# ENVIRONMENT AGENCY – ENERGY INSTITUTE COOPERATIVE PROJECTS ON IMPACT OF ETHER OXYGENATES ON GROUNDWATER RESOURCES IN THE UK

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# The Energy Institute in the UK

- Formerly the Institute of Petroleum (IP)
- A technical organisation that produces standards, guidelines, protocols and training materials for the oil industry via working groups composed of experts from the oil industry, regulatory authorities and consultants.
- Carries out small research projects for the oil industry.
- Membership open to anyone with an interest in the oil industry (oil majors, independents, regulators, consultants & individuals)

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# Cooperative project on the impact of ether oxygenates on groundwater resources in the UK

- Project partners:
  - Environment Agency
    - Central Science Group
  - Energy Institute
    - Soil & Groundwater Working Group
  - Komex (Europe)
    - independent contractor
- First study carried out in 1999/2000
  - Reported in joint EA-IP report (R&D Publication 97)
- Study being repeated in 2006
- Most comprehensive study of its kind in the public domain outside the USA

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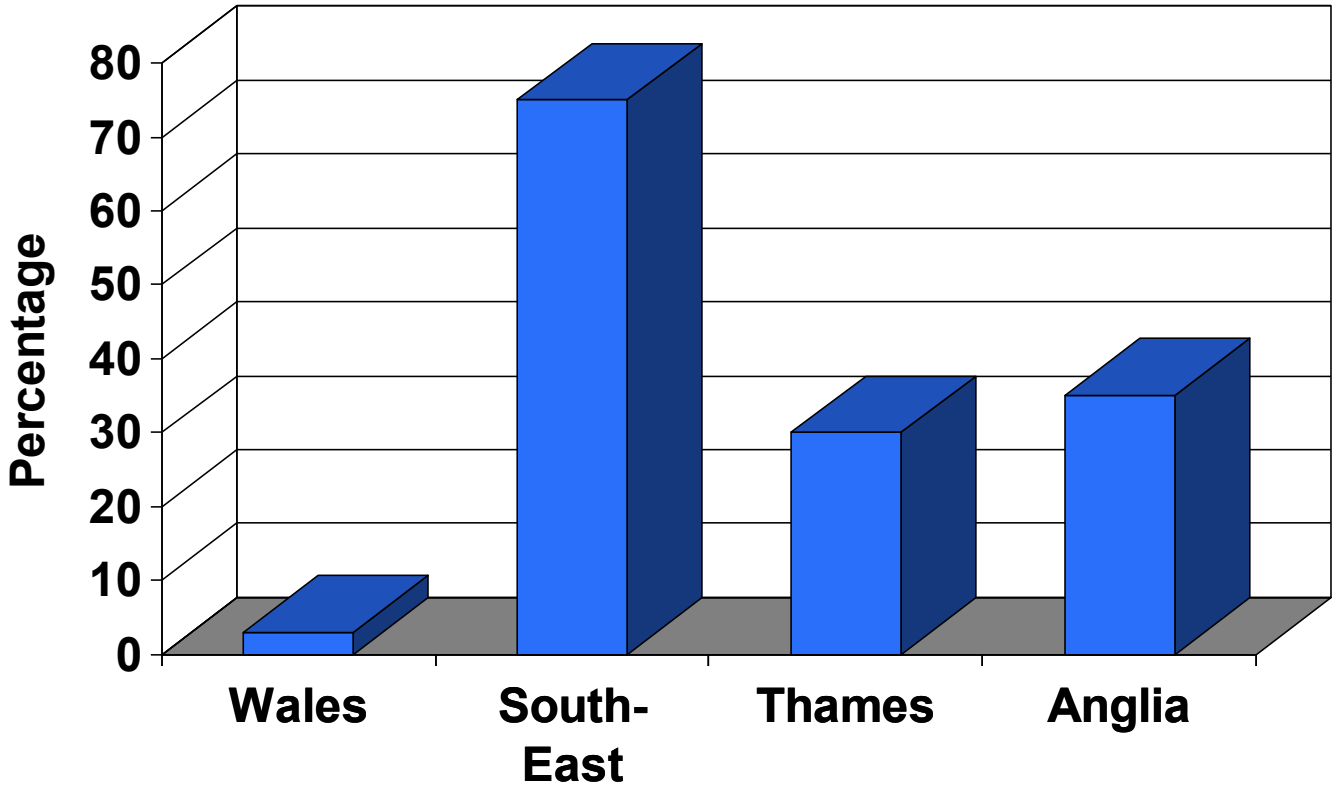
# Dependence on groundwater for drinking water in different regions of the UK



# Project objectives

- To review the state of knowledge with regards the risks posed by ether oxygenate impacts of groundwater
- To assess the usage of ether oxygenates in gasoline in the UK
- To review the state of knowledge with regards the impact of ether oxygenates on groundwater in the UK:
  - At petrol filling stations
  - In Environment Agency groundwater quality monitoring wells
  - In Public Water Supply (PWS) wells.
- To assess whether the situation has changed between 2000 and 2006.

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# Methodology

- Oil companies provided site investigation data to Energy Institute who anonymised the data before passing to Komex.
- Environment Agency regions provided data from their groundwater quality monitoring wells.
- Komex collected data from Water Companies.
- Questionnaires and spreadsheet templates were used in an attempt to standardise the data as much as possible.

# Ether oxygenate use in gasoline in the UK in 2000

- Majority of oil companies did not add ether oxygenates to the gasolines they manufactured on a routine basis.
  - Ether oxygenates enter the networks of these companies via the fuels exchange programme
- Those that do primarily use MtBE with some TAME.
- Started use in mid-late 1980s
- Primary driver quoted as octane enhancement (lead replacement)
- Gasoline contained lowest concentration of any country in Europe
  - ULG 95 (90% market) < 1% v/v MtBE (average 0.75%)
  - ULG 98 (5% market) 1-5% v/v MtBE
  - LRP (5% market) 1-5% v/v MtBE
- Approx 14,000 petrol filling stations in the UK

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# Ether oxygenate use in gasoline in the UK in 2006

- Majority of oil companies still do not add ether oxygenates to the gasolines they manufacture on a routine basis
- Those that do primarily use MtBE (70%) and some TAME (30%)
- Primary drivers quoted as octane enhancement (lead replacement) and improvements in air quality
- Moderate increase in ether oxygenate content of gasoline compared to 2000.
  - ULG 95 (90% market) <1% - 6% v/v MtBE
  - ULG 98 (5% market) <1% -10% v/v MtBE
- The use of MtBE and TAME is likely to decline in the future in favour of EtBE – driven by the EU Biofuels Directive which classifies EtBE as a biofuel component
- Approx 10,000 petrol filling stations in the UK

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# The issue of ether oxygenates in drinking water is one of taste and odour rather than risk to human health.

- According to the World Health Organisation, the issue is one of taste rather than risk to human health. Consequently, they have not produced drinking water standards for ether oxygenates (Fawell, J. 2004).
- The taste and odour thresholds of ether oxygenates in water are 20,000 – 100,000 times lower than the concentrations that have caused effects on laboratory rats (USEPA Drinking Water Advisory, 1997 – EPA 822-F-97-008).
- The European Union risk assessment of MtBE only classifies it as flammable and an irritant - based on dermal contact with the pure chemical; i.e. not dissolved in water (European Chemicals Bureau, 2002).

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# Oil company data 2000 (1)

- Retail filling stations
  - 4615 sites owned by oil companies
  - 2007 sites investigated for soil & groundwater contamination
  - 802 sites investigated for ether oxygenates
  - MtBE reported in groundwater at 235 sites (30% of those investigated)
- Oil distribution terminal & depots
  - 82 sites owned by oil companies
  - 55 sites investigated for soil & groundwater contamination
  - 32 investigated for ether oxygenates
  - MtBE reported in groundwater at 8 sites (25% of those investigated)

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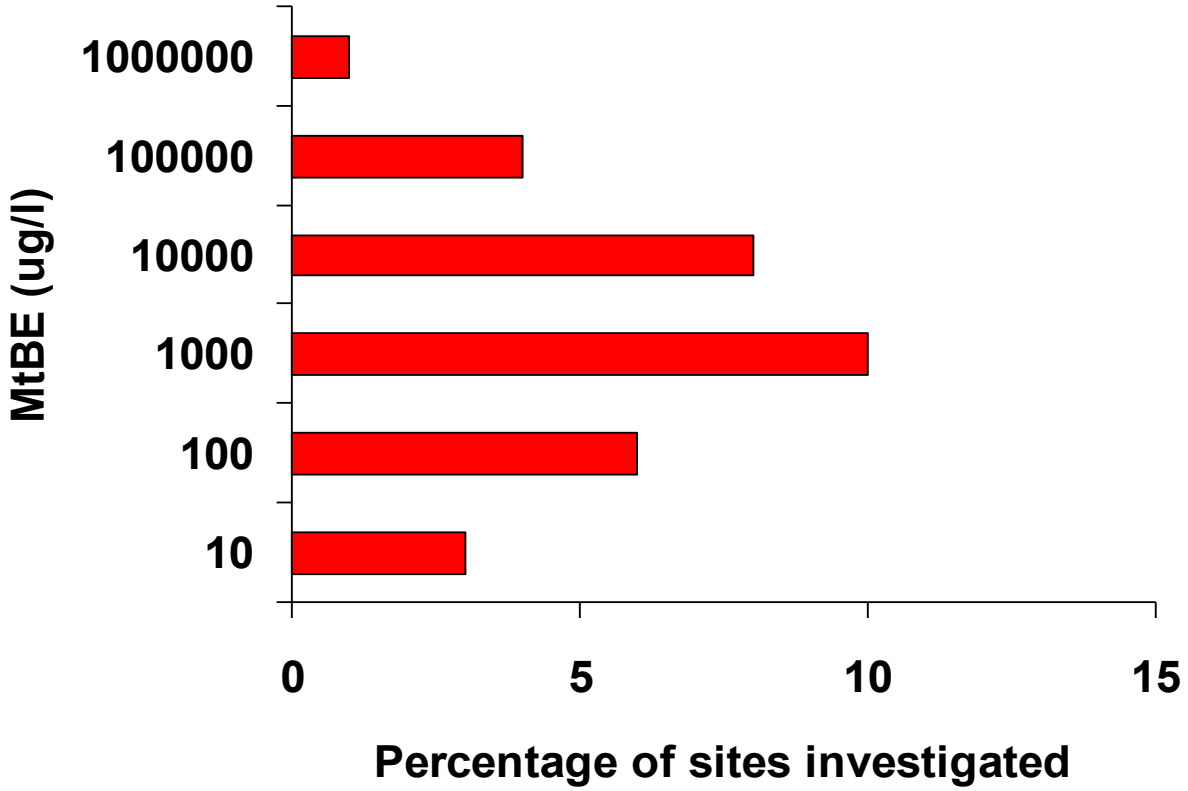
# Distribution of maximum MtBE concentrations in groundwater at petroleum handling sites in the UK



# Oil company data 2000 (2)

Of the 235 retail sites impacted with MtBE

- 8 are located above high vulnerability major aquifers
  - 5 of these are located within a Source Protection Zone
- 29 are located above high vulnerability minor aquifers
  - 1 of these is located within a Source Protection Zone.
- This indicates that a minimum of 6 out of 802 (0.6%) petrol filling stations investigated could potentially pose a risk to a PWS well.
- As far as the whole network is concerned 0.6% is probably an overestimate as the 802 sites investigated were not a random sample of sites, but biased towards those with known or suspected problems.

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# EA groundwater quality monitoring data (2000)

- 685 EA groundwater quality monitoring wells regularly analysed for ether oxygenates
- Data provided from approx 2000 samples
- MtBE reported in 10 wells (at concentrations between 0.1 and 1.0 ug/l)
- These concentrations were very close to the reported limit of detection (LoD).

# Water Company Data (2000)

- 1944 public water supply (PWS) boreholes in England & Wales
- 255 PWS regularly analysed for ether oxygenates
  - 10 contained MtBE > 1.0 ug/l
  - 3 of these contained MtBE > 5 ug/l
    - These three wells also contained pesticides and nitrate
- Only one instance where MtBE detected in mains water above the taste threshold.

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# Modelling potential future PWS well impacts

- Model constructed to predict the overall risk posed by MtBE to PWS wells
- Calibrated with real data from the study
- Based on the MtBE content of gasoline in 2000 (< 1% v/v) the model predicted that MtBE might be expected to exceed the taste threshold in 6 out of the 1944 PWS boreholes in England & Wales.
- This number could increase by an order of magnitude if the concentration of ether oxygenates in gasoline is increased to 5% - 15% v/v

# Why might the situation be different between the USA and the UK?

- Lower concentration of ether oxygenates in gasoline
- Mode of product dispensing
  - In the UK (and most of Europe) suction is favoured over pressure delivery systems. The latter is preferred in the USA.
- Predominantly deep aquifers used for drinking water
  - Protected by one or more aquitards
  - Shallow aquifers are very rarely used for drinking water in urban areas of the UK, owing to poor yields and poor water quality resulting from > 100 years of urbanisation.
- Less aggressive groundwater extraction policies
- Higher recharge

# Conclusions (1)

- The issue of ether oxygenates in drinking water is one of taste and odour rather than risk to human health
- Based on the data obtained in 2000, the impact of MtBE/TAME on potable groundwater in the UK was not a widespread problem at that time.
- Predictive groundwater modelling indicated that, at the concentrations used in gasoline in 2000, widespread PWS impacts were not expected to occur in the future.
- MtBE/TAME impacts on groundwater at petrol filling stations do not automatically mean high risk.
- Data are required on receptors (e.g. PWS wells) and pathways by which receptors may become impacted

continued

# Conclusions (2)

- At the majority of sites where MtBE/TAME have been detected in the groundwater, they were present in the first encountered groundwater. Shallow aquifers are very rarely used for drinking water in urban areas of the UK, owing to poor yields and poor water quality resulting from > 100 years of urbanisation.
- The number of petrol filling stations that may pose a risk to PWS wells is low (< 1% of the network). The risk is one of taste and odour rather than risk to health.
- The risk can be managed by identifying these sites and developing site specific risk management plans which may include one or more of the following:
  - Supplying the site with gasoline free of ether oxygenates
  - High engineering standards for containment
  - Leak detection systems
  - Groundwater monitoring programme

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# Conclusions (3)

- In 2000 it was recommended that caution be exercised over increasing the concentration of ether oxygenates in gasoline as this would result in an increased number of PWS wells impacted.
- In 2000 it was recommended that the study be repeated in 5 years to monitor the situation to see if it has changed.
  - Repeat study initiated in Q1 2006.
  - Due to report in Q4 2006.

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