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Assessing Water Use in Shale Gas Recovery

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Funded by

Lloyd's Register Foundation

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University of the West of England BRISTOL

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A campus of Monash University Australia

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Assessing Water Impacts of Unconventional Gas Exploitation

A Holistic “life-cycle” perspective requires us to consider:

1. Water use in survey and exploration (including test drilling)
2. Water use in full-scale exploitation (including processing and distribution)
3. Water use in post-exploitation site remediation

And also:

4. Water use in capital equipment manufacture, transport and final energy generation (e.g. gas fired electricity)
5. need to recognise distinction between permanently consumptive uses (injectates) and non-permanent uses

Assessing Water Impacts of Unconventional Gas Exploitation

Water Security:

"Availability of an acceptable quantity & quality of water for health, livelihoods, ecosystems and production, coupled with acceptable level of water-related risks to people, environments and economies." Grey and Sadoff (Water Policy, 2007)

"Nexus" thinking requires us to consider not just water/gas trade-offs, but also displaced/dislocated uses such as:

- Local food production
- Other forms of energy production (e.g. "run of river" hydroelectric installations)
- Needs of the natural environment

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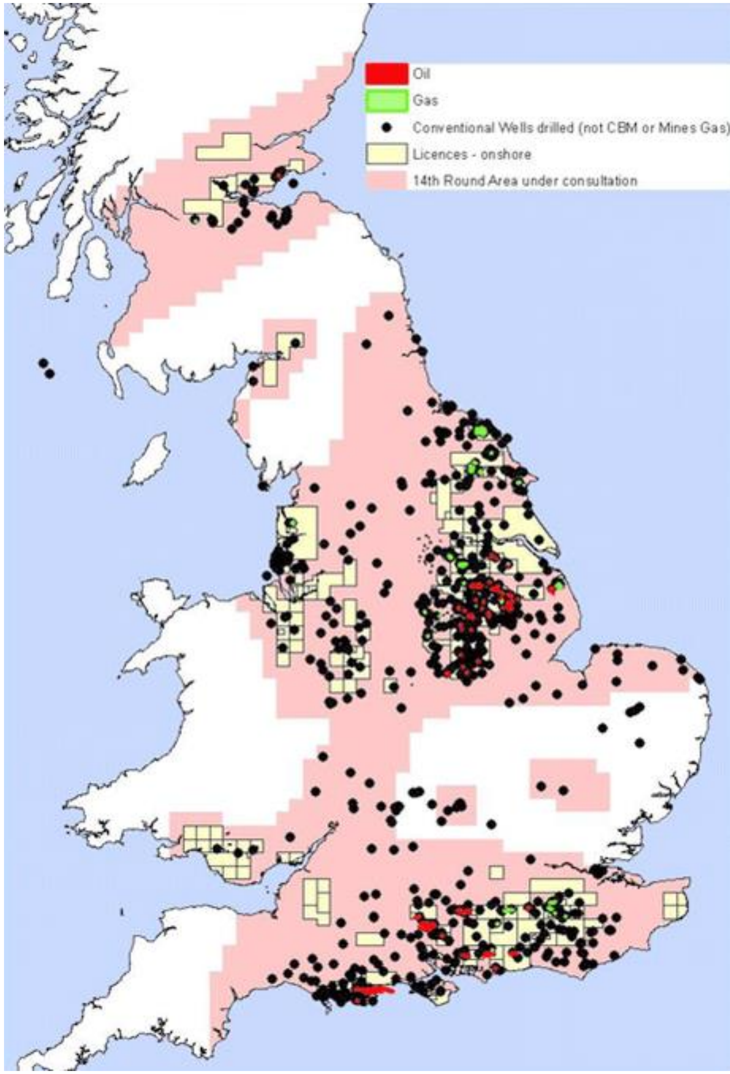

Areas of Shale Gas Interest in the UK:

- Merseyside-Blackpool
- NE England
- South Wales,
- Somerset,
- Hampshire & Sussex

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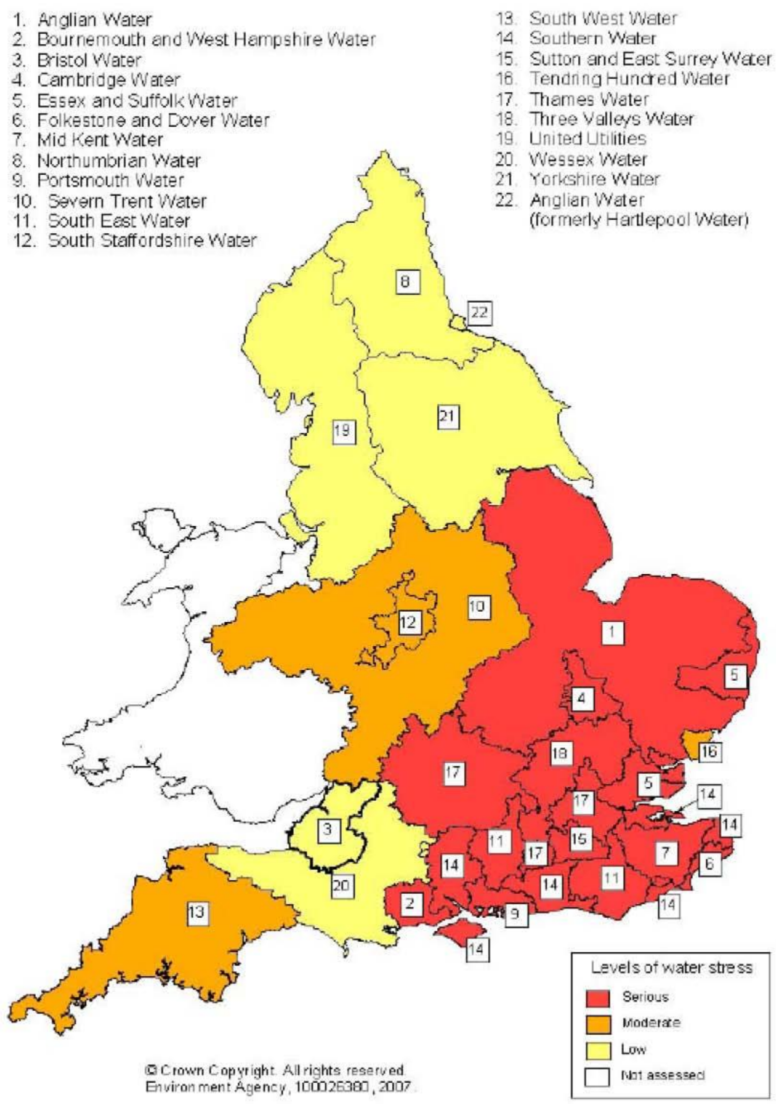
Areas of (Relative) Water Scarcity

- Merseyside-Blackpool
- NE England (parts of)
- Hampshire & Sussex



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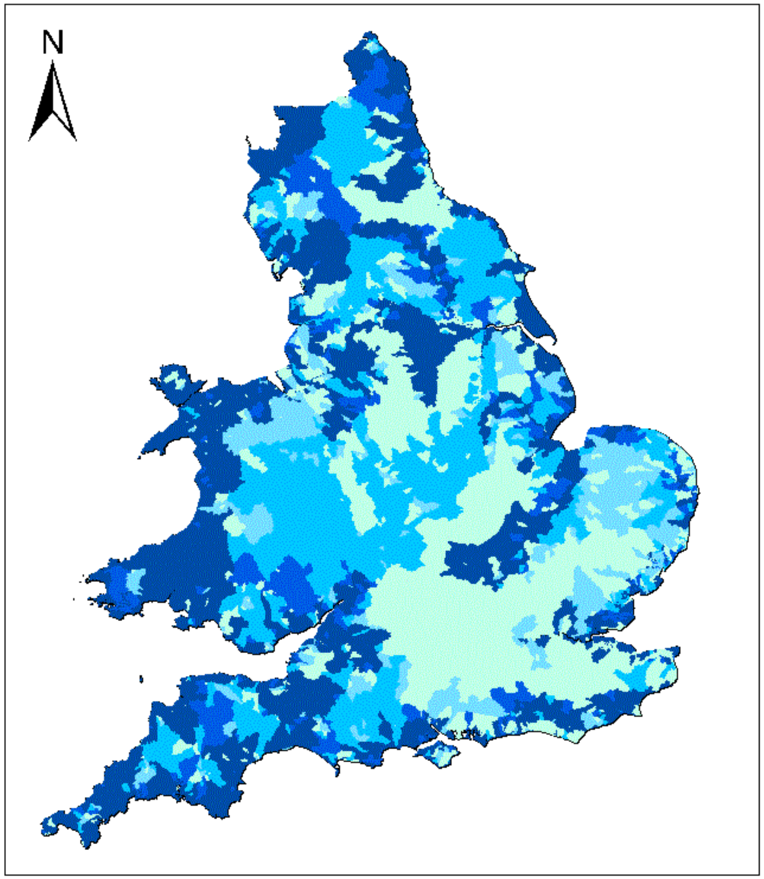
Resource availability % of the time

Environment Agency



CAMS resource availability colours

0 30 60 120 180 240 Kms

- less than 30%
- at least 30%
- at least 50%
- at least 70%
- at least 95%

Creation date 14 May 2010

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In fact, the situation is more complex due to fine ***geographical variations*** and (often unpredictable) ***temporal variations*** in water availability.

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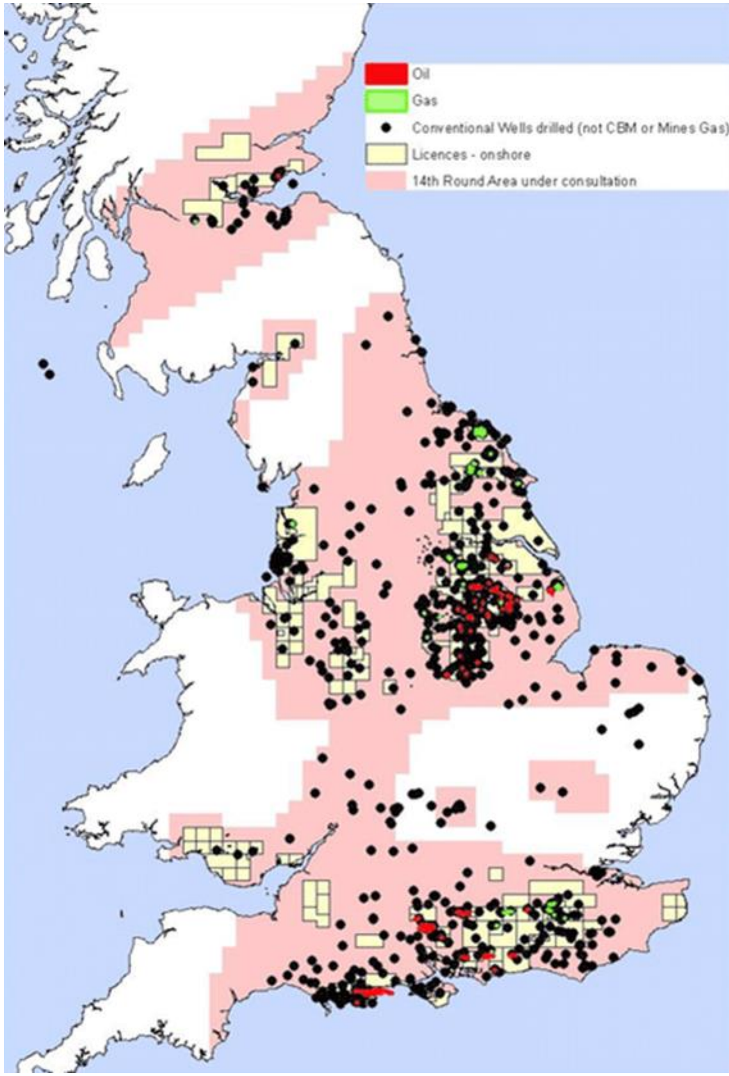
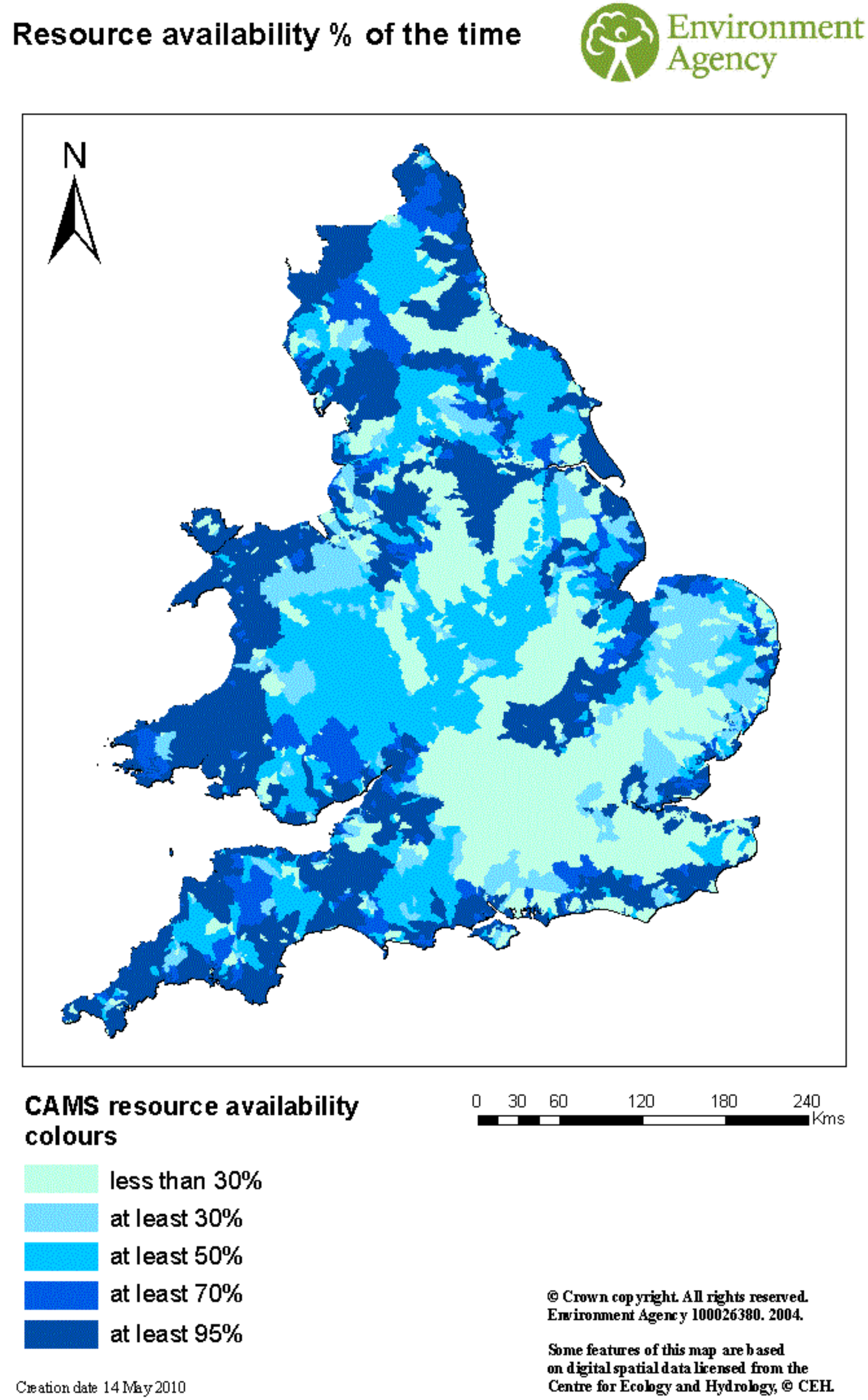

Oil
Gas
Conventional Wells drilled (not CBM or Mines Gas)
Licences - onshore
14th Round Area under consultation


Resource availability % of the time
Environment Agency
N
CAMS resource availability colours
less than 30%
at least 30%
at least 50%
at least 70%
at least 95%
0 30 60 120 180 240 Kms
Creation date 14 May 2010
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Therefore, there is a prima facie case for including the finer geographical and temporal water availabilities in any adjudication of any application for UG exploitation……

…..or we risk trading a positive increment of hydrocarbons energy security for a negative increment of water, food, and possibly (depending on local energy mix, etc.) alternative energy ***in***security!

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So, the scientific and regulatory challenge is to judiciously grant abstraction and discharge licences with due accord to:

- Energy-water trade-offs (kJ/m^3 or litres/MMBTU)
- Energy-energy trade-offs (kJ/alternative kJ foregone)
- Energy-food trade-offs (kJ/displaced kCal foregone)
- Energy-economic output trade-offs (kJ/alternative £ foregone)

Also with due recognition of geographical and temporal variation in water availability

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Approximately 24 megalitres per shale gas well, at least 80% of which is permanently lost, up to 20% returned to the surface as a “flowback” wastewater, most of which is not re-used but treated and discharged back into natural environment

But how significant is the volume of water used in fracking operations?

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We need a measure of water efficiency/intensity in UG production

$$\text{Water intensity} = \frac{\left[\text{Volume of drilling water} \quad \text{Volume of hydraulic fracturing water}\right] - \left[\cancelto{0}{\text{Volume of flowback water}} + \cancelto{0}{\text{Volume of produced water}} - \cancelto{0}{\text{Volume of disposed water}}\right]}{\left[\text{Energy from oil} + \text{Energy from natural gas}\right] - \cancelto{0}{\text{Energy used for drilling}} - \cancelto{0}{\text{Energy used for hydraulic fracturing}} - \cancelto{0}{\text{Energy used for water treatment}}} \quad (1)$$

Equation 1 is reduced to:

$$\text{Water intensity} = \frac{V_{drill} + V_{frac}}{E_{recovered}} \Rightarrow \text{Water intensity} = \frac{V_{in}}{E_{recovered}} \quad (2)$$

….and which properly understands the difference between “withdrawal” and “consumption”

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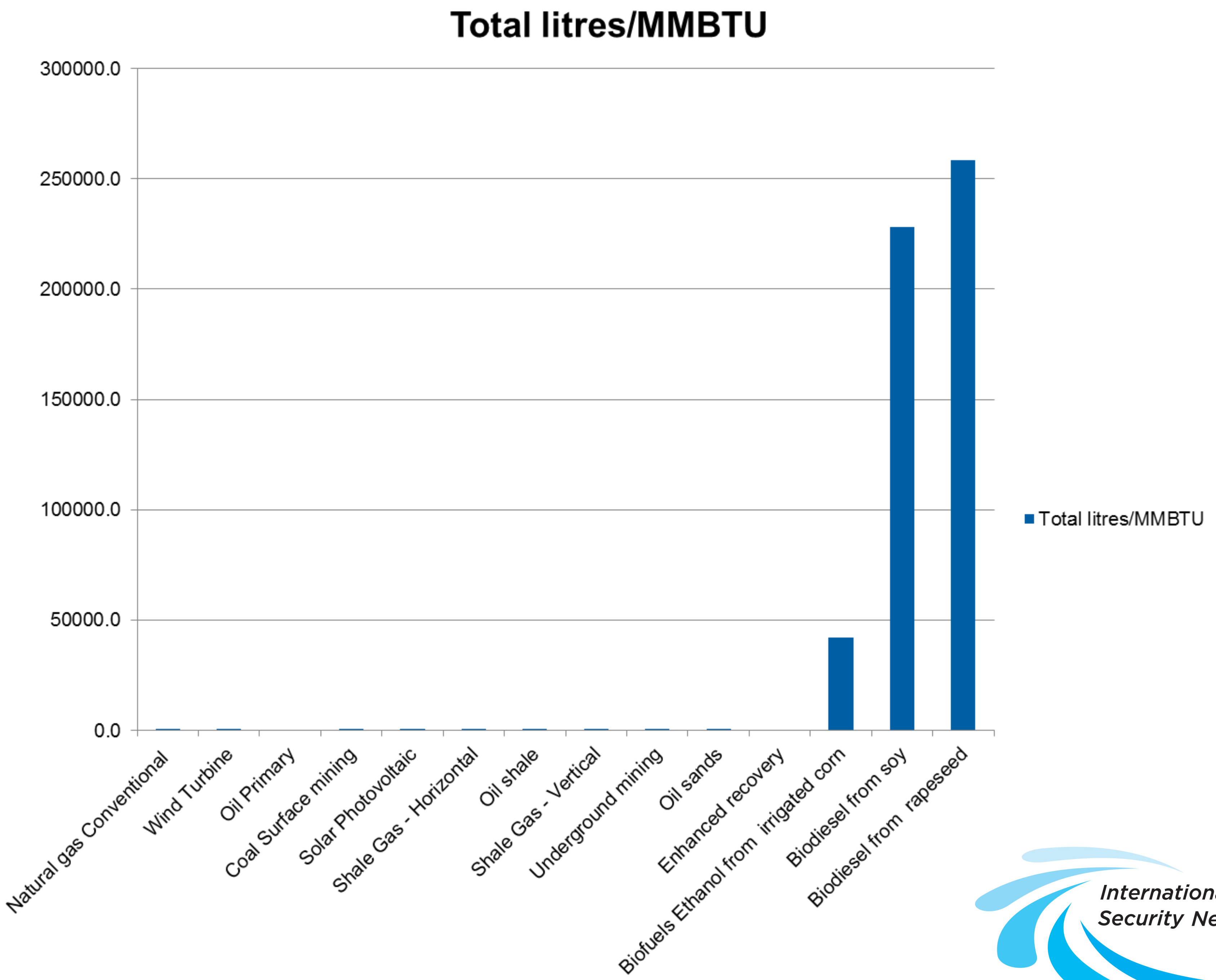

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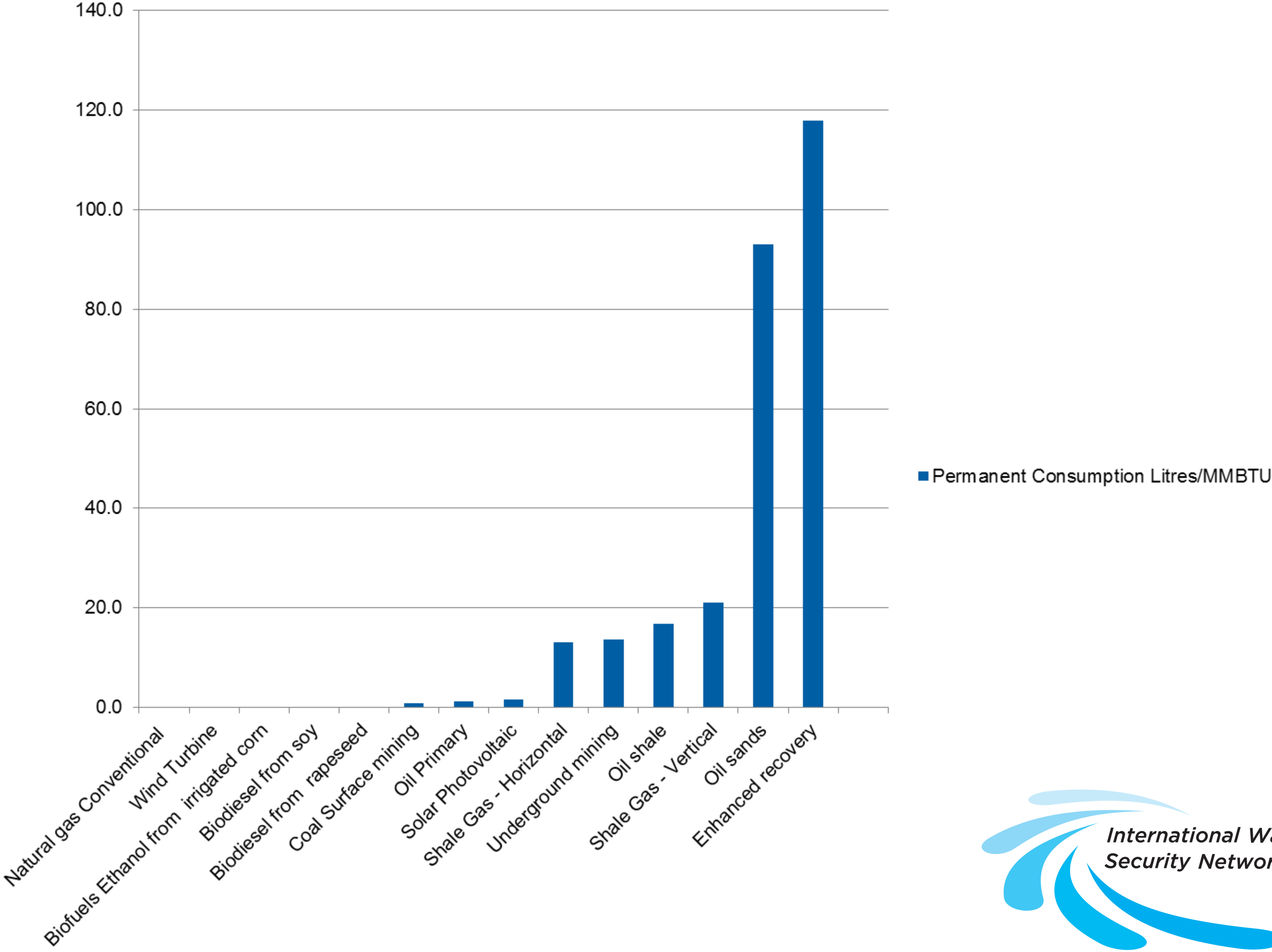
Permanent Consumption Litres/MMBTU



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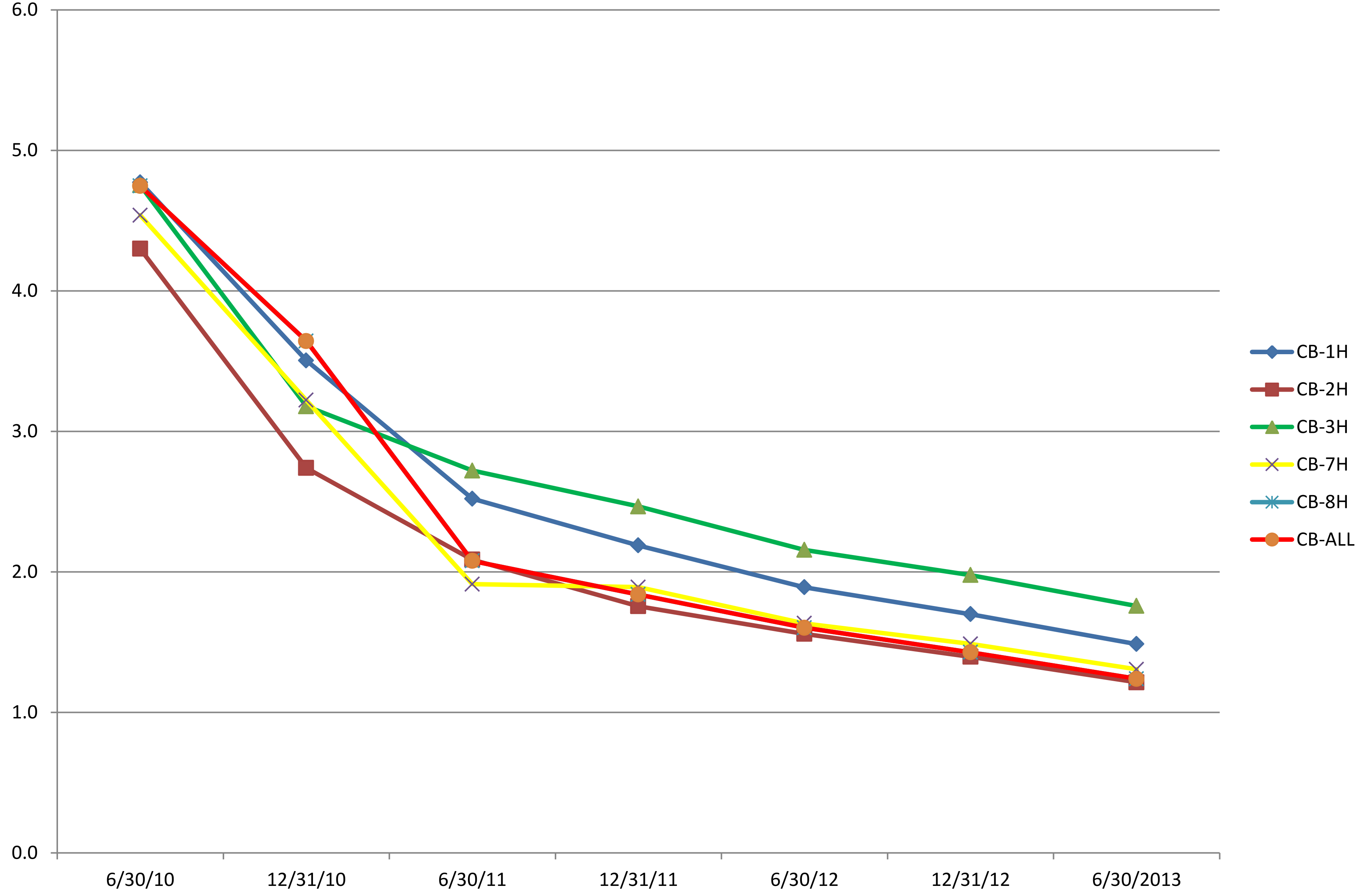

Energy production per unit water consumption in the Marcellus Shale Gas Play, Pennsylvania, USA

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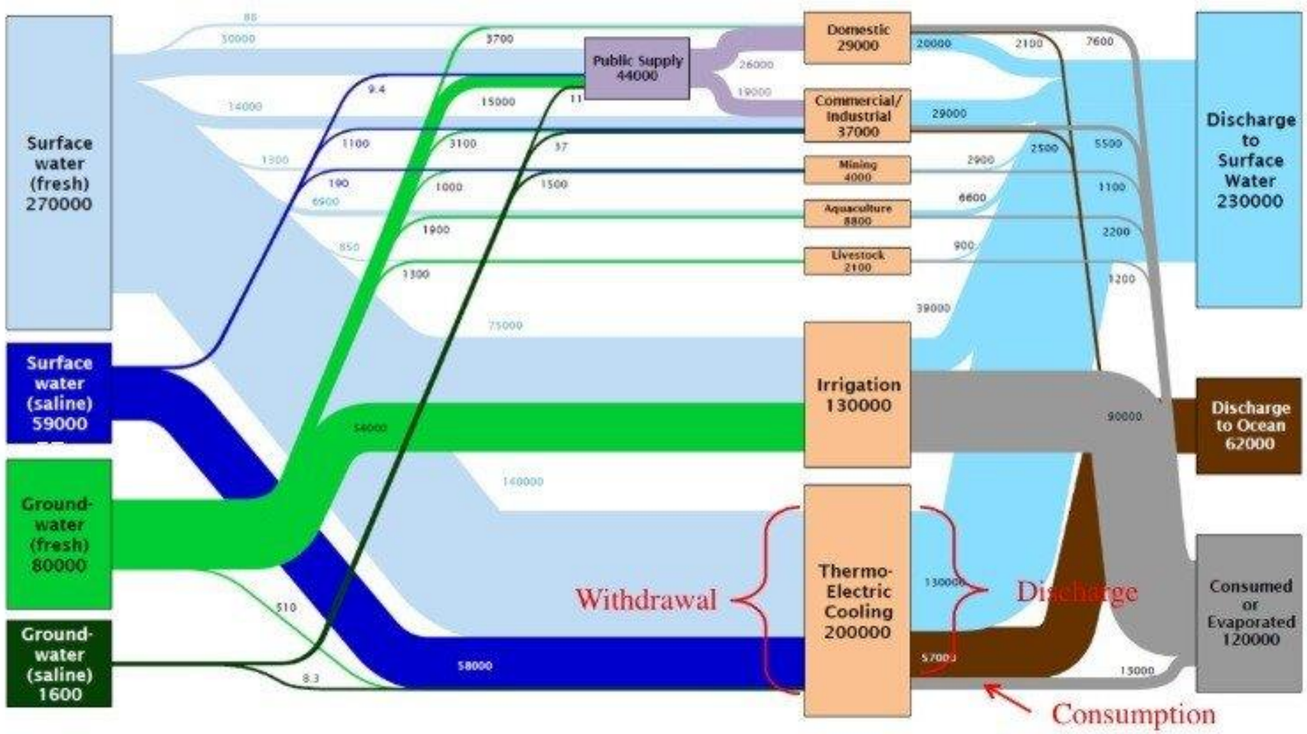
Water use in the US (2005)



Units: MGal/Day

Source: DOE / Lawrence Livermore National Labs, 2011 (Data from USGS Circular 1344, 2009).

Water Quality Impacts: Fracking Fluid Contents

- 90% water
- 9% sands
- 1% constituents such as
  - Sodium chloride
  - Ethylene glycol
  - Borate salts
  - Sodium/potassium carbonate
  - Guar gum
  - Isopropanol
  - Polyacrylamide
  - hydrochloric/acetic acids
  - Plus whatever is picked up en route: heavy metals, radionuclides, etc.

Water Quality: can water from fracking pollute other "natural" waters?

Standard Industry answer is "no, fracking layers are too deep", but:

1. Robert Jackson at Duke University, USA has positively linked fracked layers to groundwater layers in Pennsylvania using GCMS
2. The precautionary principle should incline national regulatory authorities to:
    a) Insist on "security in depth" for fracking operations
    b) Make research on hydrogeology a priority in assessing whether fracking is appropriate in any state/region
    c) Pay more attention to management of flow-back waters (in the USA some flow-back is applied to agriculture!)

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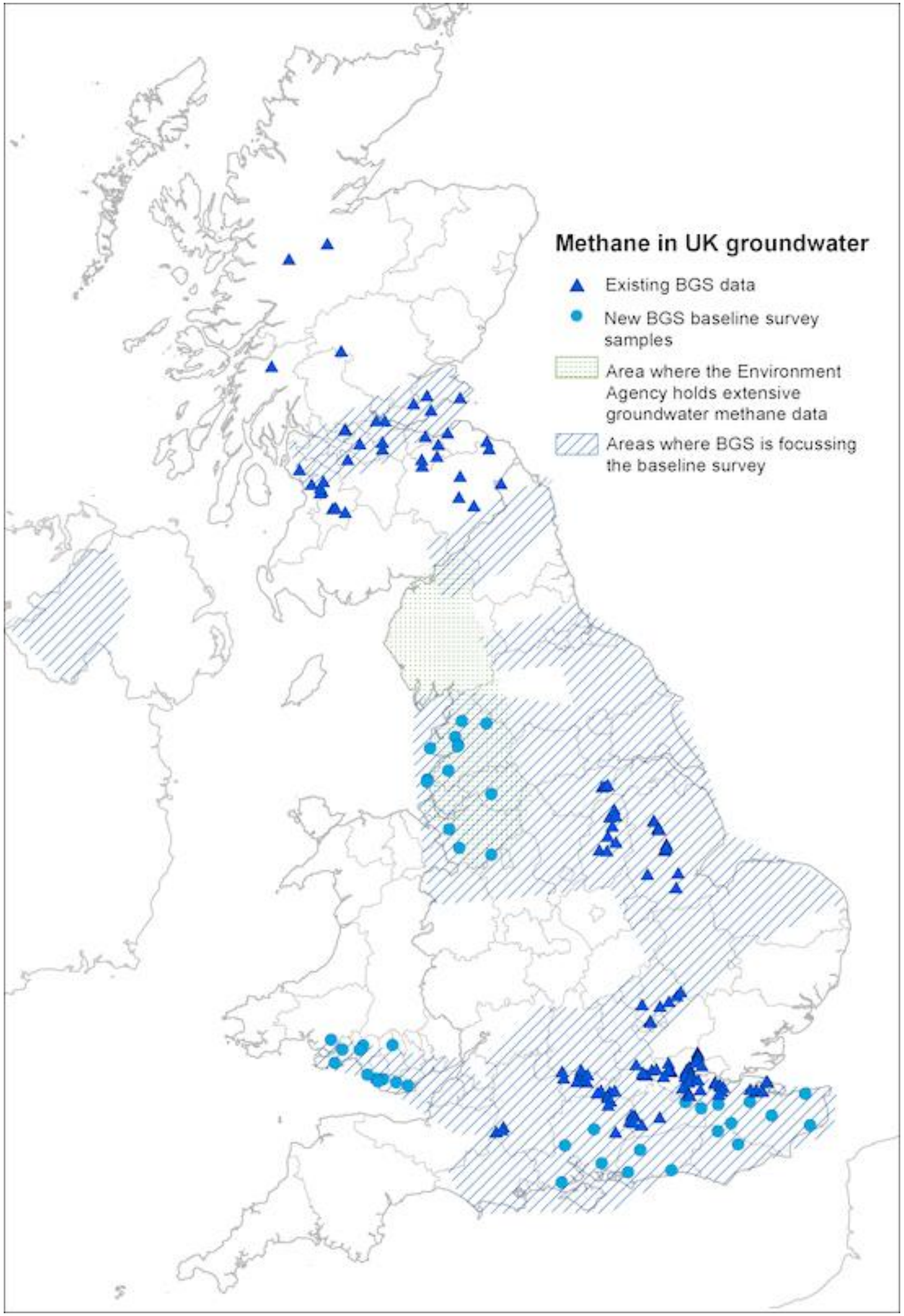

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Wastewater is either “flow-back” from the fracking process or highly concentrated subterranean saltwater

Increasing amounts of wastewater transported to treatment facilities rather than re-injected or left as tailings

Possible regulatory tools:

- Water Framework Directive (2000)
- Groundwater Directive (2006)
- Waste Directive (2011)
- Mining Waste Directive (2006)
- Hydrocarbon Directive (1994)

Some issues with trade secrecy in exact formulation of fracking fluids, especially in the US – *does the Aarhus Convention apply here?*

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Thank-you!

Questions?

Acknowledgement

This project is funded by Lloyd's Register Foundation, a charitable foundation helping to protect life and property by supporting engineering-related education, publication and the application of research.
For further information see www.lrfoundation.org.uk

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