INDUSTRY GROUND WATER PROTECTION INITIATIVE (NEI 07-07)
LESSONS LEARNED FROM NEI-SPONSORED PEER REVIEWS

Executive Summary

The commercial nuclear power industry adopted the Ground Water Protection Initiative (GPI) in 2006 to improve the management of unintentional releases of radioactive substances to soil and/or water and to enhance communications with stakeholders about those events. The objectives of this industry program build on regulatory requirements established by the U.S. Nuclear Regulatory Commission (NRC) for control of radioactive materials, environmental monitoring and reporting.

The industry's implementation of the Ground Water Protection Initiative has been successful in improving ground water protection. Each nuclear power plant site has at least one method for early detection of unintended releases to the environment and each site has improved procedures for communicating effectively to stakeholders in the event of an unintended release. Measures implemented under the initiative have provided timely detection of unintentional releases at nuclear energy facilities while the material was within the site boundary. This allows companies to take responsible actions to prevent off-site migration of the licensed material[1]. Enhanced on-site detection capability also improves the ability to determine whether there are specific types of equipment or release modes that warrant continued focus. Importantly, none of the instances of unintentional releases of radioactive materials into the soil or water at nuclear plant sites have posed a risk to public health or the environment.

Peer reviews sponsored by the Nuclear Energy Institute (NEI) reviewed each facility's programs, procedures and other documentation to assess their implementation of the initiative as of December 31, 2008. This date was the baseline implementation deadline. The peer reviews were designed to be challenging evaluations that identified opportunities for improvement.

The peer reviews determined that the industry has made significant improvements in its management of unintended releases and outreach to stakeholders about these events. The assessments also identified opportunities to further improve these efforts using shared operating experience and best practices. Identified gaps were most commonly due to incomplete documentation. For those criteria where the site provided documentation that only partially demonstrated satisfactory implementation, the peer review team described opportunities for improvements. Peer review team recommendations have been entered into each site's corrective action program and are tracked to completion with independent review and verification by the respective company's quality assurance or oversight department.

Since the adoption of the initiative in 2006, companies that operate nuclear power plants have taken additional actions over and above regulatory requirements to enhance groundwater protection, including the following:

- Updated the current characterization of the site hydrology

[1] Licensed material is defined in 10 CFR 20 and does not include previously discharged radioactive material in radioactive effluents (see Regulatory Issue Summary 2008-03)

- Improved the understanding of the potential for leakage from SSCs and implemented measures to prevent the leakage
- Established methods for early detection and response to unintended releases

, One or more of the following criteria were identified most frequently as needing increased attention at some plants:

- Documentation of evaluations of work practices to determine the potential for unintended releases;

- Improvements to the systems, structures, and components (SSC) evaluations from use of detailed information and engineering involvement, particularly on preventative maintenance programs and inspections or other means of determining the condition of some systems, structures and components (SSCs);

- Establishment of a site-specific decision-making protocol for remediation efforts; and

- Evaluation of the potential contribution of monitored and controlled radioactive effluents to detectable concentrations of plant-related licensed material in ground water (as a result of planned and permitted releases.

Efforts to better address each of these acceptance criteria are being pursued as part of a joint effort between electric utilities and industry groups, such as NEI, the Electric Power Research Institute (EPRI) and Institute for Nuclear Power Operations (INPO). The Underground Piping and Tank Integrity Initiative recently adopted by the industry is bolstering companies' active assessment and management of SSCs. This enhanced management initiative will provide greater assurance of structural and leakage integrity of piping and tanks outside plant buildings that could be sources of leakage of fluids into the soil and groundwater. The lessons learned described in this report also are being factored into future changes to industry guidance.

The nuclear power industry has devoted substantial resources to implement the GPI. The industry has successfully implemented programs and procedures that improve the management of unintended liquid releases to the environment. Early detection measures are providing timely detection of unintended releases. Industry communications about these events between plant operators and local, state, and federal stakeholders has been substantially improved. Through continued sharing of operating experience and good practices, further improvements to detection, response and prevention of unintended release are being made.

Background

In May 2006, NEI's Nuclear Strategic Issues Advisory Committee (NSIAC), made up of the chief nuclear executives of every U.S. utility company that operates nuclear power plants, unanimously voted to adopt the Ground Water Protection Initiative (GPI) that established voluntary measures to minimize the potential for unintended releases of radioactive liquids to the environment and to improve communication with external stakeholders. The initiative goes above and beyond Nuclear Regulatory Commission requirements that protect health and safety and reflects the nuclear energy industry's commitment to a high standard of public safety and environmental protection.

NEI issued NEI 07-07, "Industry Ground Water Protection Initiative – Final Guidance Document," in August 2007 to support effective implementation of the GPI. This guidance incorporated the lessons learned from industry reviews of companies' implementation of the GPI during the first nine months of program, requests for clarification and observations from member companies, and input from external stakeholders.
Other industry guidance includes NEI 08-08, "Generic FSAR Template Guidance for Life Cycle Minimization of Contamination," (October 2009) and NEI 09-14, "Guideline for the Management of Buried Piping Integrity," (January 2010) developed to support implementation of the Buried Piping Integrity Initiative adopted by the NSIAC in November 2009. The Buried Piping Integrity Initiative augments the overarching goal of the GPI by providing greater assurance of structural and leakage integrity of all buried piping, particularly piping that contains radioactive materials. To do so, the Buried Piping Integrity Initiative drives proactive assessment and management of buried piping systems and encourages the development of improved techniques for inspecting and analyzing underground piping. In September 2010, the scope of the Buried Piping Integrity Initiative was expanded to include all underground piping and tanks and reissued as the Underground Piping and Tank Integrity Initiative. The supporting implementation guidance is being revised to address the expanded scope.

There are 43 acceptance criteria in NEI 07-07 for meeting the objectives of the GPI. To assist plant personnel in implementing the initiative, EPRI formed a working group to develop detailed technical guidance for implementing the initiative. EPRI in 2008 published the "Groundwater Protection Guidelines for Nuclear Power Plants", report 1016099. Plant personnel may use alternative technical methods if they ensure equivalent or enhanced protection of ground water. Companies are expected to meet each of the GPI acceptance criteria or to document the basis for adopting alternate methodology. Self assessment and peer-review of each nuclear plant site's program is required as a part of implementation of the GPI. Self-assessment is performed within one year of initial implementation and at least every five years thereafter. The first round of self assessments was to be completed no later than December 31, 2008.

In addition to self assessments, NEI reviews each facility's implementation through an independent team of peers and subject matter experts one year after the self assessment has been completed. The NEI-sponsored peer reviews began in late 2008 and were completed in 2010.

Lessons Learned from the Peer Reviews

The peer reviews were designed to be challenging and to identify opportunities for improvement. Each facility was asked to produce clear and convincing documentation that specifically addressed each acceptance criterion. The facility was not considered to have fully met the objective if the documentation required additional interpretation or clarification. Specific observations resulting from the peer reviews are summarized below.

NEI 07-07 Conformance with Specific Acceptance Criteria

The nuclear energy industry has successfully implemented the GPI. In doing so, it has improved management of unintended radioactive liquid releases and strengthened communications with affected stakeholders.

As GPI programs have transitioned from initial development to implementation, there has been broad turnover in the personnel responsible for the program. In some cases, the turnover was not sufficiently detailed or there was incomplete knowledge transfer. One mechanism shown to facilitate effective turnover of program responsibility is a unifying program procedure or document that establishes clear links between the GPI acceptance criteria and the site's implementing documents. For some companies that have multiple nuclear plant sites, there were differences among the sites' implementation of the initiative and, in some instances, the sites were not entirely successful in building upon company-wide programs and procedures. Opportunities such as the annual EPRI-NEI Groundwater Protection Workshop provide a venue for training for plant individuals newly assigned to working with the GPI. The workshop also is an established mechanism for providing plant personnel with updates on new or changing policy focus by the industry and the regulators, and learning about new technologies related to ground water protection and management.

A unifying program document is fundamental for long-term conformance, particularly to ensure periodic evaluation of the various program elements. In addition to establishing specific frequencies for periodic evaluation of the programmatic elements in the governing document, an industry best practice is to include the periodic evaluations in the site's scheduling tool.

Objective 1: Ground Water Protection Program

1.1 Site Characterization of Geology and Hydrology

Peer reviews verified that a qualified hydrologist or geologist reviewed or updated the characterization of the ground water flow based on current site conditions and the site's geology and hydrology. The peer review team's determination relied on the site hydrology report(s) generated by the utility's hydrologist or geologist to demonstrate a reasonable effort rather than the peer review team performing a detailed independent expert review of the geophysical data. For many sites, the utility's geologist or hydrologist recommended additional studies, including installation of new on-site wells except in those cases where the site had recently performed additional studies to characterize the site. The effort to refine the characterization of the ground water gradients and predominant flow is an iterative process and will continue to be updated as necessary as part of the GPI program. Periodic review of

the site's hydrology and geology is one acceptance criterion that requires dedicated resources to ensure that it is performed at the specified frequency.

Several good practices were observed for the site characterization of hydrology and geology. For example, at some sites, the hydrologist's report or Final Safety Analysis Report explicitly describes the pathways between the source(s) and the off-site location. Another notable practice was the trending of water level (potentiometric surface maps) data from on-site wells and/or specifying in the land use census procedure to check with adjacent property owners or with the well-permitting authority as a means of determining off-site water use that could affect ground water flow beneath the site. One area that requires additional attention from several sites is the need to document the consideration of the updated hydrology and geology and the decision on whether changes are needed to the Final Safety Analysis Report.

1.2 Evaluation of Systems, Structures, and Components (SSCs) and Work Practices

Each site was asked to provide a written evaluation of the potential for unintended releases from systems, structures, and components (SSCs) and work practices due to changes in equipment or work activities. The EPRI ground water guidelines were still under development in 2006-2007 when most plants were performing their SSC and work practice risk evaluations, resulting in slight variations of approaches and making performance of the evaluation challenging. In addition, sites that experienced unintended releases prior to the adoption of the GPI had already developed their own methodologies for evaluating the potential for equipment integrity or human performance issues. For companies that evaluated their SSCs and work practices with a methodology other than that described in the EPRI Groundwater Protection Guidelines, the peer review team recommended that they perform a gap analysis. An industry good practice was the preparation of a summary report of the SSCs and work practices evaluations to help identify gaps and reallocate resources.

The level of detail in SSC evaluations frequently reflected the degree of involvement by engineering personnel. At sites that relied almost exclusively on the GPI program owner, typically Radiation Protection/Chemistry/Environmental Health & Safety, to perform all of the work needed to meet the acceptance criteria, the SSC evaluations were frequently less detailed and included less information on the maintenance history of the SSC, design operating conditions or material, or other empirical data on the current condition of the SSC. It was also apparent that the current wording of acceptance criteria 1.2b, 1.2c, and 1.2d needs clarification on whether leak detection and spill prevention methods must be explicitly correlated to each SSC or work practice that was evaluated. Another area for improved industry guidance is to provide additional examples for techniques that could be used to meet SSC leak detection and spill containment needs.

The adoption of the Buried Piping Integrity Initiative occurred after the initial evaluation of SSCs was required to be completed. However, the risk evaluation for SSCs covered by the Buried Piping Integrity Initiative will provide valuable information for future periodic updates to the SSC evaluation. Good practices identified during the peer reviews included (1) the use of operating experience to inform the SSC evaluations e.g. tunnels and trenches containing pipes, cooling tower blowdown, and storm drains and (2) amending

design engineering checklists, aging management procedures, and system health reports to include SSCs that contain radioactive liquids or water vapor to trigger updates to the SSC evaluations on an on-going basis. As SSC evaluations are updated over the next five years to reflect changes in equipment condition over time and risk ranking under the Buried Piping Integrity Initiative, utilities should consider defining the scope to include all SSCs that could result in unintended releases that would trigger the criteria for voluntary communication under the GPI.

Work practice evaluations were not well documented at many sites. Each site included as part of its radiation protection program, administrative controls and training to minimize the spread of contamination during work activities. Several facilities relied on these existing work controls and did not perform a comprehensive, documented evaluation of the work practices involving radioactive or potentially radioactive material that could result in spills or leaks to the environment. Industry guidance exists that includes examples of work practices that should be evaluated. Additional clarification on the expectations for meeting objective 1.2.2 may be appropriate, particularly if the site has performed an initial comprehensive written evaluation and includes in its work planning and radiation protection work permit processes and its periodic review of procedures requirements to ensure that no new practices have been created that could result in unintended releases to subsurface soil or water.

A noted good practice in this area was a reminder of the potential for work activities to affect ground water and the need for situational awareness in the annual worker training program. Another good practice was to categorize site procedures for work practices that could result in an unintended release of radioactive material as technical rather than administrative procedures, thereby ensuring an additional level of review.

Due to the volume of supporting documentation, it was difficult to fully assess the depth of site's SSC and work practice reviews. As with the site characterization of hydrology and geology, the 2009 NEI peer reviews provided a qualitative evaluation rather than an independent verification of specific details within the SSC and work practice reviews. The evaluation of work practices and SSCs should be an area for focused attention in future NEI-sponsored peer reviews to provide a more detailed review.

1.3 Ground Water Monitoring

Early detection for unintended releases is now in effect at every U.S. nuclear power plant. Most typically, this was accomplished by installing additional monitoring wells within the plant boundary once the utility's hydrologist or geologist had reviewed the characterization of the site's ground water flow and the location of SSCs and work practices of interest. A clear understanding of the site's hydrology by the trained professional is critical to proper placement of the on-site wells. Industry experience has shown that these on-site wells play a key role in identifying unintentional releases and enabling utility staff to take appropriate actions.

This area also reinforced the need for dedicated resources to ensure timely completion of recommended actions such as the installation of new wells. Optimally, the hydrologist's or geologist's report explicitly addressed each acceptance criterion, although other documentation such as corrective actions or site memos was used. Preventive maintenance and surveillance measures for on-site ground water wells were not consistently established in accordance with guidance based on the American Society for Testing and Materials (ASTM) or an equivalent industry standard for building and maintaining monitoring wells. These identified weaknesses are being addressed through site corrective action programs.

Sampling and analysis programs for on-site ground water frequently reflected the requirements in the site's radiological environmental monitoring program as described in the Offsite Dose Calculation Manual or equivalent. In several instances, the analytical sensitivities differed (lower) from those established for the environmental monitoring program, primarily due to agreements with stakeholders, such as state agencies that participate in split sampling efforts. Future enhancements for industry guidance may include augmenting the soil sampling and analysis protocols to specify analytical sensitivities for tritium in soil.

Generally, the requirement to establish and document a formal long term monitoring program for GPI was met. However, some companies were performing on-site monitoring but had not yet prepared a formal site-specific GPI program document. There were some companies that had a pre-existing, on-site ground water monitoring program but had not updated program documentation to readily demonstrate full compliance with the GPI acceptance criteria. A good practice exhibited is the periodic review of the ground water monitoring program that follows the review of hydrology. Some companies incorporate review of the voluntary ground water monitoring program into the annual radiation protection review of required effluent and environmental monitoring programs.

1.4 Remediation Protocol and Decommissioning Planning

Under objective 1.4, two acceptance criteria were identified during the NEI-sponsored peer reviews for additional direction. The decision-making process for remediation and the evaluation of the potential for planned radioactive releases to contribute to detectable levels of plant-related licensed material in ground water were not consistently developed or documented. One company in particular has developed a remediation decision-making protocol that is represents a good practice for the industry and EPRI has begun work to develop industry guidance. In 2009, EPRI issued "Review of Methods and Tools for Estimating Atmospheric Deposition of Tritium at Nuclear Power Plants," (report 1019226) which provides guidance for evaluating the potential contribution from planned and permitted releases. In addition, some companies have developed site-specific protocols for assessing the potential contribution from planned and permitted releases of airborne effluents that can serve as models for other companies.

Objective 2: Communication

Improved communications with stakeholders and increased transparency is one of the primary objectives of the GPI. The stakeholders who were contacted as part of the voluntary communication protocol varied widely across the industry. Some companies have reached agreement with their stakeholders for voluntary communication at different (typically lower) thresholds than those established in NEI 07-07. Companies are required to document those differences.

To ensure consistency in communications, an industry good practice is to establish and maintain the list of stakeholders both for routine updates and in the event that the voluntary communication protocol is triggered. Some utilities include an established stakeholder list in their procedural guidance.

Documentation of periodic updates for stakeholders often needs improvement, particularly for the initial briefings (circa 2006). In many instances, initial briefing on the industry initiative had been provided to the stakeholders but the briefings were not documented. Planned routine updates to stakeholders on developments in ground water protection at an industry and site level is an industry best practice.

For voluntary communication purposes, the site needs to clearly link on-site GPI monitoring wells to the environmental reporting thresholds and analytical sensitivities as described in the Offsite Dose Calculation Manual or equivalent document. Documentation that plainly describes this correlation was an issue for some plants that had on-site monitoring programs that pre-date the GPI. There are also opportunities for improving the links between procedures for preparation of the annual environmental or effluent reports and the evaluation of on-site ground water monitoring data. One good practice was an explicit statement in the annual report that no events occurred during the reporting period that triggered the voluntary communication protocol.

Objective 3: Program Oversight

Self assessments were designed to provide an independent review by qualified individuals not involved in the on-going implementation of the site's program and were required to be performed within one year of initial implementation or no later than December 31, 2008. In the majority of instances, sites used industry peers from another company to assist in the self assessment. This criterion was one where companies with more than one nuclear plant have a distinct advantage in the depth of personnel available within the company to perform the assessments. Most of the initial self-assessments were reasonably good at identifying weaknesses that were then entered into the corrective action program; however, follow-up on the corrective actions at some plants were identified as needing improvement. With the exception of four plants, every site completed their self assessment before December 31, 2008. The four plants performed self assessments during year 2008, but did not explicitly address each acceptance criterion.

Acceptance criterion 3.2a requires an NEI-sponsored peer review within one year of the initial self assessment. Each company has received a copy of their plant-specific NEI-sponsored peer review report and has discussed the results with the peer-assessment team. The industry's expectation is that the recommendations, corrections, and enhancements identified in the peer review report are tracked to completion in the site's corrective action program and that the site's oversight organization take appropriate actions to verify timely completion of those items. As discussed in the *Process Observations* section above, peer reviews took much longer than originally anticipated. More than half of the plants performed their self-assessments in the last quarter of 2008, which made completion of the peer reviews by the end of 2009 difficult to achieve due to the limitations on both plant and peer team resources to organize and evaluate the extensive documentation involved in the assessments. To improve the effective use of resources in the future, the NEI-sponsored peer reviews should be staggered over the next five years commensurate with the recent peer review for the site.

Industry commitment to NEI 07-07

The industry has devoted considerable resources to implement the GPI, but these resources vary somewhat from plant to plant. Resources to implement the GPI must be allocated as part of the site's on-going ground water protection program for a company to successfully and consistently meet the acceptance criteria in NEI 07-07. One industry best practice observed at several plant sites was the formation of multi-discipline teams to implement the GPI. Most facilities relied almost exclusively on the program owners, typically RP/Chemistry/EH&S, to perform all of the work needed to meet the acceptance criteria with minimal support from other groups, such as engineering. Participation by engineering and operations greatly improves the level of detail applied to evaluating SSCs and work practices to determine the relative potential for equipment failure or human error to result in unintended releases.

Conclusion

Companies that own and operate nuclear power plants are required to control releases of radioactive liquids and airborne materials from their facilities to ensure that they are below the regulatory limits and protect public health and the environment. Regulatory requirements for the control of radioactive effluents include provisions for sampling, analysis, monitoring during releases, and assessing and reporting the potential impacts to the public. In addition, licensees are also required to develop and implement a radiological environmental monitoring program to assess the long-term impacts of nuclear power plant operation.

The peer reviews determined that the nuclear energy industry has implemented the Industry Ground Water Protection Initiative successfully. Every commercial nuclear power plant has developed or enhanced methods for early detection of inadvertent leaks or spills to subsurface soil or water that go well beyond what is required by regulations to protect health and safety. Sites have also evaluated plant equipment, design criteria and history for the potential to result in unintentional contamination of subsurface soil and water. Additional effort to improve the

documented evaluation of work practices is underway and the level of detail used to perform the evaluation of SSCs is being expanded. The Buried Piping Integrity Initiative will help companies determine the condition of SSCs and focus on active management and assessment of those systems. The peer reviews also identified the need for enhanced guidance on two topics: (1) establishing a site-specific decision-making protocol for remediation efforts and (2) evaluating the potential contribution of planned and permitted releases of radioactive effluents to detectable concentrations of plant-related licensed material in ground water. This guidance was issued by EPRI in December 2010.

Across the industry, companies have improved their communication with external stakeholders regarding ground water protection issues. Periodic updates on the GPI and voluntary communications protocols have improved openness and transparency regarding each site's management of leaks. . In addition, plants are voluntarily including the results of their on-site ground water sampling analyses in their Annual Radioactive Effluent Release Report or their Annual Radiological Environmental Operating Report. There are, however, opportunities to improve consistency in the frequency and scope of the updates and in the range of stakeholders contacted for these events

NEI 07-07, NEI 08-08 and the EPRI Groundwater Protection Guidelines provide a technically sound, documented process for ground water protection at commercial nuclear power plants through planning, construction, operation, and decommissioning. The implementation of the Ground Water Protection Initiative will continue to provide for improved ground water protection management at nuclear power plants throughout their entire life cycle.