FORM 2

Technology Information	
Area	**6**
Title	**Understanding Groundwater Flow**
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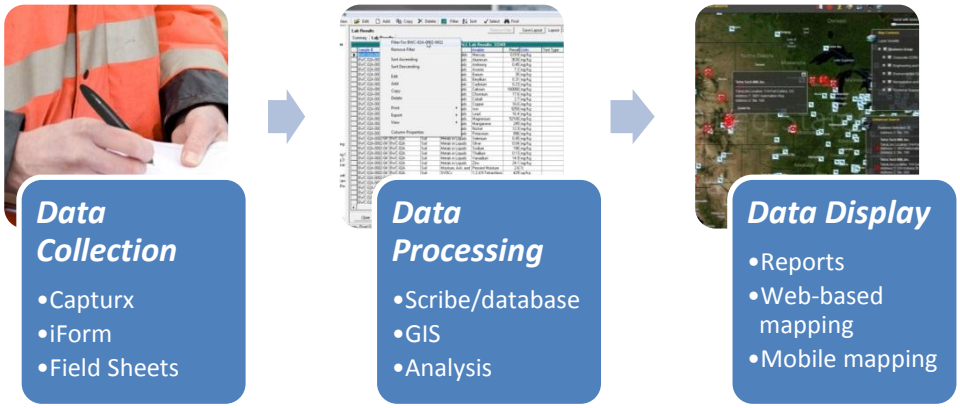
Overview of Technologies

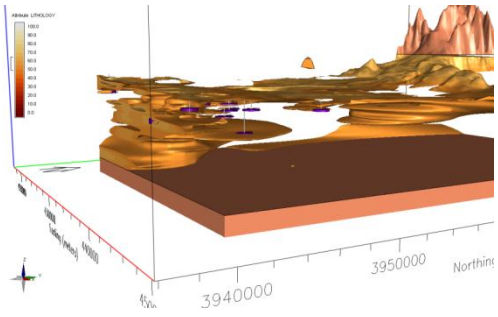
1. More efficient measurement of ^{90}Sr in the field with integration into lithology.

    a. Thermal Ionization Mass Spectrometry (TIMS) – dedicated mass spectrometer in a field facility. Water samples are extracted with ion exchange, loaded on filaments and ^{90}Sr is measured directly in the TIMS using ion counting; concentration determined by ratio to stable Sr.
    b. Soils are extracted, concentrated by ion exchange, and analyzed by the same method in the field in a field laboratory and results are posted on websites directly.



    c. Mass spectrometer is commercially available; analytical procedures, extraction, and calibration methods and protocols are internally developed and tested by Tetra Tech.

2. Borehole monitoring of radioactive constituents.



    a. Drilling boreholes is essential for many purposes such as: collecting core material, scanning core material, logging boreholes for infiltration depth, monitoring water movement, detecting tritium and ^{90}Sr distribution with respect to lithology and fractures that are transmissive, measuring and monitoring water level, and collecting samples from all saturated sections to determine water composition. Detailed examination and description of core material allows for detailed 3-D modeling of the permeable lithologies, thus allowing hydrogeologists to define zones that are transmitting both native and contaminated groundwater. Lithologic descriptions should be supplemented with geophysical log data which will provide the basic information required to create the 3-D geologic/lithologic graphics, cross-sections, and visualization needed to trace the distribution of transmissive sand lenses.

b. Boreholes are drilled with sonic methods, which minimizes the footprint, provides careful drilling and coring, and allows for core to be retrieved quickly and safely so that it is available to be scanned for radioactivity.

c. The completed borehole will be logged with wireline tools for moisture content to detect surface infiltration (neutron logging), migration of beta emitters (360-degree high efficiency beta particle detector), gamma (solid state gamma radiation detector), water level (piezometers), and water composition (low flow samplers).

d. Some basic instruments are commercially available, but modifications must be made for this application; components will be added and software will be modified by Tetra Tech for this application.

3. Detection of distribution of reactor water using stable isotopes of boron
   a. Tetra Tech has 15 years of experience with boron isotopic measurements and possesses an in-house mass spectrometer. Boron stable isotopes make ideal intrinsic tracers because they are:
      i. chemically conservative
      ii. soluble
      iii. not affected by redox
      iv. wide range of isotopic ratios greater than 70 per mil naturally
      v. high precision
      vi. NTI (negative thermal ionization requires only nanograms of sample)

      Nuclear application requires extremely depleted boron, for broad neutron cross section yielding clear signature of nuclear derive boron source labeling fugitive water.

   b. The extent and distribution of reactor water that has infiltrated into both shallow perched water zones (which are undoubtedly present) as well as groundwater can be detected and monitored by measurement of stable boron isotopic composition. Stable boron isotopic composition in groundwater should be measured in upgradient wells across the prefect to establish the end surface water samples.

   c. Stable boron at the reactor site should also be sampled and measured in all groundwater and surface water; water from the reactor, cooling water, or wastewater used to cool fuel will have extremely depleted stable boron isotopic signatures and can detect mixing of background and contaminated water to less than 1 percent mixing. Boron is chemically conservative and soluble; however, nuclides are not as soluble, and will not be reliable indicators of reactor water.

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

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

Most instruments are commercially available but will require either modification for the application, additional software, or protocols available through Tetra Tech.

- **Challenges**

Normal challenges associated with handling of radioactive equipment.

- **Others (referential information on patent if any)**

Some modifications, protocols, and software are proprietary to Tetra Tech but can be made available with appropriate contracts. Tetra Tech is positioned as the #1- ranked firm in the industry with respect to water.