Program Description

The safe processing, handling, and disposing of low-level waste (LLW) requires a detailed familiarity with both technical and regulatory issues. Similarly, as international standards on personnel exposure to radiation tighten and as public interest in radiation from nuclear energy increases, greater effort is needed to minimize and manage the human and environmental impacts from the various radiological hazards associated with nuclear plant operation.

The Low-Level Waste and Radiation Management Program investigates improvements to nuclear plant operational practices that can enhance public and worker safety and reduce risks associated with waste management and radiation exposure. The program develops guidelines and technologies for waste disposal volume reduction, dose and radiation field reduction, and radiological environmental protection, thereby informing regulations, improving public protection, and contributing to lower nuclear plant operation costs.

Research Value

Effective management of low- and intermediate-level waste and radiation exposure enables nuclear plants to operate safely, cost-effectively, and with minimal risk to plant personnel, the public, and the environment. Research results are used by nuclear waste managers to develop strategies for minimizing waste generation and reducing handling and storage costs. Research results are used by radiation protection managers to minimize radiation fields and reduce activity generation. Low-Level Waste and Radiation Management Program participants gain access to the following:

- Strategic roadmaps outlining research gaps and the collaborative actions needed to address these gaps. Active roadmaps address worker radiation exposure, low-dose radiation risk, storage and disposition of low-level waste, and radiological environmental protection.
- Technologies, evaluations, and guidelines that can reduce solid and liquid waste volumes. LLW evaluations, for example, have identified optimization recommendations valued at more than $75 million per year.
- New source-term reduction and radiation protection techniques that can reduce radiation dose. Source-term reduction studies have identified methods for reducing radiation fields by as much as 50% over five years.
- Technical guidance for early detection, mitigation, and remediation of groundwater contamination, an issue of public and regulatory concern.
- Technical guidance for risk-informed regulations in low-level waste, radiation protection, and groundwater protection that can address public safety and environmental stewardship concerns.

Approach

The Low-Level Waste and Radiation Management Program develops guidance and tools to reduce the risks and costs associated with waste management and radiation protection. The program also conducts plant evaluations and supports working group platforms to provide expert support and capture generic lessons learned that can be shared across the industry.

Base research focuses on developing the tools and technologies to reduce waste volumes, worker radiation dose, and groundwater impacts from nuclear plant operations.

Low-Level Waste: This research area supports the optimization of LLW management programs by investigating advanced technologies and techniques for minimizing the generation of LLW, developing guidance for safe and efficient on-site storage of low-level waste, and developing the technical bases for improved flexibility and risk-informed regulations for LLW disposal. For example, Electric Power Research Institute (EPRI) research identifies and conducts performance testing of media and processing strategies that may reduce LLW
generation and optimize liquid radwaste processing system performance. EPRI also is exploring and analyzing alternative classification schemes used around the world to inform the technical basis for risk informing LLW disposal.

Radiation Management: This research area develops guidance, technologies, and operational practices to aggressively reduce radiation fields (source term) and minimize worker dose to as low as reasonably achievable standards. Research activities are divided into four areas:

- Radiation field characterization – Evaluates the interaction of chemistry, fuel, and operations on activity transport and radiation fields to determine the effectiveness of dose reduction techniques and strategies. Research results will improve worker dose reduction efforts and help develop software tools for predicting the location and magnitude of radiation fields throughout the plant.
- Advanced radiation field and dose reduction – Investigates advanced technologies and techniques such as decontamination options, advanced prefilming and pre-oxidation techniques for reducing activity incorporation, shielding technologies, remote monitoring, and alternative technologies.
- Advanced dosimetry and dose/dose rate prediction – Provides a set of advanced calculation tools to more accurately estimate and report worker dose. A comprehensive worker dose prediction tool based on radiation field modeling and EPRI's 3D dose rate extrapolation algorithm is being developed to more accurately estimate worker dose and perform "what-if" analyses.
- Technical guidelines and sourcebooks – Improves radiation protection programs across the industry through regular updates to remain current with regulatory requirements and industry experiences/best practices.

Radiological Environmental Protection: This research area develops technical guidance and technologies for accurately reporting nuclear power plant effluents and associated dose, and advances understanding of nuclear power plant impacts on the environment. The research is divided into five areas:

- Groundwater protection guidance – Provides guidance related to characterization, monitoring, and remediation of licensed material in groundwater (e.g. tritium.) The EPRI Groundwater Protection Guidelines and technical bases for these Guidelines are developed under this research area.
- Groundwater protection advanced technologies – Explores and demonstrates technologies for groundwater protection, including those for monitoring, characterization, and remediation. Examples include tritium separation technologies, in-situ sensors and automatic samplers for groundwater, and monitored natural attenuation of radionuclides in groundwater.
- Effluent management: radionuclide generation and release – Develops tools to accurately quantify and report radionuclides released through gaseous and liquid effluent pathways from nuclear power plants. EPRI developed a methodology for accurately estimating the amount of Carbon-14 in gaseous effluents, and is currently conducting research on accurate reporting of hard-to-measure radionuclides.
- Effluent management: dose pathways – Improves understanding of how effluents from nuclear power plants are incorporated into dose pathways. EPRI is currently conducting research related to Carbon-14 in the environment due to natural and other (non-power generating) anthropogenic sources and incorporation into human dose pathways.
- Environmental protection, low-dose impacts, and emergency planning – Explores other areas of environmental and public protection due to nuclear power plant operations, such as low-dose radiation, protection of non-human biota, emergency planning and preparedness, and non-radiological constituents or characteristics.

Low-Dose Radiation Health Risks: EPRI is leading a comprehensive, multi-year effort to enhance the scientific underpinnings for future radiation protection standards. EPRI is analyzing key data sets to examine low-dose and low-dose rate effects, synthesizing findings from ongoing worldwide research, and developing risk models that are more relevant to the low doses and low-dose rates typically associated with nuclear plant operations. The scientific understanding gained through this research will help improve the communication of health risks to the public, regulators, and other stakeholders. Specifically, it will be used to inform discussions on the National Academy of Sciences study of cancer in populations living near nuclear facilities.
To address strategic objectives established for each of its programs, EPRI has developed roadmaps to plan, coordinate, and execute needed research among multiple entities. For the Low-Level Waste and Radiation Management Program, roadmaps have been developed to address the technical barriers related to low-dose science, worker radiation dose, low-level waste disposal, and groundwater protection. Additional roadmaps will be developed as significant research gaps are identified.

Through separate supplemental projects, nuclear plant owners can gain access to a variety of interactive forums to discuss technical issues and share lessons learned in LLW management, radiation management, source-term reduction, groundwater protection, and radiological environmental protection. Participants also can obtain on-site technical evaluations to help plant personnel evaluate performance and fully benefit from research results.

Accomplishments

EPRI’s Low-Level Waste and Radiation Management Program supports industry efforts to enhance the safe handling and management of low-level waste and to drive reductions in public, environmental, and personnel exposure to radiation. The Program develops and demonstrates innovative technologies, converts industry operating experience into practical guidelines, and explores alternative approaches for more effective LLW and radiation management.

- Published a sourcebook that describes a two-pronged strategy for cobalt reduction: 1) a tabulated list of available cobalt reduction methods, with expected costs and estimated time required to observe radiation field reduction benefits; and 2) flowcharts for implementing a cobalt reduction strategy for boiling water reactor and pressurized water reactor plants.
- Drawing on subject matter experts and detailed on-site observations during refueling outages at two nuclear plants, EPRI compiled best practices, evaluated emergent technologies, and demonstrated a novel shielding application to optimize dose reduction for refueling activities.
- Revised the EPRI Alpha Guideline to enhance international applicability, incorporating work control and in-vitro bioassay collection considerations, and updated lessons learned and best practices.
- Worked with 3D simulation experts to combine EPRI’s advanced Radiation Field Estimation Algorithm with state-of-the-art 3D visualization software to develop a tool for simulating radiation exposure in a virtual environment so that maintenance activities can be optimized for dose.
- Provided detailed epidemiological study design recommendations and comments to the Nuclear Regulatory Commission and National Academies of Science for conducting a cancer risk evaluation of populations living around nuclear facilities.
- Developed a technical basis for low activity and very low level waste disposal classifications.
- Completed multi-year review of research on the health effects associated with low-dose radiation. Analysis concluded that the radiation damage/response paradigm should be expanded to account for increased complexity in biological response mechanisms. Results shared with regulatory community to inform revisions to radiation protection standards.
- Published comprehensive technical guidance on groundwater sampling and analysis.
- Developed database to document information related to the radiological dispersion due to the Fukushima accident.
- Published current industry best practices for estimating dose to public from carbon-14 emissions through nuclear power plant gaseous effluent streams.
- Summarized industry experiences with decommissioning costs and the technical factors that impact decommissioning costs.

Current Year Activities

Low-Level Waste and Radiation Management program research and development for 2014 will sustain progress toward lower-cost waste handling and disposal, reduced worker dose, and improved detection and monitoring of groundwater. Specific efforts will include the following:
- Initiate projects to enhance the global value of LLW research: (1) functionalize the RadBench™LLW benchmarking software for international use, and (2) develop an international comparison of how the same radioactive waste is characterized in different countries.
- Continue research on a novel spent resin volume reduction technology designed to shift the radioactive burden in spent resin to a smaller more stable waste form and render the original resin very low in radioactivity.
- Collaborate with Nuclear Maintenance Application Center to investigate alternative techniques for reactor head set techniques to minimize the potential for equipment damage and reduce radiation exposure to workers.
- Release EPRI’s Radiation Field Estimation Algorithm 1.0 for public use in 3D simulation programs.
- Revise the programs for the collection of plant radiation monitoring data to improve the ability to identify trends, evaluate performance of radiation protection technology, and identify research needs.
- Provide site-specific implementation support for source-term reduction technical guidance developed by the program.
- Investigation of hard-to-measure nuclides in nuclear power plant effluents to support accurate reporting of these radionuclides and their doses to the public.
- Benchmarking industry software tools for estimating radiological dispersion and dose from nuclear accidents (e.g. MIDAS, RASCAL, Raddos) using Fukushima Accident data.

**Estimated 2014 Program Funding**

$4.0 million

**Program Manager**

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**Summary of Projects**

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<tr>
<th>Project Number</th>
<th>Project Title</th>
<th>Description</th>
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<tr>
<td>P41.09.01.02.01</td>
<td>Low-Level Waste Technical Strategy Group (supplemental)</td>
<td>The LLW Technical Strategy Group provides a forum for discussing technical issues and sharing lessons learned regarding strategic LLW management. Members also receive expert technical consulting as part of their membership. The LLW Technical Strategy Group is available in 3-year and 1-year membership options. The 3-year membership includes one full LLW assessment once during the three-year period. Plants may elect to have a LLW Assessment performed at their facility independent of joining the LLW Technical Strategy Group. This can be arranged by contacting the project manager or account executive directly.</td>
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<tr>
<td>P41.09.01.03.01</td>
<td>Radiation Management/Source Term Technical Strategy Group (supplemental)</td>
<td>The Radiation Management/Source Term Technical Strategy Group provides an interactive forum for members to share and get expert advice in applying ALARA technologies and to gain insights on how to effectively reduce source term. Industry lessons learned and discussion of emergent issues will provide members with the most up-to-date information for making informed decisions on job planning and preparation.</td>
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<tr>
<td>P41.09.01.05.01</td>
<td>Groundwater Technical Strategy Group (supplemental)</td>
<td>The Groundwater Technical Strategy Group provides members a forum for discussing groundwater protection experiences, lessons learned, and advanced technologies. Members will have access to the Groundwater Strategy Group collaboration website and quarterly conference calls. Those utilities participating in the 3-year membership are eligible for one site-specific Groundwater assessment once during the 3-year period.</td>
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Low-Level Waste Technical Strategy Group (supplemental) (004514)

Description
Nuclear plants frequently benefit from broader awareness of the low-level waste (LLW) management activities practiced at other plants. The LLW Technical Strategy Group (TSG) provides a forum for discussing technical issues and sharing lessons learned regarding strategic LLW management. Emerging technical issues include the Nuclear Regulatory Commission (NRC) Branch Technical Position on LLW concentration averaging; potential changes to 10CFR61; and LLW disposal site development, blending, encapsulation, solidification, and economics. Participants also receive expert technical consulting.

The LLW Technical Strategy Group is available in 3-year and 1-year participation options. The 3-year participation includes one full LLW assessment once during the 3-year period. Plants may elect to have an assessment performed at their facility independent of joining the LLW Technical Strategy Group. This can be arranged by contacting the project manager or account executive directly.

Approach
The Technical Strategy Group conducts periodic conference calls to keep participants apprised of emerging issues and to solicit input on industry responses to these issues. Webcasts are used to provide participants with up-to-date status of LLW disposal options, presentations on new processing strategies, information on new regulatory notices, technical exchanges of lessons learned, and new ideas on cost control.

Participants of the LLW Technical Strategy Group receive annual on-site expert technical consulting as part of their participation. This consulting time is typically used for continuous improvement of LLW program management strategies and for analysis of special projects. On-site consultation topics are scheduled with individual participants. International participants will receive their site-specific support remotely.

Utilities committing to 3-year participation are eligible for one site-specific LLW assessment once during the 3-year period. This assessment is conducted on-site for both U.S. and international participants. Plants may elect to have a LLW assessment performed at their facility independent of joining the LLW Technical Strategy Group. Participants can select from several assessment focus areas: on-site storage, BC reduction, solid LLW, liquid LLW, and Liquid System Manager software installation. The utility also may specify a focus area currently challenging the plant. The utility and Electric Power Research Institute (EPRI) Project Manager will then work together to define the scope.

Impact
Participation in the Technical Strategy Group keeps participants abreast of emerging issues surrounding LLW management and provides participants with a forum for technical exchange.

Site-specific consulting time provides expert support for specific plant or corporate project requests. Individual plant and fleet strategies for LLW management are frequently evaluated with this support. Cost evaluations conducted during these consultations often identify significant cost-saving measures.

The on-site assessment provided for 3-year participants (or arranged independent of the LLW Technical Strategy Group) evaluates how specific research results, technologies, industry experience, and industry best practices could be applied at a given plant. The assessment delineates actions with the largest potential benefit to the site and identifies potential gaps that, if closed, could provide economic, performance, and/or regulatory margin benefits.

How to Apply Results
The LLW TSG provides nuclear plant owners access to a variety of interactive forums to discuss technical issues and share lessons related to LLW management. Participants also can obtain on-site technical evaluations to help plant personnel evaluate performance and fully benefit from the EPRI research results and application of these results to emerging and critical plant-specific LLW management issues. Participation in periodic webcasts keeps participants abreast of emerging issues in the rapidly changing climate surrounding LLW management and provides participants with a forum for technical exchange.
The much more comprehensive LLW assessment helps plant personnel gain insights about their plant-specific performance and how to apply EPRI guidance, technologies, and tools to the plant's advantage. As an example, a participating utility recently completed a comprehensive LLW assessment resulting in several recommendations related to better storage and over $1.5M in potential savings for implementing the recommendations.

Radiation Management/Source Term Technical Strategy Group (supplemental) (071061)

**Description**

While the industry's annual collective radiation exposure continues to trend down, aggressive industry goals to further minimize station dose are challenging to meet in the life extension, increasing power demand, and changing regulatory environment. An integral component is the monitoring of factors that impact radiation fields and how to address issues related to these fields. The health of radiation protection programs is regularly assessed using cumulative exposure and exposure estimating, and utilities remain obligated to minimize the impact of ionizing radiation on plant personnel.

Technology transfer and sharing of lessons learned can assist plants in implementation of technologies and strategies related to as low as reasonably achievable (ALARA) and radiation management programs. The Radiation Management/Source Term Technical Strategy Group is designed to enhance the technology transfer between the Electric Power Research Institute (EPRI) and participating utilities by providing a forum for radiation protection stakeholders (including health physics, chemistry, operations, and maintenance professionals) to share experiences and gain insights to implement a comprehensive strategy for reducing worker dose. The strategy includes the use of effective measures for reducing source term and ideas for applying ALARA technologies or techniques such as remote monitoring. Sharing of industry lessons learned and discussion of emergent issues will also help participants make informed decisions on job planning and preparation. Such engagement helps plants "take the research off the shelf and put it into the plant." Generic results and lessons learned from this program will be used to support base research and development program products and reports.

Participation requires a 3-year commitment and includes a full radiation management assessment that can be tailored to address specific dose or source term challenges at a specific site once during the 3-year period. Participants may also elect to have a radiation management assessment performed at their plant independent of the Radiation Management / Source Term Technical Strategy Group. These arrangements can be made by directly contacting the project manager or account executive.

**Approach**

The Radiation Management/Source Term Technical Strategy Group provides an interactive forum for participants to share and get expert advice in applying ALARA technologies and to gain insights on how to effectively reduce source term. Industry lessons learned and discussion of emergent issues will provide participants with the most up-to-date information for making informed decisions on job planning and preparation. This comprehensive approach to managing radiation exposure will help educate and cross-train personnel with differing backgrounds on topics highly relevant to dose minimization and management.

The Strategy Group focuses on best practices, advanced technologies, and the most efficient implementation options for dose reduction and source-term reduction technologies, thereby achieving cost-effective sustainable ALARA program success. The group typically sponsors workshops on topics of interest to dose management such as source-term reduction and advanced shielding applications. These workshops bring together plant personnel and service providers to ensure participants are kept abreast of emerging technologies and have the advantage of a peer-to-peer forum for exchanging ideas and information. Results obtained from these workshops and information exchanges will be made available to all attendees and as appropriate, integrated into a summary report that will provide Strategy Group participants with the benchmarking information they would need to develop a site-specific dose reduction strategy. The information will also supplement research performed within the EPRI base-funded Radiation Management Program. Additional topical reports may be produced based on resource availability and participant interests.
Participants are eligible for one site-specific radiation management assessment once during the 3-year period and access to the workshops and associated deliverables. This assessment is conducted on-site for both U.S. and international participants and provides a detailed evaluation of how specific research results, technologies, industry experience, and industry best practices could be applied at a given plant. Participants may elect to have a radiation management assessment performed at their plant independent of the Radiation Management/Source Term Technical Strategy Group.

**Impact**

Plants that have implemented relevant EPRI technology in the ALARA area have realized significant benefits in personnel exposure control. EPRI’s radiation field control technologies provide a menu of techniques to reduce out-of-core shutdown radiation fields and for continuing development of worker risk-minimization techniques that target increased worker productivity. The Radiation Management/Source Term Strategy Group provides an opportunity to drive exposure performance success that, in turn, can impact regulatory requirements, insurance premiums, benchmarking, and performance metrics.

The assessment included once during each 3-year commitment period allows for a detailed review of the site-specific parameters that can be paramount to a successful dose reduction plan delineating actions with the largest potential benefit and identifies potential gaps that, if closed, could provide economic, performance, and/or regulatory margin benefits.

**How to Apply Results**

Participants sponsor annual meetings and workshops that address key worker dose and radiation source-term issues. These workshops provide an interface for peer-to-peer and utility-to-service-provider interactions on topics of specific interest to dose management. Lessons learned and insights are brought back to the plant for implementation.

Participants also have access to Radiation Management/Source Term Technical Strategy Group industry experience databases and reports. These mechanisms enable radiation protection and chemistry personnel to more effectively address technical ALARA and source term issues and implement worker risk-minimization techniques.

The full radiation management assessment can be used to gain insights about plant-specific performance and how to apply the EPRI guidance, technologies, and tools to the plant’s advantage. The assessment team will develop a confidential site-specific report that details the strengths and gaps associated with the program and highlights prioritized recommendations and potential benefits. Later, generic results and lessons learned may be compiled for use within the base research program.
Groundwater Technical Strategy Group (supplemental) (071064)

Description
Leaks and spills from nuclear power plant operations can potentially impact site soil and groundwater throughout the life of the plant and the decommissioning of the plant. Experiences from other nuclear power plants can provide valuable insight into effective practices for addressing both technical and non-technical elements associated with groundwater protection. The Groundwater Technical Strategy Group provides a forum for sharing such experiences with industry colleagues and defining best practices applicable across the industry using industry and EPRI research.

Participation requires a 3-year commitment and includes one site-specific groundwater assessment during the commitment period.

Approach
The Groundwater Technical Strategy Group (TSG) is composed of participants interested in sharing and discussing groundwater experiences and lessons learned, new technologies, and EPRI projects. Participants will have access to the Groundwater Strategy Group Collaboration work and quarterly conference calls.

Relevant groundwater experiences, lessons learned, and technology information will be uploaded to the TSG cockpit area for participant access. Participants also will be able to post their own experiences, lessons learned, and technology ideas to spark discussion with other participants. Questions on groundwater topics also can be posted so that EPRI groundwater experts and other participants can provide answers and associated information.

Conference calls on groundwater protection experiences, lessons learned, and technologies are typically held each quarter (March, June, September, December.) These conference calls will be used to discuss promising technologies, key experiences and lessons learned, and EPRI projects.

The site-specific assessment included once during each 3-year commitment period is conducted on-site for both U.S. and international participants and provides a detailed evaluation of how specific research results, technologies, industry experience, and industry best practices could be applied at a given plant. Typical Groundwater Assessment topics include assistance in implementing groundwater protection programs, assistance in conducting self-assessment of compliance to NEI 07-07, demonstration of innovative technologies, and plant tritium modeling. Plants can choose one of these focus topics for their groundwater assessment. Other plants may elect to have a groundwater assessment performed without joining the Groundwater Technical Strategy Group. This can be arranged by contacting the project manager directly.

Impact
By taking action against groundwater contamination, utilities will be able to allay stakeholder concerns about environmental protection. By implementing site-specific groundwater protection programs and the best technologies available for groundwater protection at nuclear power plants, utilities will be able to optimize costs and reduce waste due to groundwater monitoring and remediation:

- Improve relationships with communities, government, and regulatory agencies about the industry’s commitment to public radiation safety and environmental protection
- Achieve cost savings at the decommissioning stage due to preemptive action during the operating stage
- Achieve cost savings due to advanced and efficient monitoring and remediation technologies
- Achieve cost savings due to prevention of radioactive liquid leakage to the environment

The assessment included once during each 3-year commitment period delineates actions with the largest potential benefit to the site and identifies potential gaps that, if closed, could provide economic, performance, and/or regulatory margin benefits.
How to Apply Results

Participants can use the real-time information from the Groundwater Technical Strategy Group to implement improvements to their groundwater protection programs and to evaluate new technologies.

The EPRI Team conducted Groundwater Protection Initiative Self Assessments at two nuclear power plants, providing them with ideas and recommendations for enhancing and improving their groundwater protection programs to meet requirements per the EPRI Groundwater Protection Guidelines and NEI 07-07 Groundwater Protection Initiative. These assessments provide insights into the plant’s performance and into applying the EPRI guidance, technologies, and tools to the plant's advantage. The assessment team will develop a confidential site-specific report that details the strengths and gaps associated with the program and highlights prioritized recommendations and potential benefits. Later, generic results and lessons learned may be compiled in program reports for industry use. Plants may elect to have a groundwater assessment performed without joining the Groundwater Technical Strategy Group. This can be arranged by contacting the project manager directly.