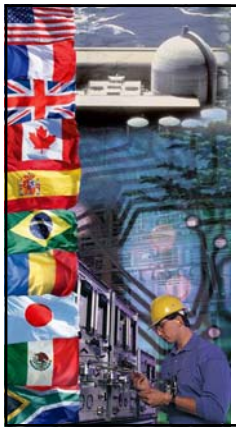


Lessons Learned in Response to Groundwater Contamination at NPP and The EPRI Groundwater Characterization Assistance Program

U.S.NRC Regulatory Information Conference

Bethesda North Marriott Hotel
North Bethesda, MD
March 11-13, 2008

Dave Scott, CPG, LEP
Radiation Safety & Control Services, Inc.

NEI Ground Water Protection Initiative

- Established in Spring, 2006
  - Response to recent incidents at a few operating NPPs
  - To improve industry credibility and bolster public confidence
  - Agreed to by CNOs of all member utilities
- Purpose: enhance detection, management and communication of inadvertent releases of radiological material into ground water
  - For levels well below federal radiation safety standards for NPPs
  - Embraces ALARA versus dose-based protection
  - Recognizes recent guidance of American Nuclear Insurers and potential liability for off-site releases
- Relies upon EPRI guidance to implement a Ground Water Protection Program
  - Incorporates a graded approach to site characterization
  - EPRI offers "GW Characterization Assistance" to member utilities

EPRI Ground Water Assessments: Program Scope

- Perform a site-specific assessment of the ground water protection program at each participating NPP.
- Evaluate the contamination risks.
- Evaluate the effectiveness of the GW monitoring program.
- Bring lessons learned from ground water investigations at other sites.
- 4 Days on-site with 2 technical experts
  - Health Physics/REMP
  - Hydrogeologist
- Prepare a site-specific report
  - Provide recommendations for improving: GW characterization, MW placement & design, sampling technique, data management, DQOs
  - Provide specific recommendations for implementing the 2007 EPRI Guideline Document

Assessment Objectives

- Review the results of any on-site investigations of radioactive contamination of groundwater.
- Evaluate the interpretation of the available data.
- Provide recommendations for proceeding with ongoing investigations.
- Provide recommendations for implementing the document “EPRI Groundwater Protection Guidelines for Nuclear Power Plants” (November 2007).

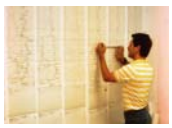
Typical Review Areas

- Review the radiological events documented in the files required by 10CFR50.75(g) to plan for decommissioning.
- Review documents prepared in support of the NEI groundwater protection initiative (July 2006).
- Review available reports of hydrogeologic investigations completed at the site.
- Review laboratory analytical data for environmental samples.
- Review the monitoring well sampling process.
- Review selected plant maps, photos and drawings.
- Review evaluations of selected systems containing liquid radioactive material to determine their potential for leakage to the environment.
- Complete a site tour inside and outside the protected area, including the interior of buildings inside and outside the RCA.
- Conduct discussions with selected site personnel.

Assessment Observations
Historical Events in 10CFR50.75(g) File

- Documentation of Spills to Facilitate Decommissioning Varies Among Plants
- Issues Where Improvements Can Be Made:
  - Evaluate tritium as part of remediation efforts
    - H-3 travels farther than gamma emitters
    - H-3 remaining in soil within the vadose zone is a source for ongoing ground water contamination
  - Consider Low-Level H-3 Contamination of “Secondary Side” SSCs
    - Steam leaks, vacuum breaker leaks, stabilization ponds, storm drains
  - Evaluate selected H-T-D radionuclides in addition to gamma emitters
    - Strontium-90, Nickel-63
  - No need to document spills in RCA buildings
- Recommendations
  - Identify spill locations using GPS or surveyed coordinates
  - Conduct exit interviews of key managers and supervisors to capture institutional knowledge of spills

Assessment Observations
Review of Hydro-Reports and Investigations



- Some Sites
  - Have completed several iterative comprehensive hydrogeologic investigations
    - Drilled and sampled monitoring wells
    - Some included analysis for radioisotopes
    - Others only chemical contaminants - mostly fuel oil
- Other Sites
  - As of early 2007 only geological data was from plant construction, as included in FSAR
    - Geotechnical data to support construction
    - Regional geological data
- Recommendations
  - Develop a site conceptual model to guide Investigations
  - Institute a ground water monitoring program, as required by the NEI GW Initiative
    - Drill and sample monitoring wells

Assessment Observations
Environmental Sample Analytical Data

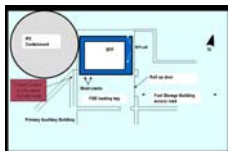
- DQO Process Generally Not Applied
- MDCs for H-3 Not Consistently Established
  - 200 to 3,000 pCi/L
- Inconsistent Selection of Analytes
  - Level of hard-to detect radionuclides in source systems generally not determined
    - Sr-90, Ni-63, Fe-55, Tc-99
  - MDCs Based on Waste Characterization Criteria
    - i.e. Ni-63 ~ 700 pCi/L
- Data Management Systems Do Not Allow:
  - Easy retrieval and trending of all data
  - Demonstration of chain-of-custody controls

Assessment Observations
Monitoring Well Construction and Sampling

- Some Sites Use “Push-Probe” Temporary Wells Extensively
  - OK for shallow, homogeneous materials
- Groundwater Sampling Techniques Include:
  - Bailers
  - Low Flow Methods
  - High Flow Methods
  - Composite Samplers (not recommended)
- Procedural Controls are Not Well Documented
- Well Maintenance Should Not Be Overlooked
  - Need Protection from Vandalism
  - Need Protection from Sample Bias
    - Provide Water-Tight Caps
    - Prevent Surface Water Intrusion for Flush-Mount Wells

Assessment Observations
Structures, Systems and Components

- Spent Fuel Pools
  - Most leak
  - Effectiveness of leak detection systems difficult to establish
- Unlined Concrete Sumps
  - Most leak
  - Small volume, but high concentrations
    - Safety injection rooms, waste processing areas
- Refueling Water Storage Tanks
  - Leakage and overflows not uncommon
- Subsurface Radwaste Discharge Pipelines
  - Integrity difficult to establish
    - NDE methods?
- Secondary Side SSCs
  - High volume/low concentration sources
    - Component cooling water, stabilization pond



NDE Methods for Buried Pipe

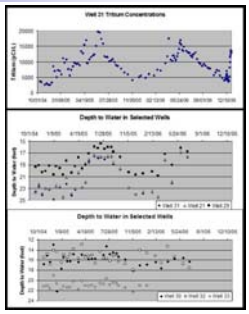
- Guided Wave Survey
  - Performed by attaching transducer array on exterior pipe wall
  - Gross measure of loss of wall thickness
- Robot-Mounted Camera (small pipe) & Manned Visual Inspection (large pipe)
- Inspection of Wall Thickness With Tethered Pig, Measuring:
  - Magnetic flux leakage
  - Remote field eddy currents
- Pressure Testing
  - Monitor for pressure drop - with or without tracer gas
  - Monitor acoustic emissions of escaping pressure
- Ground Potential Surveys to Identify Active Corrosion Zones
- Measure Soil Characteristics
  - Lower pH = higher acidity and higher corrosion rate
  - Higher TDS = lower resistivity and higher corrosion rate
  - Higher % Silt & Clay = more contact with soil moisture and higher corrosion rate

Assessment Observations
Detecting Ground Water Contamination

- Monitoring Wells Close to Source Areas Provide:
  - Early detection
    - Most REMP monitoring only detects contaminants off site
  - Easier discrimination of contaminant source
- Thorough Characterization is Vital
  - For dose assessment
  - To justify monitored natural attenuation (MNA)
- Vadose Zone Processes Can Be Important
  - Most releases occur at ground surface and pass through the VZ
  - H-3 is bound in the VZ by capillary forces and can be remobilized by rising groundwater levels
  - When bedrock surface is in the VZ, fractures can produce unexpected contaminant flow paths
- Anthropogenic Site Features Can Influence Flow
  - Dewatering sumps, production wells, deep foundations, storm drains

Assessment Observations Significant Challenges

- Soil and Concrete Contaminated With H-3 From Historical Spills
  - H-3 is held by capillary forces in vadose zone and migrates slowly (continuing source to aquifer).
  - Concrete contains ~15% H_2O. H-3 will be absorbed and may be a continuing source to the aquifer.
- Data Management Must be Optimized
  - To allow easy retrieval & tracking
  - To prevent becoming overwhelmed
- Conceptual Site Model is Needed to Integrate All Site Data
- Atmospheric Deposition Can Elevate Background H-3 Levels
- Fractured Bedrock Complicates GW Flow Patterns
- Radionuclide Content of Significant Sources Should be Characterized



Which Radionuclides are Most Important in Evaluating Ground Water Contamination

- EPRI Developed a Ranked List Based Upon:
  - Inventory (PWR)
  - Relative Dose
  - Solubility
  - Ease of Transport Through Soil (K_d)

Ranked List of Important Radionuclides

Relative Rank	Radionuclide
1	Sr-90
2	Cs-137
3	Co-60
4	H-3
5	Cs-134
6	I-129
7	Ni-63
8	C-14
9	Pu-238
10	Am-241

Excerpted From EPRI Report No. 1011730 "Groundwater Monitoring Guidance for Nuclear Power Plants", September 2005

Assessment Observations
Groundwater Numerical Modeling

- Most Operating NPPs Have NOT Performed Contaminant Fate and Transport Modeling.
  - Exceptions include plants where recent GW impacts raise public concern
- EPRI Endorses a Graded Approach to Site Characterization, in Which Only Those NPPs with Relatively High Potential for Ground Water Contamination Need Develop Numerical Models
- A Numerical Model is a Mathematical Expression of the CSM
- Models Can Be Useful for:
  - Predicting future plume concentration and extent
  - Evaluating potential remediation alternatives
  - Demonstrating compliance with license conditions
  - Validating the conceptual site model
  - Understanding monitoring data and SW – GW interactions
  - Designing a ground water monitoring network
- Most Used Computer Code: ModFlow (USGS)

Yankee Rowe
Lessons Learned

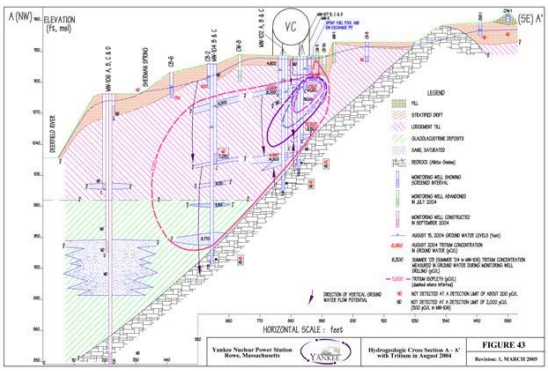
- A Numerical Fate and Transport Model was Developed During Decommissioning
  - Incorporates:
    - Stratigraphic model from drilling and site characterization
    - Water level measurements with pressure transducers
    - Results of ground water sample analyses
    - Results of pumping tests
  - To Validate Site Conceptual Model
  - To Predict H-3 Concentrations at Compliance Point
  - To Demonstrate Compliance with Criteria for License Termination

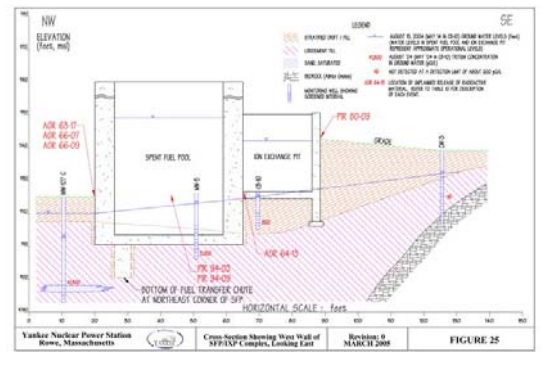
Yankee Rowe
Lessons Learned

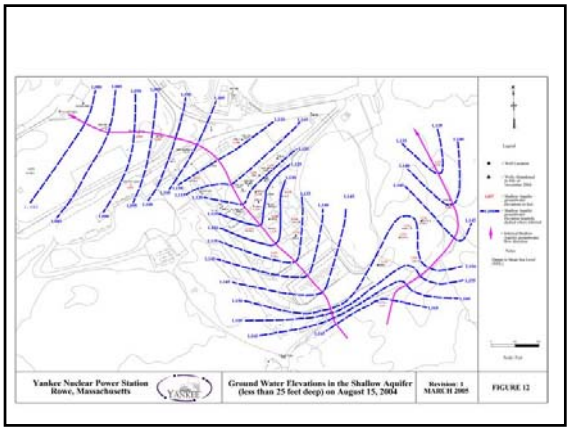
- Long-Term Water-Level Monitoring is Instructive
  - Useful for calibration of numerical model
  - May demonstrate connection or isolation of aquifers
  - May demonstrate correlation with contaminant concentrations
- Early Investigations at YNPS Not Sufficiently Rigorous
  - MWs not deep enough
  - Stratigraphy not well defined
- Involve All Stakeholders and Share Monitoring Results
- Analyze for Wide Suite of Radionuclides
  - Reduce the list of analytes based upon monitoring results
- Include Non-Rad Constituents for Site Closure

Yankee Rowe Lessons Learned

- Develop a Hydrogeologic Conceptual Site Model:
  - To integrate information related to ground water contamination
  - To explain monitoring data
  - To understand contaminant transport mechanisms
  - To aid monitoring well placement and guide investigative effort
- Hydrogeologic Characterization is an Iterative Process
  - Not all questions are answered on the first try
  - Generally a multi-year process
- Long-Term Trends in Analytical Data Are Important
  - Allow detection of analytical bias or false positive results
  - Identify seasonal fluctuations
  - Identify new contaminant releases (not an issue at Rowe)
- Contamination can Migrate Through Multiple Aquifers to Depths >100 feet.
- Hydraulic Conductivity of Soils Controls H-3 Attenuation






Yankee Nuclear Power Station
Rowe, Massachusetts
Ground Water Elevations in the Shallow Aquifer
(less than 25 feet deep) on August 15, 2004
Revision: 1
MARCH 2005
FIGURE 12


Questions?