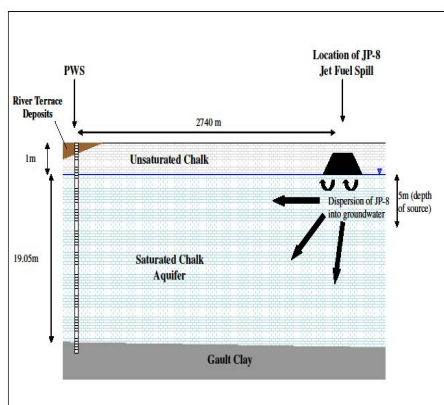


Groundwater Risk Assessment without Source Term Data

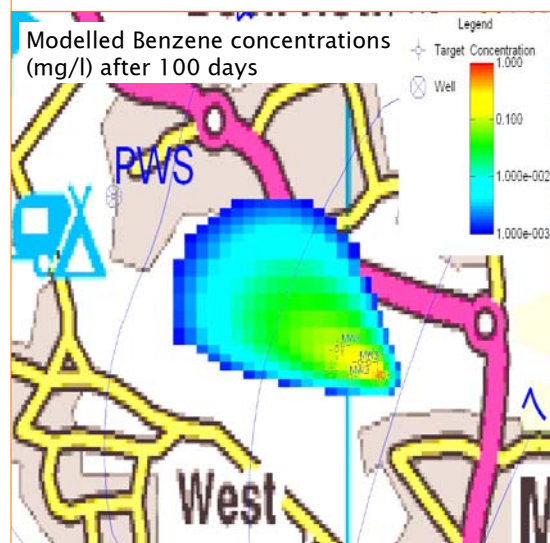
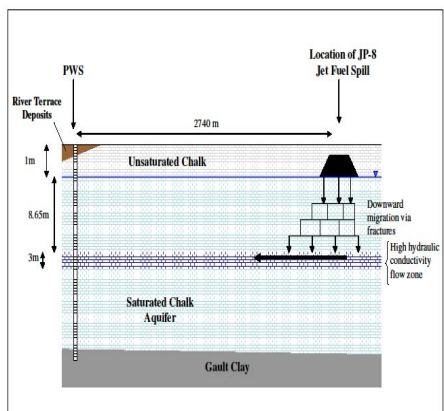
Authors
Incident
Site characteristics
Aim
Constraints

Lucy Heaney and Jane Dottridge (Mott MacDonald)
Accidental rupture of a pressurised subsurface fuel line at an air base which released approximately 200m³ of JP8 jet fuel into the ground
Thin drift overlying highly vulnerable Lower Chalk. The Chalk is thin but highly transmissive. The spill was located approximately 2.5km upgradient of a Public Water Supply (PWS) abstraction in the Total SPZ. The PWS has a history of previous contamination by hydrocarbons and chlorinated solvents.
To safeguard the PWS, a rapid risk assessment was required to predict breakthrough time at the abstraction point and forecast concentrations with time to allow provision of additional treatment as or if required.
Due to urgency and lack of access to site and data, it was necessary to estimate the source term.

Conceptual model – minor fracture flow



Conceptual model – major fracture flow



A tiered risk assessment approach was used:

Step 1 – Contaminant Screening and Identification of Contaminants

- US specification for JP-8 obtained to define components of fuel and their proportions. Assumed no significant additives (but no site specific data)
- 54 potential contaminants identified – mainly hydrocarbons from >C8-C20
- Obtained published data on solubility and used Raoult's law to calculate total dissolved phase concentrations of each compound

$$S_{\text{actual}} = S_{\text{theoretical}} \times \text{fraction in mixture}$$

- Calculated maximum concentrations, compared to Drinking Water Standards (DWS) and ruled out if below the DWS. Where DWS were not available, concentrations of less than 1µg/l were also ruled out

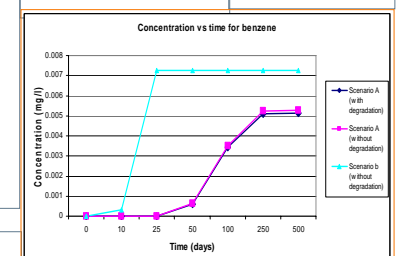
Step 2 – Preliminary Assessment of Contamination

- Thirteen Contaminants of Concern (CoCs) identified
- Defined a conceptual model with two scenarios – minor fracture flow and major fracture flow. Logging and testing at the PWS borehole indicated that flow in the Chalk aquifer may be concentrated in a major fissure zone with extremely high hydraulic conductivity, but the lateral extent of this feature is unknown. This leads to uncertainty in the conceptual model, thus two alternative conceptual models were tested
- Defined model input values (including sensitivity analysis) and model settings for EA's RTW model v 3.1, assuming 1-D flow from source to receptor
- Predicted breakthrough times and concentrations from modelling. Two indicator compounds assessed in more detail – benzene (shortest breakthrough time) and aromatic fraction >C8-C10 (highest concentrations)

Contaminants of Concern	Calculated dissolved phase concentration (µg/l)
Benzene	5233
Toluene	1061
Ethylbenzene	302
m&p xylenes	2002
o-xylene	1434
1,2,4-trimethylbenzene	1460
(1 methylpropyl) cyclohexane	769
Naphthalene	150
Aliphatic >C8-C10	151
Aliphatic >C10-C12	6.25
Aliphatic >C12-C16	0.047
Aromatic >C8-C10	24109
Aromatic >C10-C12	3538

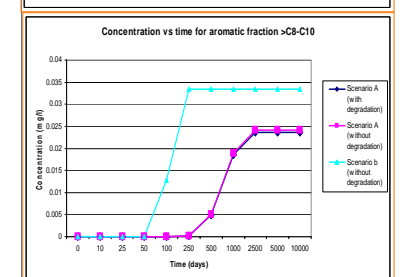
Step 3 – Calibration of Model

- Site specific data on contaminant concentrations and movement was supplied following initial risk assessment
- Model was calibrated by revising the RTW models for benzene, aromatic >C8-C10 and aromatic fraction >C10-C12 and checking site data against forecast concentrations. Although uncertainty is high, the calculated source terms were found to be credible
- Predicted concentrations found to be a good 'fit' using Minor Fracture Flow Scenario with degradation using Xu and Eckstein dispersivity. Sensitivity analysis indicated that calculated dispersivity resulted in very high dispersivity values due to the pathway length.



Step 4 – Modelling of contaminant fate and transport

- Refined simple model by using Modflow for steady state groundwater flow, with data inputs and flow pattern based on the EA's regional groundwater model, and MT3D for contaminant fate and transport
- Modelled input data and results are consistent with the RTW modelling
- The model predicts that benzene could be detected in the PWS 6 months after the spill, if remediation was not effective. For aromatics >C8-10 and aromatics >C10-12, detectable concentrations predicted to occur after 5 and 7 years respectively.



Quote from the Squadron Commander at the base "Yes, we had a mishap"... "But we have been very diligent in attacking it"

