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

Technology Information	
Area	6 (Select the number from “Areas of Technologies Requested”)
Title	Leak Detection and Monitoring Technologies
Submitted by	UK National Nuclear Laboratory (NNL)

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

It is important in the current situation at Fukushima Daiichi that the ground is continually monitored around the buildings and elsewhere on site so that any new leaks of contaminated water are detected and that the migration of existing contamination can be tracked. While groundwater sampling and analysis for radionuclides is an essential part of this process, other technologies are available or under development which may either complement or offer advantages over this method; for instance:

- Electrical Resistivity Tomography (ERT)
- Cross-borehole radar (XBR) in conjunction with cross-borehole seismic (XBS)
- Neutron Probe Logging
- Gamma Logging
- Acoustic Emission
- Soil gas monitoring (e.g. He isotope measurements)
- Tritium *in-situ* monitoring
- Enhanced Groundwater monitoring including:
    - Chemical parameters
    - Physicochemical e.g. temperature, pH, electrical conductivity
    - Addition of designed tracers to liquor e.g. chemical, isotopic, organic ions.

The NNL have experience in assessment of many below ground leak detection and monitoring technologies including those above. The likely success of any of the technologies is highly dependant on site conditions and therefore requires specific assessment, from desk based screening and feasibility analysis through to field trialing and full scale deployment.

At Sellafield, the NNL have been involved in taking a number of technologies up to the level of field trialing, in particular down-hole gamma monitoring and ERT (supporting the British Geological Survey (BGS)). These are described briefly below:

Electrical Resistivity Tomography (ERT)

Electrical Resistance Tomography (ERT) is a geophysical technique that can be used to measure and record changes in the resistivity of geological materials. The technique can be used for in-ground detection and volumetric monitoring of leaks.

For the ERT field trial, down hole ERT sensor arrays have been installed in six boreholes to a depth of 40 m. The arrays are connected to BGS-designed ALERT instrumentation, which allows the autonomous scheduled collection of large amounts of electrical resistance data. A telemetric link enabled fully remote operation of the ERT system, upload of command schedules and regular download of datasets via broadband internet.

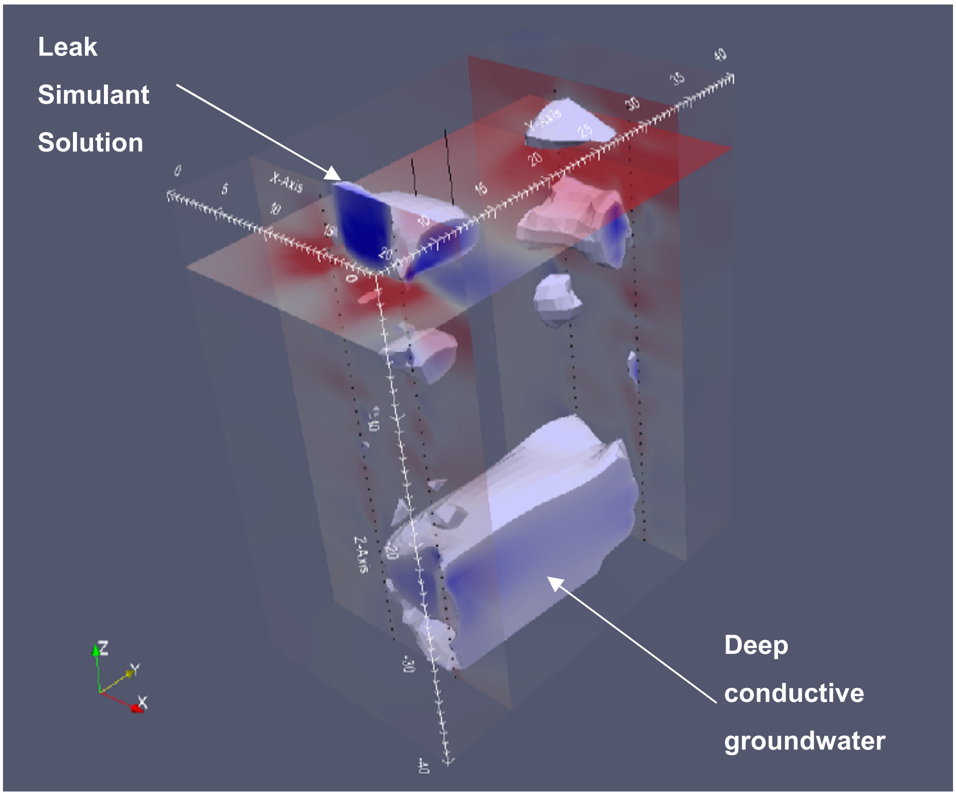

Figure: Resistivity changes in the trial area compared to baseline measurements

The trial involved an initial period of baseline measurements, followed by multiple controlled injections of benign conductive simulants (saline tracer solution) into the vadose zone via shallow boreholes at two different locations near the centre of the trial area. The simulants were developed to replicate the range of measured conductivities of measured silo liquors. Repeated ERT cross-borehole measurements before, during and after the injections were made in order to assess the information content of the ERT data with respect to the occurrence of the simulated leak and the fate of the resulting plume.

The results of the trial to date have proved sufficiently sensitive and images of resistivity change relative to a baseline date have revealed likely pathways of simulant flow in the vadose zone and shallow groundwater.

Downhole Gamma Logging

The NNL and its contractors have trialled a variety of potential gamma detection equipment in the laboratory and field for leak detection and radiation monitoring purposes, including:

- Gross Dose Rate Measurement using Geiger Muller (GM) tubes
- Low Resolution Gamma Spectroscopy (LRGS); &
- High Resolution Gamma Spectroscopy (HRGS)
- NNL RadLine™ - scintillating crystal detector with fibre optic cable

These detectors can be deployed as either individual logging units for intermittent or one-off deployment, or integrated into multiple detector stringers for long-term deployment.

The NNL has also designed gamma leak detection arrays around source buildings using knowledge of the ground and contaminant characteristics, and radiation transport modelling. This work enabled appropriate borehole and detector spacings to be calculated and limits of detection and detection times to be determined.

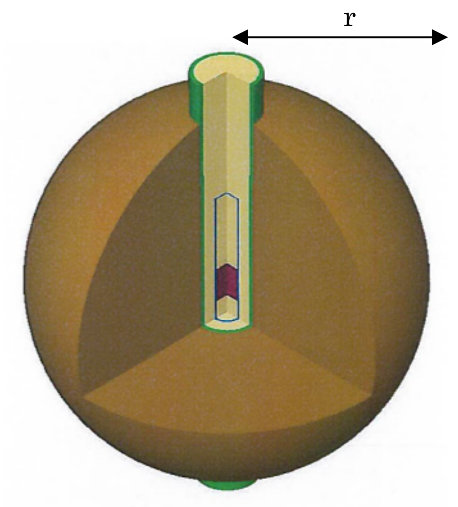

Figure: Sphere of detection of single LRGS detector for ^{137}Cs in glacial sediment

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

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

TRL is dependent on individual technology. Most are Commercial off the shelf. Readiness largely dictated by site-specific factors.

- Challenges

Availability of suitable deployment positions

- Others (referential information on patent if any)

Depends on specific equipment.

【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