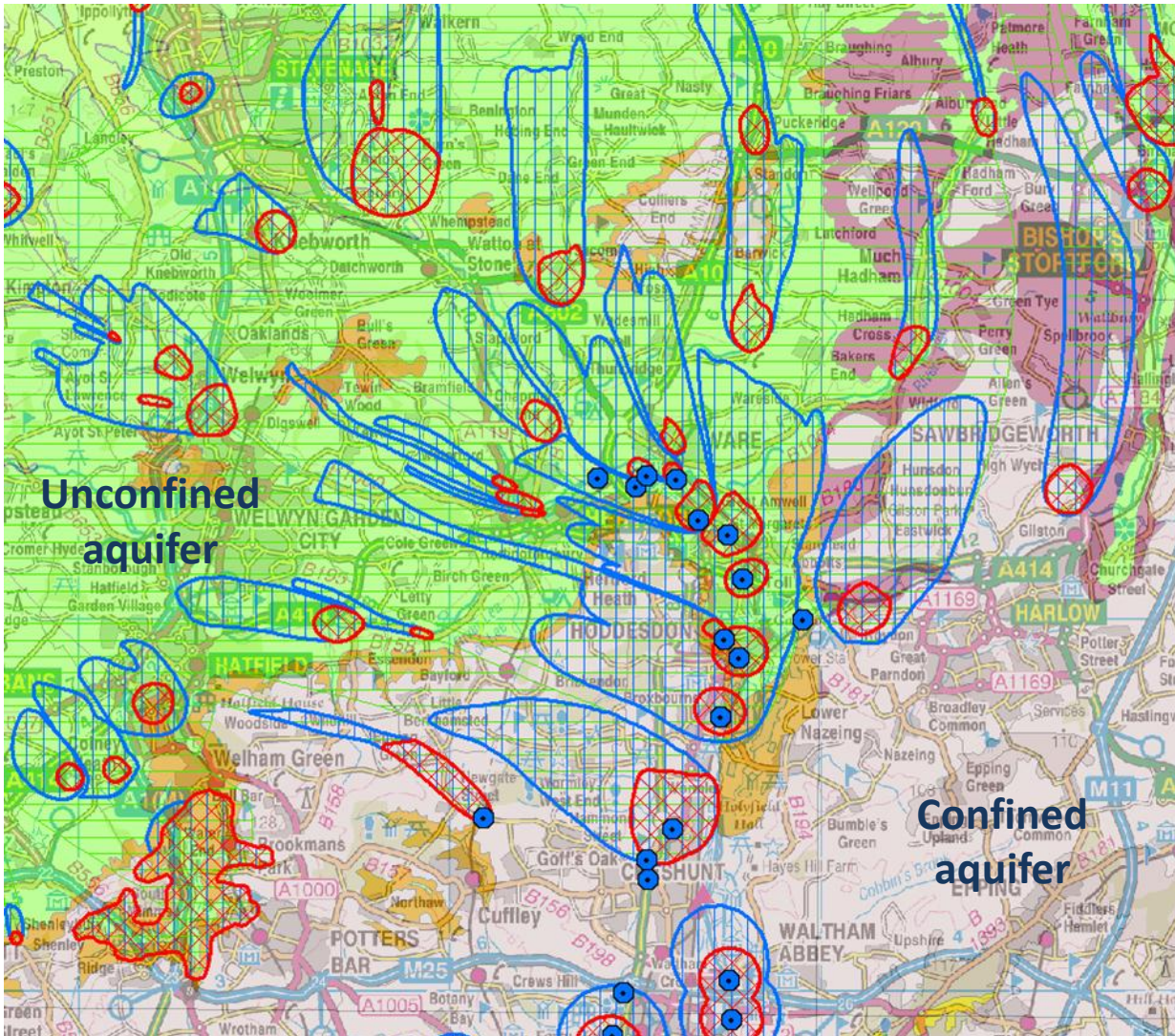
Geology & hydrogeology can provide natural protection

- Contaminants move slowly through unsaturated zone
- Groundwater moves faster through aquifers with fractures
- Clays have low permeability



http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf034.jpg UK Groundwater Forum

Groundwater Supply Protection



Source Protection Zone 1
SPZ1 50 days travel time
Greatest protection required

Source Protection Zone 2
SPZ2 400 days travel time

Thames Water, 2012

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Safest Locations to Protect Groundwater

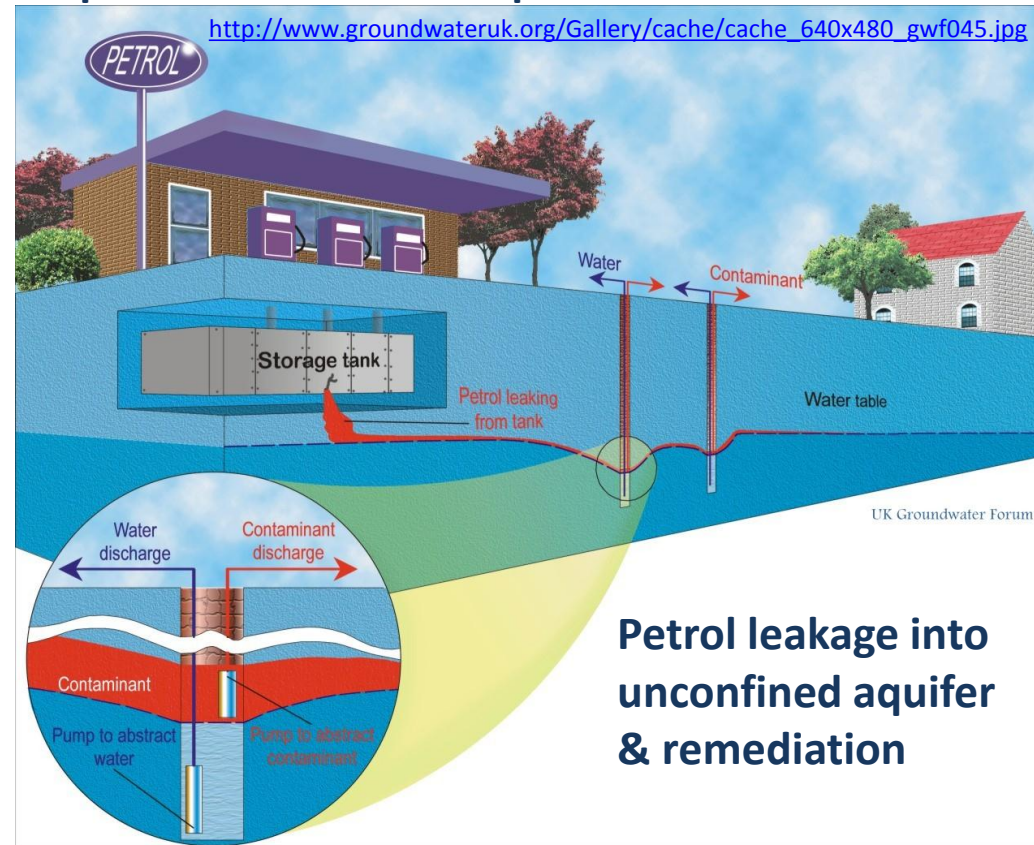


<http://thumbs.dreamstime.com/z/petrol-station-illustration-blue-background-32733765.jpg>

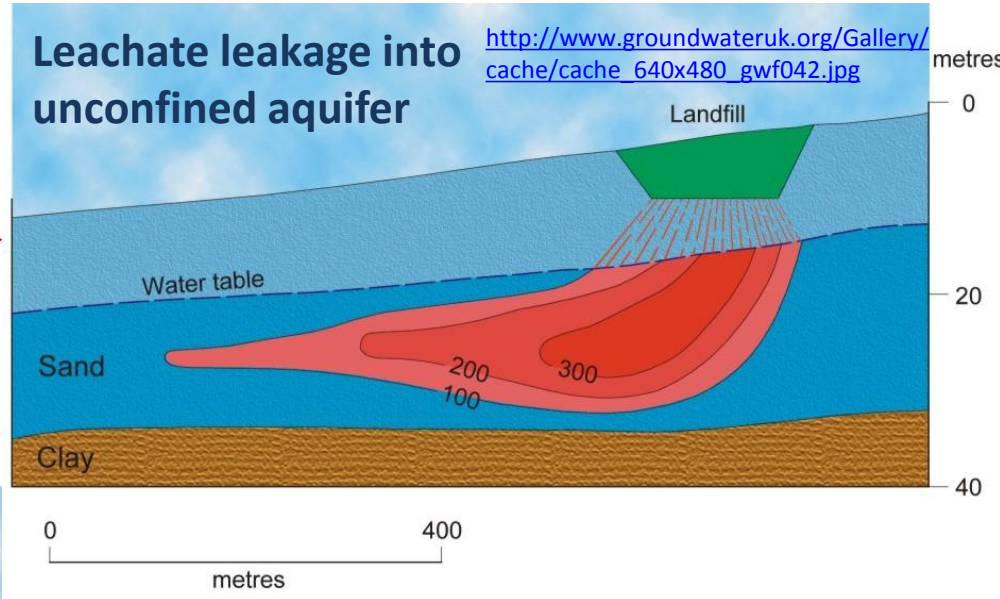
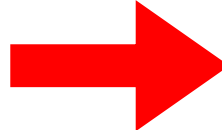
1. Confined aquifer
2. Confined, inside SPZ
3. Unconfined aquifer
4. Inside SPZ2
5. Inside SPZ1



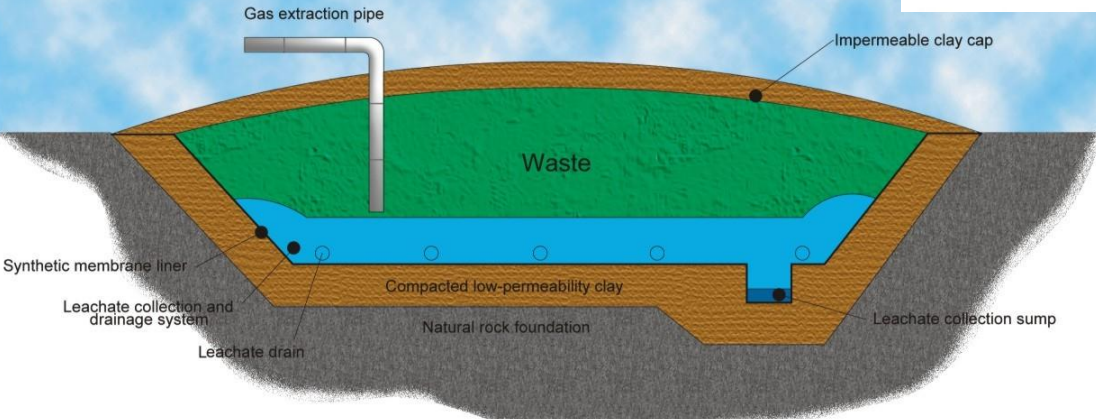
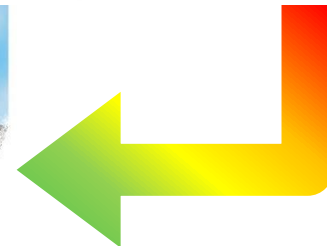
Impact on unconfined aquifer



Safest Locations to Protect Groundwater

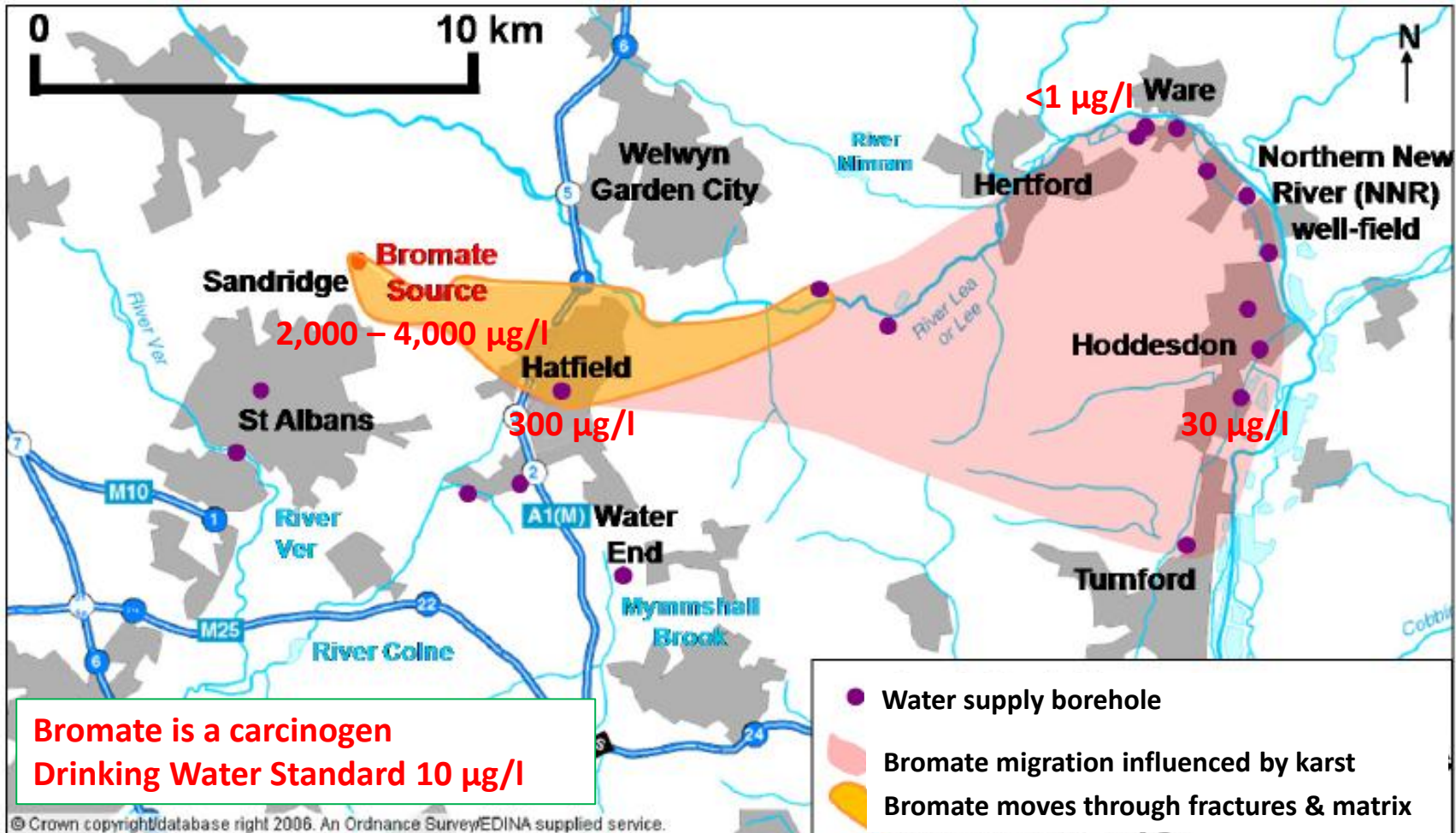


Design to protect groundwater



http://www.groundwateruk.org/Gallery/cache/cache_640x480_gwf041.jpg UK Groundwater Forum

Bromate Contamination of Chalk Aquifer



www.groundwateruk.org/Groundwater-projects-bromate-pollution.aspx

Complexity of Contaminant Migration

Cook et al., 2012 in *Groundwater Resources Modelling: A Case Study from the UK*

North ←

Rapid low attenuation distributary conduit flow system intersects the bromate plume in the Hatfield area

Sinking streams drain the Palaeocene Escarpment contributing up to 40MI/d

Karst Spring discharges 15MI/d

Diffusive double porosity fracture-matrix exchange dominates transport in the Vale of St Albans and near source area

Diffuse recharge and groundwater flux from Chiltern Hills 150MI/d

River Lea or Lee

Vale of St Albans
Hatfield

Bromate plume

Locally perched on till

Typical Abstraction 80MI/d

Extensive karst development and water table mound beneath the Mymmshall Brook catchment

Flow to London Basin 50MI/d

Seaford and Lewes Nodular Chalk

Bromate source in dry valley

Relict karst beneath former Proto-Thames corridor

Solution pipes and minor karst development beneath and adjacent to Clay-with-Flints

Higher transmissivity in river and dry valleys

Impact is managed by pump & treat and blending



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