[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	5 and 6 (Select the number from "Areas of Technologies Requested")
Title	Techniques for estimating contaminated land and groundwater volumes
Submitted by	UK National Nuclear Laboratory (NNL)

1. Overview of Technologies (features, specification, functions, owners, etc.)

In order to support the understanding of groundwater flow and the transport of radionuclides in groundwater, and to support decision making on the treatment of areas of contamination or other countermeasures, it is useful to develop estimates of volumes of contaminated soil and groundwater, according to specified concentration levels and waste categories. Techniques that can be applied to the estimation of contaminated soil and groundwater volumes include:

- Geographical Information System (GIS) techniques to assess volumes of contaminated soil and groundwater based on measurements of activity in soil and groundwater samples; and
- Groundwater flow and contaminant transport modelling techniques based on modelled activity levels in soil and groundwater.

GIS techniques

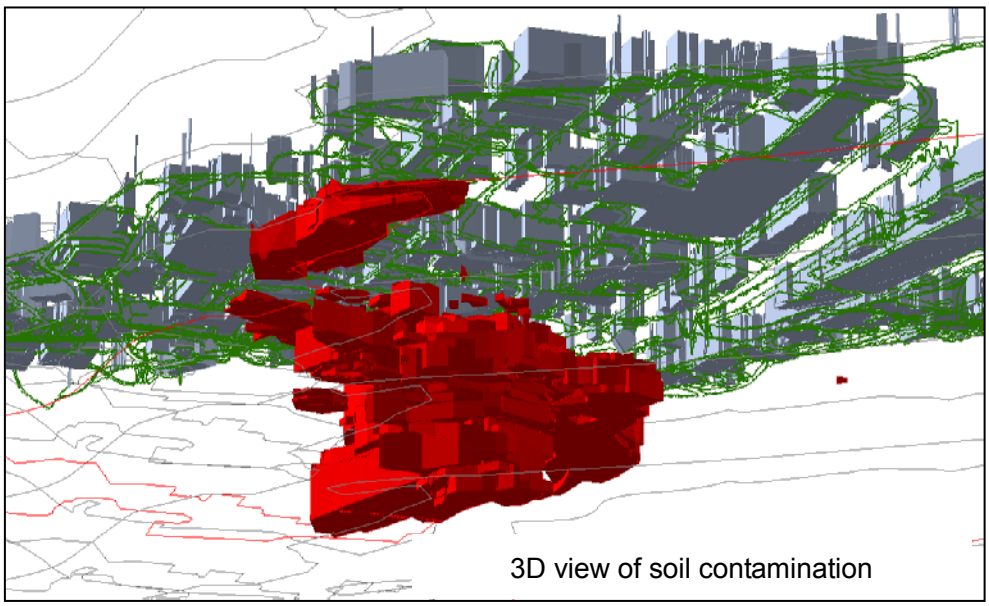
The data from measurements of soil samples and groundwater samples obtained during site investigation and monitoring studies can be mapped using interpolation methods and analysed using GIS software. This can be carried out by analysing individual horizontal 'slices' of unit depth. Volumes of soil and groundwater corresponding to reference levels, e.g. waste categories/soil disposal limits, drinking water standards, can then be calculated. GIS techniques can also be used to provide 3D visualisation of sub-surface layers and volumes of contaminated soils and groundwater within the specified reference level categories.

The National Nuclear Laboratory has applied this technique to estimate volumes of contaminated soil and groundwater at a large industrial site. Using GIS techniques, volumes of contaminated soil were calculated with reference to soil disposal limits. The analysis was carried out using ESRI's ArcGIS™ Desktop Geographical Information System (GIS) software (particularly ArcGIS Spatial Analyst, 3D Analyst and Geostatistical Analyst) and Microsoft Excel.

The data comprised measurements of alpha and beta activity from soil samples obtained during site investigation and construction work at the site. This was then mapped using interpolation methods for metre thick intervals from the topographical surface down to tens of metres below

ground level (BGL) and GIS analysis techniques used to produce a map for each depth level, dividing contamination into the soil disposal limit categories. The area of soil contaminated to each waste category for each interval was calculated and exported to a spreadsheet where total volumes were calculated.

The sub-surface layers of contamination could then be visualised in 3D. A 3D visualisation gives a useful view of the relative size and shape of the volume according to soil disposal category.



3D view of soil contamination

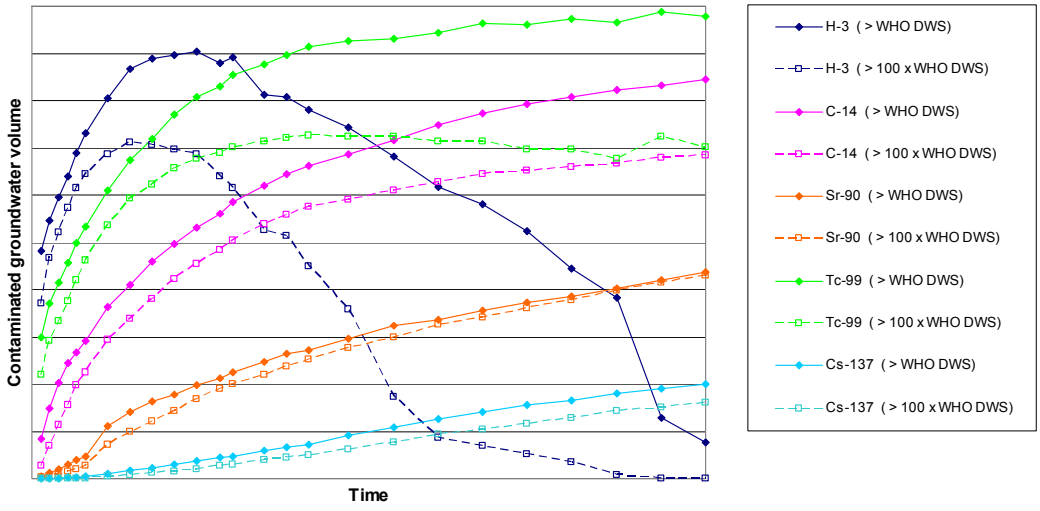
Groundwater flow and contaminant transport modelling techniques

Based on the site conceptual model relating to the current understanding of the features and processes affecting groundwater flow and contaminant transport modelling at a site, 3D groundwater flow and contaminant transport modelling using continuum modelling techniques (e.g. finite element or finite difference approaches) can be applied to assess historical, current and potential future contaminant locations. Such models need to be calibrated and provide an appropriate good fit to measured site data. The outputs from these models, providing simulated activity levels in the aqueous and solid phases (i.e. in groundwater and soils) within the spatially discretised model area, can be used to calculate volumes of contaminated land and groundwater, corresponding to reference levels, e.g. waste categories/soil disposal limits, drinking water standards.

The National Nuclear Laboratory has applied this technique to estimate volumes of contaminated soil and groundwater associated with leakage of radionuclides to ground/groundwater from a building at a nuclear site. The groundwater flow and contaminant transport modelling was

undertaken using the National Nuclear Laboratory's code TRAFFIC (TRansport And Fluid Flow Including Chemistry). Volumes of contaminated soils relating to waste categories and volumes of contaminated groundwater relating to World Health Organisation drinking water standards (WHO DWS) were calculated for times from the start of the building leak for up to 150 years into the future. This has allowed changes in volumes with time to be assessed to provide input into decisions on management of contaminated land and groundwater and to identify the impacts on waste or treatment volumes of the timing of potential remediation.

Example of variation in modelled contaminated groundwater volume with time



2. Notes (Please provide following information if possible.)

- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

9 – applied to nuclear industry site.

- Challenges

GIS techniques – need to handle scarcity of data and spatial distribution of data in the area of interest.

Modelling techniques – Requires development of a robust conceptual model, supported by site data, and management of uncertainties in data and understanding of processes.

- Others (referential information on patent if any)

【Areas of Technologies Requested】

(1) Accumulation of contaminated water (Storage Tanks, etc.)

(2) Treatment of contaminated water (Tritium, etc.)

(3) Removal of radioactive materials from the seawater in the harbor

(4) Management of contaminated water inside the buildings

(5) Management measures to block groundwater from flowing into the site

(6) Understanding the groundwater flow