Ground Water Monitoring Guidance for Nuclear Power Plants

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Principal Author: Dave Scott, LEP
RSCS Inc.

Contributions

- EPRI Project Manager
  - Sean Bushart
- Contributing Authors
  - David Keefer - RSCS
  - Matthew Darois - RSCS
  - Eric Darois – RSCS
- Editor
  - Ron Cardarelli – C.N. Associates
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Introduction

- 150-page Ground Water Monitoring Guidance sponsored by EPRI
- Draws on experience at two Decommissioning power plants:
  - Yankee Nuclear Power Station (Rowe, MA)
  - Connecticut Yankee Nuclear Power Station (Haddam Neck, CT)
- And one operating power plant:
  - Salem Generating Station, (Hancocks Bridge, NJ)

Introduction (con't)

- Review of history of GW monitoring at three nuclear power plants
- Review of Federal, State & Local regulatory requirements
  - US NRC
  - US EPA (Clean Water Act, Safe Drinking Water Act, CERCLA, RCRA, UST
  - State DEP
- Assessment of the potential for GW impacts
  - Plant structures, processes, materials, fuels
  - Hydrogeology

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The Bottom Line

- Experience gained shows that the release of radionuclides and non-radiological contaminants to ground water can occur.
- REMP programs should consider GW pathway.
- NRC site release criteria (10CFR Subpart B) require that plant-related subsurface contamination, including that in GW, be fully included in total site dose (25 mrem).

Best Approach

- GW Monitoring optimization recognizes that it may be required - hence early planning and execution.
  - Before major leaks and events.
  - Avoid surprising findings.
  - Minimize the potential for politicizing the process.
  - Maintain control and minimize cost
  - Document zero release (best case)

Objectives of the Guidance

- To provide a framework for planning and implementing a GW monitoring program.
  - hydrogeology characterization
  - GW quality
  - input to the decommissioning process
  - continued plant operation in compliance with state or federal requirements

Objectives (continued)

- Provide an organized approach to evaluation of the many factors that influence GW contamination:
  - occurrence,
  - nature,
  - and extent.

Benefits of Guidance

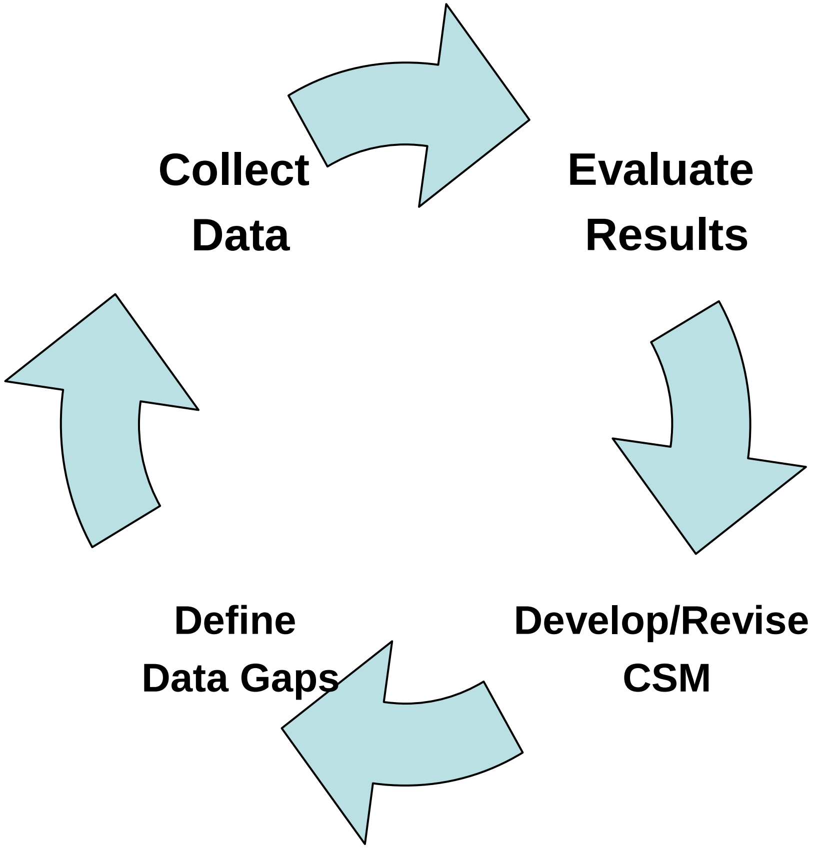
- Use of the principles and techniques will demonstrate appropriate standard of care.
- A thorough review of the operating history may identify an understanding of:
  - what contaminants may have been released
  - where releases to GW have occurred.

Tools

- Characterization of the hydrogeologic system.
- Understanding of transport mechanisms that
  - Cause the movement of the contaminants released, and,
  - Determine ultimate fate of those substances in the environment
- Delineation of the horizontal and vertical extent of the contaminants released:
  - Concentration within the local GW flow domain
  - Variability in position and time

Initiating the Investigation

- Proceed with a phased approach that implements a "scientific method"
- Develop a Conceptual Site Model (CSM)
  - Evaluate the existing site data (hydrogeology, source areas, contaminant distribution, transport mechanisms)
  - Formulate a preliminary CSM (hypothesis) that explains the observed data
  - Collect data: drill monitoring wells, sample and analyze GW, and conduct hydrogeologic testing
  - Evaluate and interpret the resulting data



Designing a GW Investigation

- Evaluate possible sources of contaminants
- Evaluate possible radionuclides
- Determine GW flow directions & mechanisms
  - Install monitoring wells
    - Drilling methods
      - Overburden wells
      - Bedrock wells
  - Measure GW levels
  - Sample and analyze GW to determine contaminant concentrations and distribution

Investigative Tools for Hydrogeologic Investigation

- Site Stratigraphy:
  - Geologic maps
  - Borehole sampling
  - Geophysical techniques (surface & down hole)
    - Seismic
    - Resistivity
    - Electromagnetics
    - Ground penetrating radar
    - VLF
    - Gamma logging

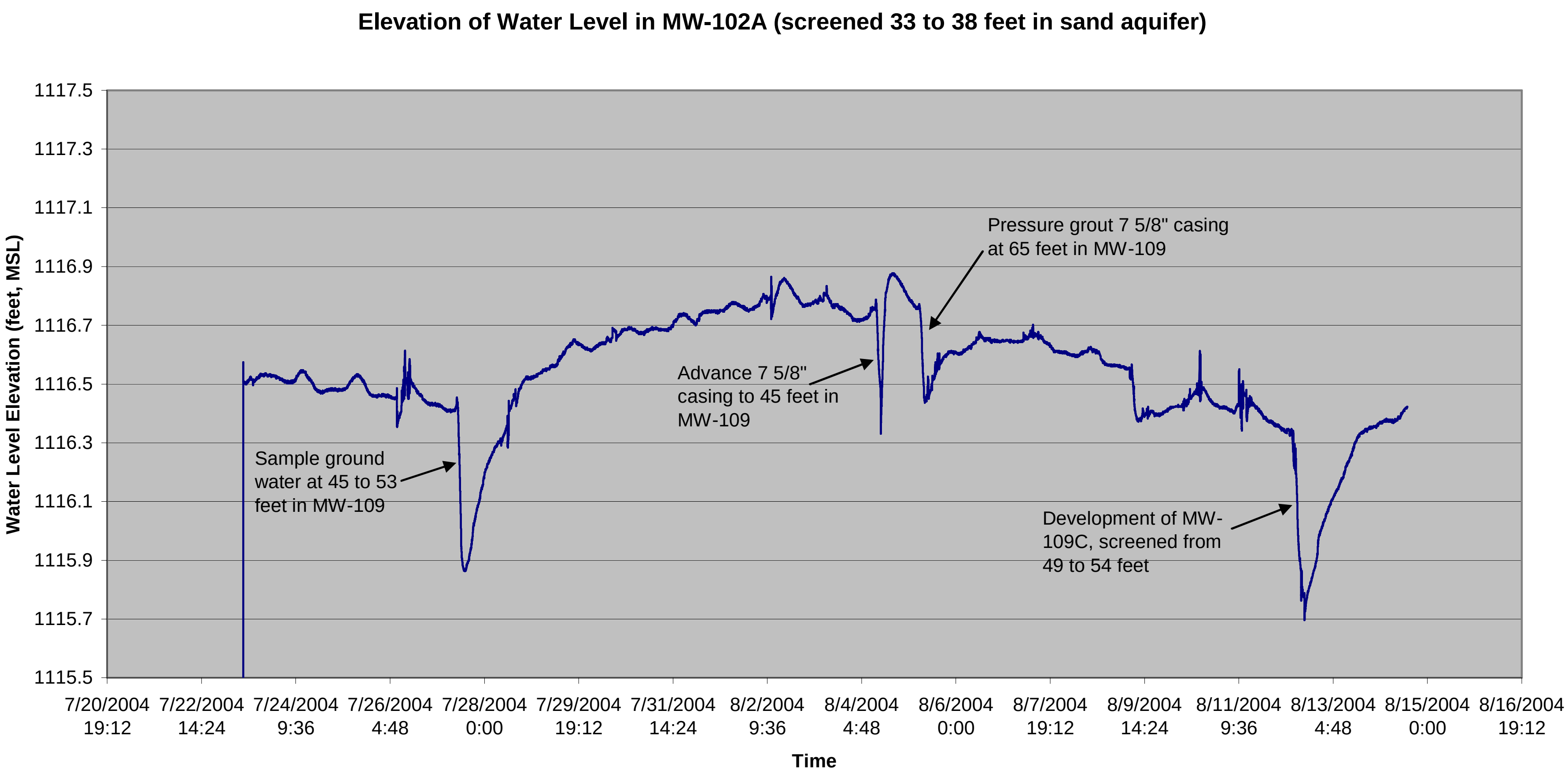
More Tools…

- Hydraulic Conductivity (K) – a key parameter that determines rate of GW flow
  - Piezometer tests
    - Relatively quick and easy
    - Measure K close to the borehole
  - Pumping tests
    - Longer and more complex
    - Measure K over a wider area

and More Tools…

- Water-level monitoring
  - Precipitation (primary input to GW)
  - Surface water (tidal interaction with GW)
  - Ground water (flow direction and gradient)
- Water-level measurement techniques
  - Electronic measuring tapes
    - Synoptic measurements in a set of wells
  - Data-logging pressure transducers
    - Continuous measurements in selected wells

Example of GW Level Data Logging

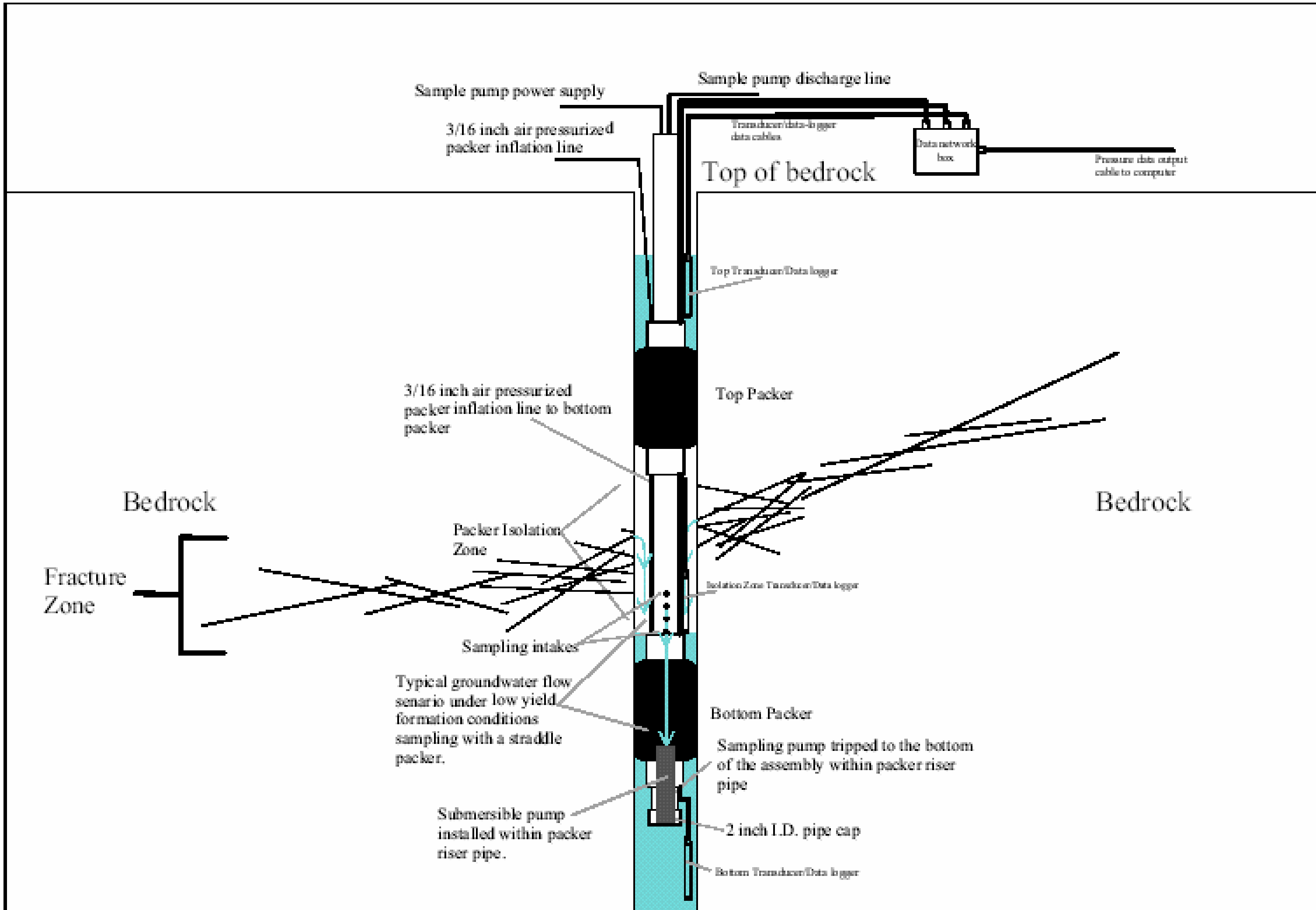


Even more tools…

- Tracer studies
- Isotopic GW dating
- Packer Testing
- Bedrock Borehole Logging

Packer Testing ?

- Inflatable down-hole device to isolate and test discrete zones within a bedrock borehole
  - Identify water-bearing fractures
  - Identify interconnectivity of fractures
  - Identify contaminated zones

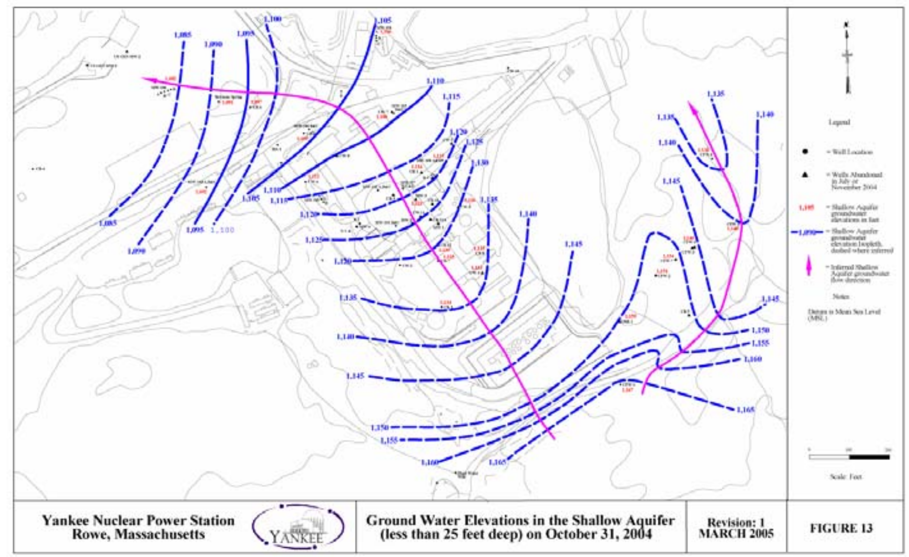


Straddle Packer Assembly Configuration

Subject: EPRI Guidance Figure	
Created By: Matt Darois	
Date Created: December 28th, 2004	
Revision No. Original	
Comments: Straddle Packer with Transducer Instrumentation	Figure No.

Groundwater Modeling

- Only May be Needed for Unusual Contaminated GW Systems
- Numerical Modeling – a mathematical representation of the conceptual site model
  - Don't Try this at home…
  - Model domain is partitioned into a series of rows, columns and layers, to form "cells"
  - Flow in and out of each cell is described by a series of differential equations
    - These equations balance the movement of mass, momentum and energy in and out of each cell
    - Representative values for various hydrologic properties are assigned to each cell.
  - Can Become Complex



Ground Water Sampling

- Analytical data from sampling used to describe the “nature and extent”
  - samples must be representative
- Considerations
  - Well-defined “data quality objectives”
  - Robust quality assurance / data quality assessment
    - Precision – field duplicates, laboratory replicates
    - Accuracy – calibration standards, matrix spikes, blank spikes
    - Completeness - number of valid measurements produced vs. number planned
  - Statistical analysis of data trends to identify bias and false positive or false negative results

Ground Water Sampling (cont.)

- Sampling Methods
  – Low-flow produces most representative samples
  – Bailed samples OK for screening
- Sampling devices
  – Electric submersible pump
  – Peristaltic pump
  – Positive pressure displacement pump
  – Inertial displacement pump
  – Bailer

Ground Water Sampling (cont.)

- Flow-through cell with probes to measure water-quality indicator parameters in the field & determine when samples are representative
  - Temperature
  - pH
  - Turbidity
  - Dissolved oxygen
  - Specific conductance
- Water-level meter

Observations/Guidance

Potential GW Sources (10 to 50 Million pCi/L):

- Spent Fuel Pools
- Refueling Water Storage Tanks

- Primary Radionuclides of Concern Sr-90, Co-60, Cs-137, and H-3.
- Tritium is the most mobile and pervasive.

Conclusions

- State Regulations may "Drive" the Investigation.
- Engage All Stakeholders Through the planning and implementation of the Investigation.
- By applying the Recommended Techniques, plants will demonstrate an Appropriate "Standard of Care".

Conclusions (continued)

- Investigation and monitoring of releases to GW should begin early
  - Avoid delays in achieving objectives for final site closure
- GW investigations are iterative.
  - May require several years to complete.
- Need a Conceptual Site Model
- Modeling is a "Specialty"

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