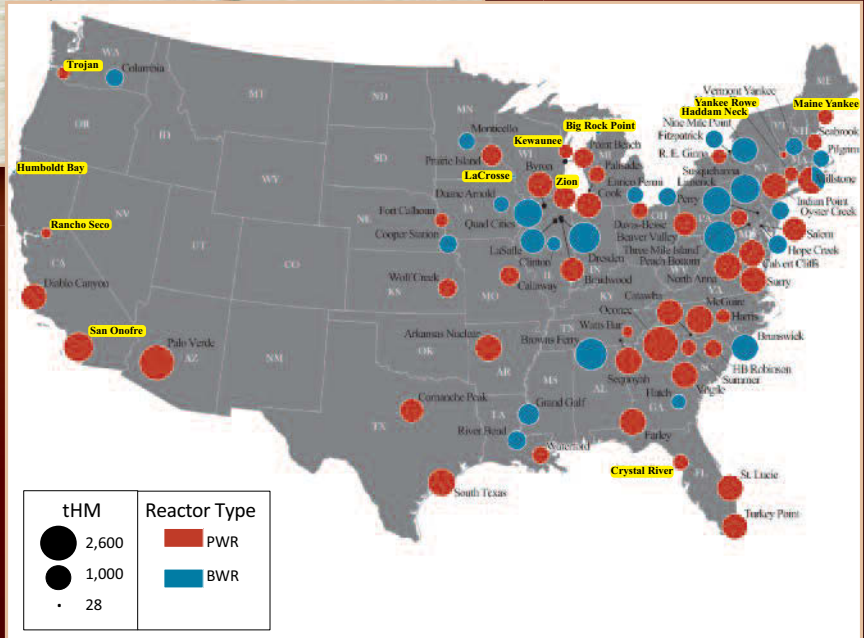
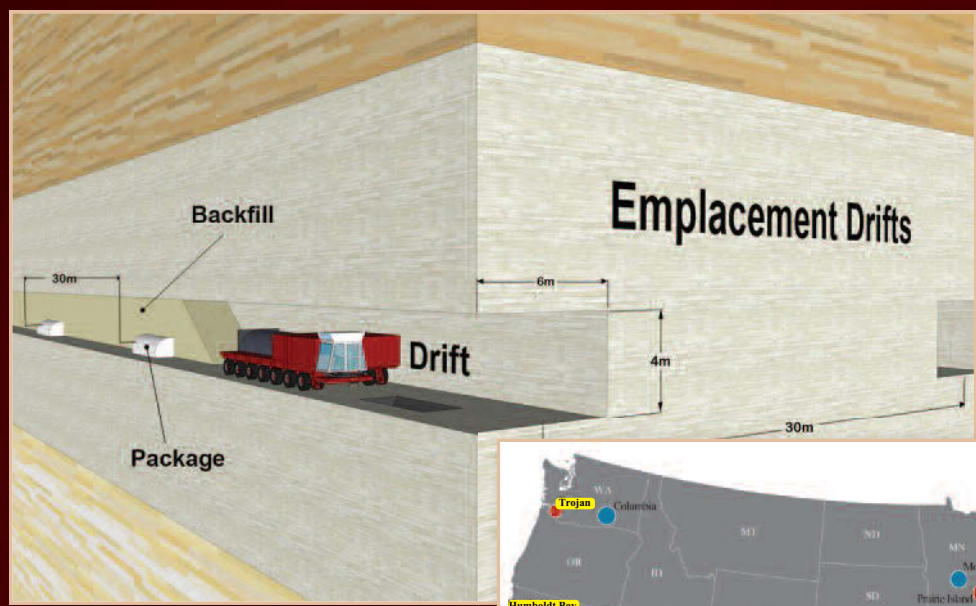


# Radwaste Solutions

THE MAGAZINE OF RADIOACTIVE WASTE MANAGEMENT AND FACILITY REMEDIATION

JANUARY-MARCH 2014

## Spent Fuel/High Level Waste



### Also in this issue

- Meeting reports: RadWaste Summit . . . . . p. 60
- Waste Management & Cleanup Decisionmakers' Forum . . . . . p. 66
- WM13 Best Papers . . . . . pp. 70 and 74

# Brilliant

*“Everything should be made as simple as possible, but not simpler.”*

*~ Albert Einstein*

We agree. And in our business simple equates to efficiency. From Glove Boxes, to Melters, to Containers, and more, Petersen Inc. takes your plans and creates the most efficient way to build your project. With more than 53 years of experience, work and knowledge under our belts, it's no surprise we are still here and growing. We have the open capacity to complete your project efficiently, on-time and within budget.

## Simply Brilliant

ASME, NQA-1, U, U2, S, R • ISO9001-2008  
In-House CGD Test Lab • 801-732-2000

Manufacturing • Fabrication • Large Precision Machining  
Field Services • Small Precision Machining  
Warehousing & Distribution

[www.peterseninc.com](http://www.peterseninc.com)



**PETERSEN**  
INCORPORATED

"A Winning Combination."  
Utah-Idaho



**ENERGYSOLUTIONS**  
problemsolved

EnergySolutions has it all when it comes to safely managing radioactive and hazardous waste. Our staff of 4,000+ professionals are highly skilled individuals who take our customers' trust and safety seriously.

*radioactive and hazardous waste*  
PROCESSING • TRANSPORTATION • DISPOSAL

[www.energysolutions.com](http://www.energysolutions.com)

## Editorial Staff

Betsy Tompkins  
Publisher

Chris Salvato  
Desktop Editor

## Advertising & Circulation Staff

Jeff Mosses  
Sales Manager

Erica McGowan  
Advertising/Production  
Assistant Manager

Lisa Dagley  
Advertising Designer/  
Circulation Specialist

## American Nuclear Society Administration

Donald R. Hoffman  
President

Michaele C. Brady Raap  
Vice President/President-Elect

Michael J. Lineberry  
Treasurer

Martin Grossbeck  
Chair, Publications Steering  
Committee

Robert C. Fine  
Executive Director

## Editorial Advisory Board

Donald E. Clark  
A. Scott Dam  
Ramesh Dayal  
Audeen Fentiman  
Martin N. Haas  
David W. Hayes  
Gerald P. Motl  
Ken Powers  
Michelle R. Rehmann  
James S. Tulenko  
Ruth F. Weiner  
Ali Yazdi

A PUBLICATION OF THE AMERICAN NUCLEAR SOCIETY

# Radwaste Solutions

## Advertising sales representatives

### U.S. and Canada

*Mid-Atlantic/Midwest:* The Kingwill Company, Barry and Jim Kingwill, 664 Milwaukee Ave., Suite 201, Prospect Heights, Illinois 60070 (Tel: 847/537-9196; Fax: 847/537-6519; barry@kingwillco.com, jim@kingwillco.com)

*Northeast:* Northeast Media Sales, Lee Fernandez, 4 Emerson Place, Suite 616, Boston, Massachusetts 02114 (Tel: 617/722-8333; Fax: 617/722-8334; advertising@ans.org)

*Southeast:* Jobson/Jordan/Harrison & Schulz, Inc., Bill Powell, 18103 Mahogany Forest Dr., Sping, Texas 77379 (Tel: 281/376-2368; Fax: 281/251-8555; citadel62@aol.com)

*West:* Jobson/Jordan/Harrison & Schulz, Inc., Warren DeGraff, 700 Irwin St., Suite 205, San Rafael, California 94901 (Tel: 415/721-0644; Fax: 415/721-0665; wdegraff@jjhs.net)

### International and Other

*Sales Manager:* ANS Headquarters, Jeff Mosses, 555 N. Kensington Ave., La Grange Park, Illinois 60526 (Tel: 708/579-8225; Fax: 708/352-6464; jmosses@ans.org)



# ANS

*Radwaste Solutions* (ISSN 1529-4900), Volume 21, Number 1. Published four times a year (February, May, August, November) by the American Nuclear Society, Inc., with business, executive, and editorial offices at 555 N. Kensington Ave., LaGrange Park, IL 60526.

Subscription rate for 2014 is \$530, which includes complimentary electronic access, 2003 to current issue; for subscriptions outside of North America, add \$35 for shipping and handling. This rate is valid for all libraries, companies, departments, and any individual subscribers (who are not ANS members). Alternatively, subscription rate is \$480 for Electronic Access Only, 2003 to current issue. ANS member rate is \$45; members who live outside of North America should add \$35 for additional postage and special handling. Single copy price is \$120 plus \$15 for customers outside of North America. Inquiries about the distribution and delivery of *Radwaste Solutions* and change-of-address information should be directed to the American Nuclear Society. Allow six weeks for a change to become effective. Postmaster, please send changes of address to *Radwaste Solutions*, 555 N. Kensington Ave., La Grange Park, IL 60526.

Nonprofit periodicals postage is paid at La Grange, Ill., and additional mailing offices. Copyright © 2014 by the American Nuclear Society.

Opinions expressed in this publication are those of the authors and do not necessarily reflect the opinions of the publisher, the editor, the American Nuclear Society, or the organizations with which the authors are affiliated, nor should publication of the authors' points of view be construed as endorsement by the American Nuclear Society.

## Radwaste Solutions

Editorial correspondence: *Radwaste Solutions*, 555 N. Kensington Ave., La Grange Park, IL 60526; phone 708/579-8241; fax 708/579-8204; e-mail: [editor@radwastesolutions.org](mailto:editor@radwastesolutions.org).

Advertising correspondence: Jeff Mosses, Advertising Sales Manager, *Radwaste Solutions*, 555 N. Kensington Ave., La Grange Park, IL 60526; phone 708/579-8225; fax 708/352-6464.

ANS Headquarters: all numbers are in the 708 area code; finance, 579-8206; information systems, 579-8237; executive director, 579-8200; member services, 579-8266; officer and board services, 579-8284; procurement, 579-8207; communications and outreach, 579-8230; scientific publications, 579-8216; standards, 579-8269.

ANS Headquarters—General Information  
phone: 708/352-6611  
fax: 708/352-0499 or 708/352-6464  
e-mail: [nucleus@ans.org](mailto:nucleus@ans.org)  
ANS Web Site: <http://www.ans.org>

Reprints of articles that appear in *Radwaste Solutions* can be purchased by contacting Wayne Witek, Procurement Supervisor, American Nuclear Society, (708) 579-8207; fax (708) 579-8314.

# Radwaste Solutions

Volume 21, Number 1  
January–March 2014



Decommissioned boilers await shipment from the United Kingdom to Sweden. See the article that starts on page 74 for the lead-up to the shipment.

## Features

### Cover Stories—Spent Fuel/High-Level Waste

**Evaluation of Direct Disposal of Spent Fuel in Existing Dual-Purpose Canisters** 26  
*Costs, worker dose, and complexity of fuel management operations could possibly be reduced through direct disposal of DPCs.*

**Predicting Stress Corrosion Cracking in the Canisters of Used Nuclear Fuel Dry Cask Storage Systems** 40  
*A research initiative at the Massachusetts Institute of Technology's H. H. Uhlig Corrosion Laboratory aims to determine the role of stress corrosion cracking in predicting the life span of dry cask storage canisters.*

**Characteristics of Commercial Spent Nuclear Fuel: Distributed, Diverse, and Changing with Time** 50  
*Understanding the current and future characteristics of commercial spent nuclear fuel is key to designing and licensing appropriate systems for its storage, transportation, handling, and disposal.*

### Meeting Reports

**Debate Continues over Part 61 Regulations** 60  
*A report from the Seventh Annual RadWaste Summit, held September 3–6, 2013, in Las Vegas, Nev.*

**The DOE, State Regulators, and Small Businesses—and Budgets** 66  
*A report from the 25th Annual Weapons Complex Monitor Waste Management & Cleanup Decisionmakers' Forum, held October 21–24, 2013, in Jacksonville, Fla.*

### Waste Management 2013 Best Papers

**Communicating Performance Assessment Results** 70  
*The primary goal of communicating the results of performance assessments prepared to support the closure of waste tanks at the Savannah River site is to provide a clear understanding of the involved risks.*

**Studies, Transport, and Treatment Concept for Boilers from the Berkeley Nuclear Power Plant** 74  
*In the first project of its kind in the United Kingdom, Studsvik was contracted to transport five decommissioned boilers from the Berkeley nuclear plant site to Studsvik's waste treatment facilities in Sweden for metal treatment and recycling.*

## Departments

Editor's Note	4
<i>Comments on this issue</i>	
Headlines	8
<i>Industry news</i>	
Index to Advertisers	85
It's Business	88
<i>Contracts, business news, etc.</i>	
Moving Up	95
<i>People in the news</i>	
Index to Articles in <i>Radwaste Solutions</i> 1994–2013	102
<i>Radwaste Solutions</i> Subscription Information	124
Calendar	126
<i>Meetings of interest</i>	

## Next Issue:

*Low-Level Waste*

## And we're off!

With this first issue of *Radwaste Solutions* for 2014 comes a change. The frequency of the magazine has returned to four times a year, as it was when the magazine was launched in 1994, from five times a year, as it has been for the last three years. The goal, however, is to keep the total amount of content essentially the same for the entire year, even though we are producing one fewer issue. The four issues are scheduled to be mailed in the middle month of each quarter: February, May, August, and November.

Each year's first issue of *Radwaste Solutions* is distributed to all attendees at the Waste Management Conference, sponsored by WM Symposia and held in Phoenix, Ariz. And the topic of the issue again this year is Spent Fuel/High-Level Waste. The features on this topic cover three aspects of spent fuel: direct disposal of spent fuel in existing dual-purpose canisters (page 26); predicting stress corrosion cracking in the canisters used for dry-cask storage (page 40); and how the current and future characteristics of commercial spent nuclear fuel affect the design and licensing of systems for its storage, transport, handling, and disposal (page 50).

To keep you up to date on radwaste policy issues and emerging waste management topics, our colleagues at ExchangeMonitor Publica-

*A change in the frequency of Radwaste Solutions for 2014 has been implemented, but the magazine will still offer a variety of features, meeting reports, and news throughout the year.*

tions & Forums provided us with reports on two of their meetings—the Seventh Annual RadWaste Summit, held in September (page 60), and the 25th Annual Weapons Complex Monitor Waste Management & Cleanup Decisionmakers' Forum, held in October (page 66). Special thanks go to Make Nartker, editor-in-chief, for his assistance in preparing these reports for publication in *Radwaste Solutions*.

It has also become a tradition for this issue to include articles based on the best oral presentations from the previous year's Waste Management Conference. The ANS Best Oral Presentation Award for 2013 went to Mark Layton, of Savannah River Remediation LLC, for "Communicating Performance Assessment Results" (page 70); and the ASME Best Oral Presentation Award went to Bo Wirendal, of Studsvik Nuclear AB, and David Saul, Joe Robinson, and Gavin Davidson, of Studsvik UK

Ltd., for "Studies, Transport, and Treatment Concept for Boilers from the Berkeley Nuclear Power Plant" (page 74).

The subsequent issues of *Radwaste Solutions* for 2014 also have specific topics assigned and will be distributed at meetings throughout the year, including Low-Level Waste (April-June)/EPRI's International Low-Level Waste Conference & Exhibit; Environmental Remediation (July-September)/Exchange Monitor Publications' Eighth Annual RadWaste Summit and 26th Annual Waste Management & Cleanup Decisionmakers' Forum; and the 10th Annual Buyers Guide (October-December), with a Decontamination and Decommissioning editorial feature.

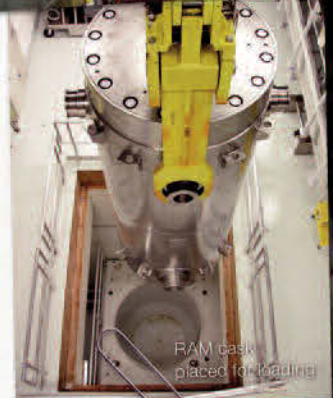
We welcome your contributions to the magazine, and as always, thank the authors and advertisers who have helped make this annual Waste Management Conference Show Issue a big success.—*Betsy Tompkins, Publisher*

## FIELD REPORT

Topic	RadWaste
Location	North America



RAM cask prepped for closure



RAM cask placed for loading

### RAM Cask PLUS... a Turnkey Solution

Nuclear plants need a streamlined turnkey service for the safe and cost-efficient processing, packaging and transport of irradiated reactor components. As part of its commitment to enhanced and client-driven services, AREVA TN is pleased to announce RAM Cask PLUS. Through partners, AREVA TN can now provide the latest design of effective volume reduction processing equipment for use with our new RAM disposal liners. The AREVA TN-owned RAM Cask ensures safe delivery of the disposal package to the available disposal facility.

RAM Cask PLUS includes a team of management and support personnel with extensive years of experience giving you the advantage of decades of "lessons learned" combined with proven technology for safe, low dose and cost-efficient results... another smart solution from AREVA TN that demonstrates our commitment to operational excellence.

Return on Experience

**SAFE, LOW DOSE AND  
COST-EFFICIENT RESULTS**

Find out why: [us.aveva.com/AREVATN](http://us.aveva.com/AREVATN)





# JUST HOW MUCH EXPOSURE

As the new kid on the block, we figured there had to be a better way to dispose of radioactive waste. Elaborate “processing” and dilution schemes for retro-fitting waste to meet limited waste acceptance criteria at old school sites clearly isn't the safest way to go.

While processors are losing money and going bankrupt, one disposal site has bonds outstanding that are junk rated.

**The fall-out from this financial mess could land squarely on you** if there isn't sufficient financial assurance to cover for inadequate processing prior to disposal. *Could you still be on the hook ten-years from now for waste that you thought was permanently and properly disposed of today?*

**At WCS you don't have that worry.**

In a one-of-a-kind partnership, the State of Texas – with its AAA credit rating – **takes title to your waste. There is no current or future liability to you. None.** The state only entered into this partnership because WCS sited and constructed a state-of-the-art 100-foot below surface, concrete-lined facility located in a very remote and arid part of Texas.

**At WCS, there is no above ground or shallow trench disposal with nearby water tables.**

As a result, there's no need to dilute, mix, blend, stir, shake, bake or do other exotic things to the waste. WCS offers a very





# EXPOSURE CAN YOU AFFORD?

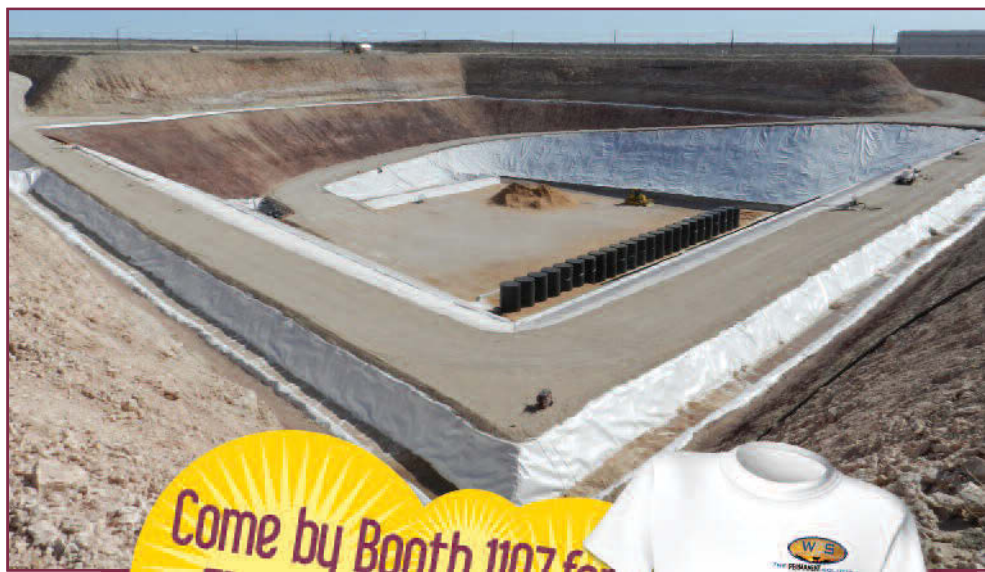
robust (and we don't use the word lightly with forty-feet of cap and cover), straight-forward direct disposal system for around the same price as the other guys.

**REALLY.**

Let's talk.

Learn more, visit WCS online:

[www.WCSTexas.com](http://www.WCSTexas.com)



THE TEXAS SOLUTION

**DALLAS OFFICE:**  
**ANDREWS SITE:**

Three Lincoln Centre, 5430 LBJ Freeway, Suite 1700, Dallas, Texas 75240-2697  
9998 West State Highway 176, Andrews, Texas 79714

(972) 715-9800  
(888) 789-2783

Come by Booth 1107 for  
a FREE **EXPOSED** T-Shirt!  
A Different Shirt Each Day!  
\*While supplies last



## DOE: Hanford tanks “not actively leaking”

Nineteen of the 20 waste tanks at the Hanford Site, near Richland, Wash., that have shown decreased liquid levels are “not actively leaking,” the Department of Energy announced on November 6. “The one tank previously identified as leaking, T-111, appears to be stabilizing,” the DOE said in a statement. The 20 tanks are among 149 underground single-shell tanks holding chemical and radioactive waste left over from national defense plutonium production at the site.

The DOE’s Office of River Protection and its tank farm operations contractor, Washington River Protection Solutions, confirmed in February 2013 that liquid levels in tank T-111 were decreasing. It was later announced that five additional single-shell tanks could be leaking liquid. The suspect tanks—TY-105, T-203, T-204, B-203, and B-204—were built between 1943 and 1964 and have capacities ranging from 55,000 gallons to 1 million gallons.

The DOE also identified for further evaluation 14 additional single-shell tanks with lower liquid levels, decreasing surface levels, or both. According to the DOE’s evaluation, none of these tanks showed evidence of leaking, with estimated liquid loss rates less than the estimated rate of tank evaporation. The loss of liquid in tanks T-203, T-204, B-203, and B-204 can also be explained by evaporation, according to the DOE.

For tank TY-105, the DOE concluded that evaporation is “the probable cause” of lower observed liquid levels and that a decrease in the waste surface level is “likely related to waste settling following evaporation.” The surface level in the center of the tank has decreased 14 inches since 1982, according to the DOE’s evaluation.

The DOE estimates that tank T-111 leaked between 1,000 and 3,900 gallons of liquid between 1995 and April 2013. In its evaluation, the DOE said, “The leak rate as of April 1, 2013, is estimated to range between 2.0 and 3.1 gal/day, with the most probable rate approximately 2.8 gal/day.”

The Washington State Department of Ecology, however, does not agree that the decrease in the levels of tank TY-105 is entirely due to evaporation, or that the leak in T-111 is slowing, according to a November 6 report in the *Tri-City Herald*. The newspaper quoted Nancy Uziemblo, a tank waste retrieval specialist with the department, as saying, “Some of the tanks need to be revisited to look at their liquid waste content. They’re not as dry as we

think they are.”

The DOE, in an effort to stabilize the single-shell tanks, transferred pumpable liquids from the tanks to more reliable double-shell tanks. That work was completed by 2005. The DOE estimates that prior to that, 67 of the single-shell tanks leaked a combined total of roughly 1 million gallons of waste.

“We will continue to keep the state of Washington, Congress, and other key stakeholders apprised of the situation as we continue to monitor the liquid levels inside the single-shell tanks,” the DOE said in a statement.

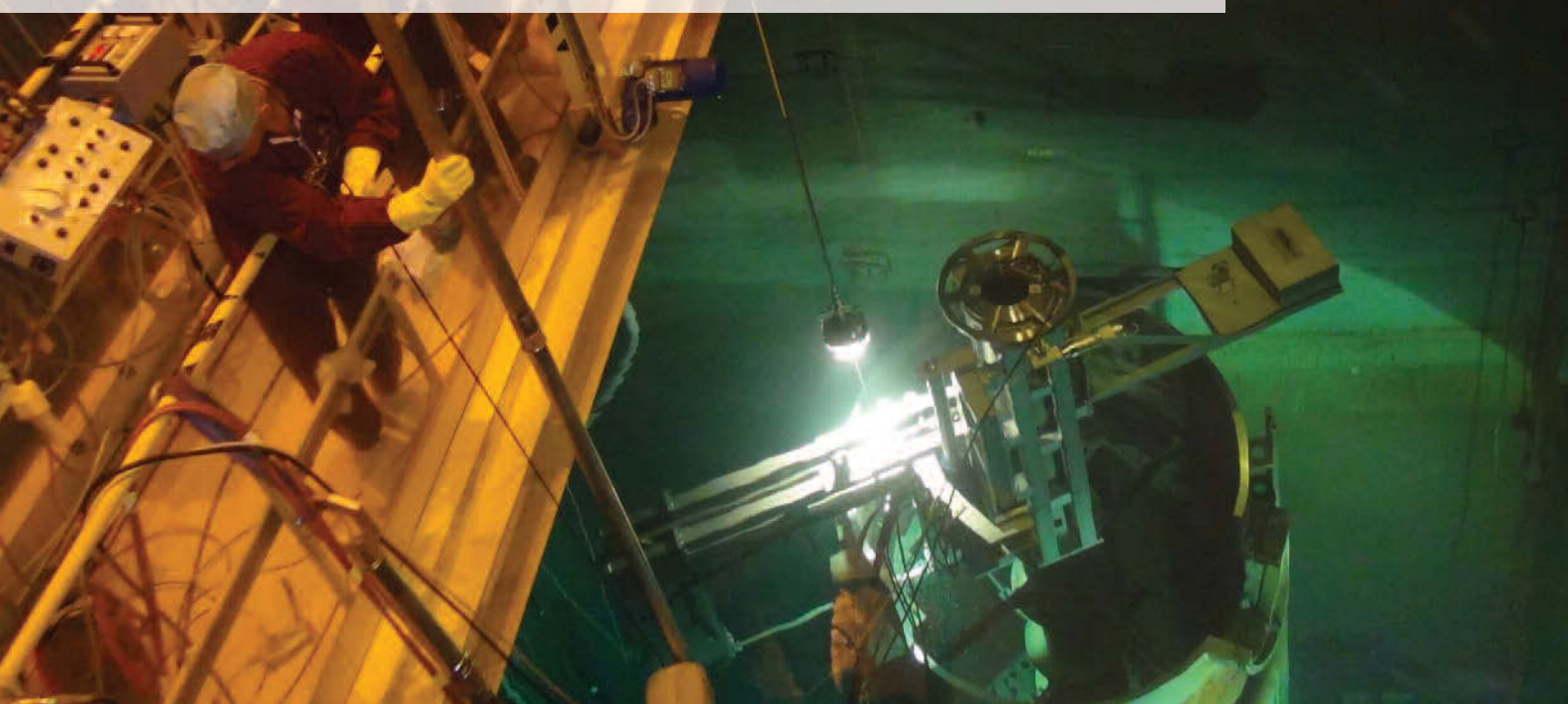
● A record of decision for closing Hanford’s waste tanks was issued by the Department of Energy, notice of which was published in the December 13 *Federal Register*. The decision follows the DOE’s cleanup plans at the Hanford Site as outlined in the department’s final tank closure and waste management environmental impact statement for the site, which was issued in December 2012.

Under the record of decision (ROD), 99 percent of the radioactive and chemical waste currently stored in Hanford’s 177 underground storage tanks would be retrieved and vitrified using the yet-to-be completed Waste Treatment and Immobilization Plant (WTP). After being filled with grout to immobilize residual waste, the 148 single-shell tanks will be left in place and covered with an engineered barrier. Treatment of the tank waste will include pretreatment, with separation into low-activity and high-activity waste (LAW and HLW). The LAW will be disposed of at Hanford and the vitrified HLW will be stored on-site until a permanent repository is available. The DOE did not identify a preferred method for the supplemental treatment of the LAW.

For the decommissioning of Hanford’s Fast Flux Test Facility, the DOE has decided on entombment, with the removal of all above-grade structures, including the reactor building. Similar to the waste tanks, the facility’s below-grade structures will remain in place and be filled with grout and covered with an engineered barrier. Remote-handled special components from the reactor are to be treated at Idaho National Laboratory and returned to Hanford for on-site disposal, while bulk sodium inventories will be processed at Hanford for use in the WTP. All low-level and mixed low-level radioactive waste will be disposed of in a single integrated disposal facility at Hanford, while a separate disposal facility for tank closure waste will be constructed as needed. The DOE is deferring a decision to import waste from its other sites (with limited exceptions) for disposal at Hanford until the WTP

# WESTINGHOUSE DECOMMISSIONING AND REMEDIATION SERVICES

# GLOBAL PROJECT EXPERIENCE ADVANCED TECHNOLOGY



**Visit us at booth #201 at  
the Waste Management  
Conference, March 2 -6,  
in Phoenix, AZ**

Westinghouse provides comprehensive, integrated services and solutions to the decommissioning and dismantling (D&D) and waste management industries. We have extensive experience in the dismantling of nuclear installations from uranium mill plants to nuclear power plants. We provide state-of-the-art solutions for spent fuel services and for the treatment and handling of radioactive waste. Westinghouse offers proven solutions for the interim storage and final disposal of low-, intermediate- and high-level waste.

Our dedication to a cleaner environment extends to servicing existing nuclear power plants and managing by-products in an environmentally responsible manner.

For more information, visit us at [www.westinghouse\*\*nuclear\*\*.com](http://www.westinghouse<b>nuclear</b>.com)



is operational.

Also, on December 11, the DOE issued an ROD for the cleanup of contaminated soil and groundwater along the Columbia River in Hanford's 300 Area. This is the first of six RODs that are being issued for the site's 220-square-mile River Corridor. Covering about 40 square miles, the 300 Area was home to nuclear fuel manufacturing operations, as well as experimental and laboratory facilities, including six small-scale nuclear reactors. Previous cleanup work within the River Corridor was done under interim RODs.

### Canada narrows list of potential repository sites

Canada's Nuclear Waste Management Organization (NWMO) announced on November 21 that it has completed preliminary assessments of eight Canadian communities that have "expressed interest in learning about Canada's plan for the safe, long-term management of used nuclear fuel," four of which will continue to be studied as possible repository sites. Thirteen other communities that have yet to be assessed also remain in the running to host the repository.

According to the NWMO, which has developed an "adaptive phased management" approach to selecting a nuclear repository site, the communities of Creighton, in Saskatchewan, and Hornepayne, Ignace, and Schreiber, in Ontario, "were assessed as having strong potential to meet site selection requirements and have been identified for further study." The communities of English River First Nation and Pinehouse, in Saskatchewan, and Ear Falls and Wawa, in Ontario, were not selected for more detailed study. The NWMO said that its findings to date do not confirm the suitability of any site, and no community has yet declared an interest in hosting the repository.

The preliminary assessments are the first phase of study in step three of the NWMO's nine-step, multiyear adap-

tive process for evaluating the suitability of potential sites. In May 2010, the NWMO launched its selection process for identifying a site location in an "informed and willing host community." Since then, the NWMO said, it has worked collaboratively with the interested communities to explore their potential to meet site selection requirements.

"Each of the eight communities that completed the first phase of assessments has shown strong leadership," said Kathryn Shaver, NWMO's vice president of adaptive phased management engagement and site selection, in a news release. "As we prepare for increasingly more detailed field studies and engagement, it is necessary to narrow our focus to those areas with strong potential for meeting strict safety and geotechnical requirements, and for the project to align with their long-term vision."

For the four selected communities, the next phase of the process will involve more intensive community learning and engagement, with a broader focus that will include surrounding communities and First Nations and Métis peoples. According to the NWMO, this ongoing engagement will be important to understanding the potential to foster acceptance among the broader area and the ability to work together to implement the project. Preliminary fieldwork also will begin, including aerial



Canada's Nuclear Waste Management Organization selected Schreiber, Ontario, as one of four communities suitable for further study as a possible site for a deep geologic repository. (Photo: Wikimedia Commons)



# DAHER-TLI

**DAHER-TLI**, the North American Nuclear subsidiary of **DAHER**, provides turnkey solutions to the front and back-end sectors of the nuclear fuel cycle. **DAHER** designs and provides products and services based on its comprehensive portfolio of expertise: Engineering, Packaging, Transport and Logistics, Waste Treatment, Characterization, Volume Reduction, etc.

**DAHER** is a tier-1 equipment supplier to the high-technology industries. Created in 1863, **DAHER** is an international group present in 12 countries across the world, which generated a turnover of over 1.3 billion dollars in 2013.



Our services include:

- Door-to-door international logistics
- MCEP approved motor carrier
- Licensed radioactive storage facility
- Engineering services
- DOT-Compliant HAZMAT Training
- FMC licensed
- Shipping and Waste Containers
- Certified Type A Fissile Transportation Packaging



See our website for further information [www.tliusa.com](http://www.tliusa.com)

**Visit our display at WM 2014**

surveys, and, at a later date, limited borehole drilling to further assess geology and site suitability against technical safety requirements.

At this milestone in the process, the NWMO said, it is recognizing the contribution that all eight communities have made to advancing Canada's plan for the safe, long-term management of its used nuclear fuel. According to the NWMO, each community, through its participation in the site selection process, has built understanding of the project and helped ensure meaningful citizen engagement.

In acknowledgment of their contributions, the NWMO is providing \$400,000 to each of the eight communities for the establishment of a community use fund. Administered by the communities, the funds will support efforts to build "community sustainability and well-being." This could include projects, programs, or services that benefit community youth or seniors, community sustainability, energy efficiency, or economic development initiatives. The other communities undergoing phase-one assessments will be similarly recognized, according to the NWMO.

The NWMO expects that it will take several years to complete the necessary studies to identify a preferred site and a willing host. Until a final agreement is signed, communities may choose to end their involvement at any point during the site evaluation process.

## NRC to release Yucca Mountain safety report

The Nuclear Regulatory Commission will complete its safety review of Yucca Mountain, according to an order issued by the agency on November 18. Responding to an August 2013 writ of mandamus by the U.S. Court of Appeals for the District of Columbia that ordered the NRC to resume the licensing review of the Department of Energy's application for the Yucca Mountain waste repository, the commissioners voted 4-0 (Commissioner George Apostolakis has recused himself from Yucca Mountain matters) to direct the NRC staff to finish work on the safety evaluation report (SER) for the repository. Only one of the five planned volumes of the Yucca Mountain SER was published before work on the project was halted in 2010.

According to the NRC order, the staff has indicated that Volumes 2-5 of the SER can be completed and issued concurrently in 12 months at a cost of approximately \$8.3 million. The NRC staff will use the remaining money it has

available from the Nuclear Waste Fund (NWF) to complete and release the remaining SER volumes. As of September 30, the NRC had about \$11 million left in NWF-appropriated funds for the license review. The NRC also requested that the DOE prepare a supplemental environmental impact statement (SEIS) so that the staff can meet its review obligations under the National Environmental Policy Act.

In resuming its review of Yucca Mountain, the NRC will not reconstitute the Licensing Support Network, the online database of documents used in the application's adjudicatory hearings. Likewise, the nearly 300 contentions against the repository will continue to be held in abeyance until funding becomes available to restart the hearing process, according to the order. The agency staff will, however, place LSN documents into the NRC's nonpublic ADAMS online database. While the NRC said that documents used as references in the SER and SEIS will be publicly released, the publication of all LSN documents will depend on whether adequate funds are available to do so.

- On November 27, parties both for and against the Yucca Mountain nuclear waste repository filed responses to the NRC's plan for resuming the Yucca Mountain license application review.

Five petitioners in the writ of mandamus case that ordered the NRC to resume the license review—Nye County, Nev., the state of South Carolina, the state of Washington, Aiken County, S.C., and the National Association of Regulatory Utility Commissioners—filed a motion requesting that the NRC reconsider its order, claiming that it neither adequately addresses issues originally raised by the five parties nor fully complies with the court's order.

Claiming that the NRC's estimate of 12 months and \$8.3 million needed for completing the remaining four SER volumes is inflated, the five parties are asking that the NRC create a schedule for the release of each individual volume and provide detailed statements of the remaining work to be done on each volume, along with a cost estimate for each volume's completion.

Noting that the NRC staff had previously estimated the cost of completing the SER at \$6.5 million, the parties also asked that the NRC provide a detailed analysis of, and justification for, its new cost estimate. "Without such information and analysis, it is impossible to determine why the commission has estimated the cost of completion of all the SERs at such enormous and unsubstantiated levels, between \$6.5 and \$8.3 million," the parties wrote in their

# NEW! **ISO-CART-85 System** from **ORTEC** Free-release radwaste assay goes mobile!



## 1 IDM-200-V

*Interchangeable Detector Module for performance versatility:*

- High sensitivity: large (85 mm dia) HPGe detector, up to 2X as sensitive.
- 100% integrated portable spectrometer: electrical detector cooling, internal battery.
- ~3 hour operation on internal, swappable battery.
- Rugged design.
- Modular collimation.

and:

## 3 ISO-Plus Software

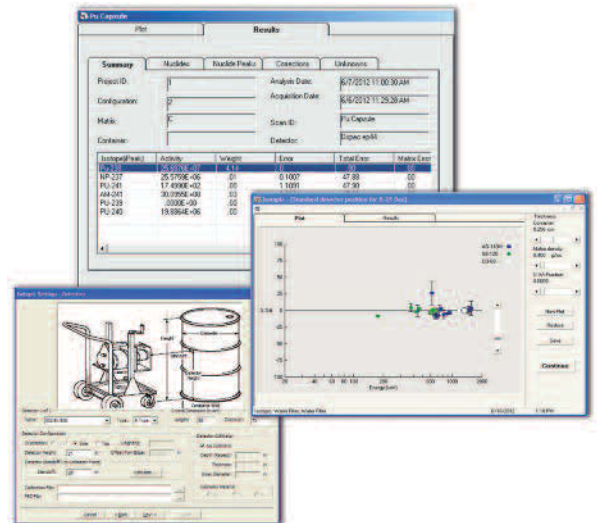
*Proven results on thousands of real-world samples.*

- Measures all common geometries: pipes, cylinders, floors, ceilings, walls, drums, boxes, and soils.
- Simple to calibrate with a single inexpensive mixed isotope point source.
- Flexible results reporting.

## 2 ISO-CART-II

*New cart design for enhanced operation:*

- Easy-roll cart for maneuvering over any surface.
- Adjustable track for increased stability.
- Continuous height and variable tilt adjustment.
- Disassembles to fit into a vehicle.



## Practical Radwaste Solutions

801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411 • Fax (865) 483-0396 • [ortec.info@ametek.com](mailto:ortec.info@ametek.com)

For International Office Locations, Visit Our Website

[www.ortec-online.com](http://www.ortec-online.com)

**ORTEC**®

**AMETEK**®  
ADVANCED MEASUREMENT TECHNOLOGY

motion to the NRC. Also, the parties contend that even using an inflated cost estimate for completing the SER, enough money should be available for the first phase of the adjudicatory process and prehearing discovery to be resumed.

Meanwhile, the state of Nevada, which opposes the licensing of Yucca Mountain, filed a petition seeking clarification of the order. Of primary concern to Nevada is the NRC's deviation from its own scheduling rules. In suspending the discovery phase of the adjudicatory process, the NRC made a "temporary modification" to its procedural rules, which hold that discovery should occur in parallel with the completion of the SER.

The NRC's schedule for completing licenses also requires that all prehearing discovery be completed 60 days after the completion of the SER. Claiming that it is unlikely that the suspension of discovery will be lifted after the SER is completed, Nevada said that the NRC should clarify that the 60-day deadline will not apply if discovery is resumed. Even given two months, Nevada said it will not have enough time to finish gathering materials related to discovery. "It will not be possible to complete discovery within sixty days for the simple reason that the depositions of fifty to one hundred witnesses (including NRC staff, DOE, Nevada, and other parties' witnesses) cannot possibly be scheduled and completed within this brief period, even if discovery resumes immediately upon completion of the SER," the state wrote in its petition.

Nevada also is asking that the commission clarify its directions to its staff that it "adopt work previously completed as a first principle, to the maximum extent possible, and should undertake original investigation or inquiry only as necessary to account or adjust for new information." Nevada asserts that this direction "implies, or could be read to imply, a commission judgment that all of the work relevant to Yucca Mountain safety completed by any technical staff personnel to date is adequate based on the information already available, and is therefore suitable for adoption without further 'investigation or inquiry' absent new information."

The state said that it is unaware of any commission review on the adequacy of the staff's SER work that would justify such a conclusion.

- Earlier, on October 28, the U.S. Court of Appeals for the District of Columbia rejected a petition by the state of Nevada for a rehearing of the writ of mandamus case against the NRC. In a one-sentence order, the court denied the state's petition to rehear the case *en banc* (with all

10 of the court's judges presiding). The order offered no explanation for the denial.

The *Las Vegas Sun* reported on October 22 that Robert Halstead, director of the Nevada Agency for Nuclear Projects, which along with the Attorney General's Office of Nevada is fighting the project, told state legislators that about \$9 million would be needed annually for the state to litigate Yucca Mountain should the NRC hearings resume.

## DOE can't collect waste fees, court says

The Department of Energy has been told by the U.S. Court of Appeals for the District of Columbia Circuit to stop collecting Nuclear Waste Fund (NWF) fees. On November 19, the court ordered Energy Secretary Ernest Moniz to submit to Congress a proposal to change the waste fund fee to zero until such time as either the secretary chooses to comply with the Nuclear Waste Policy Act (NWPA) as it is currently written, or until Congress enacts an alternative waste management plan.

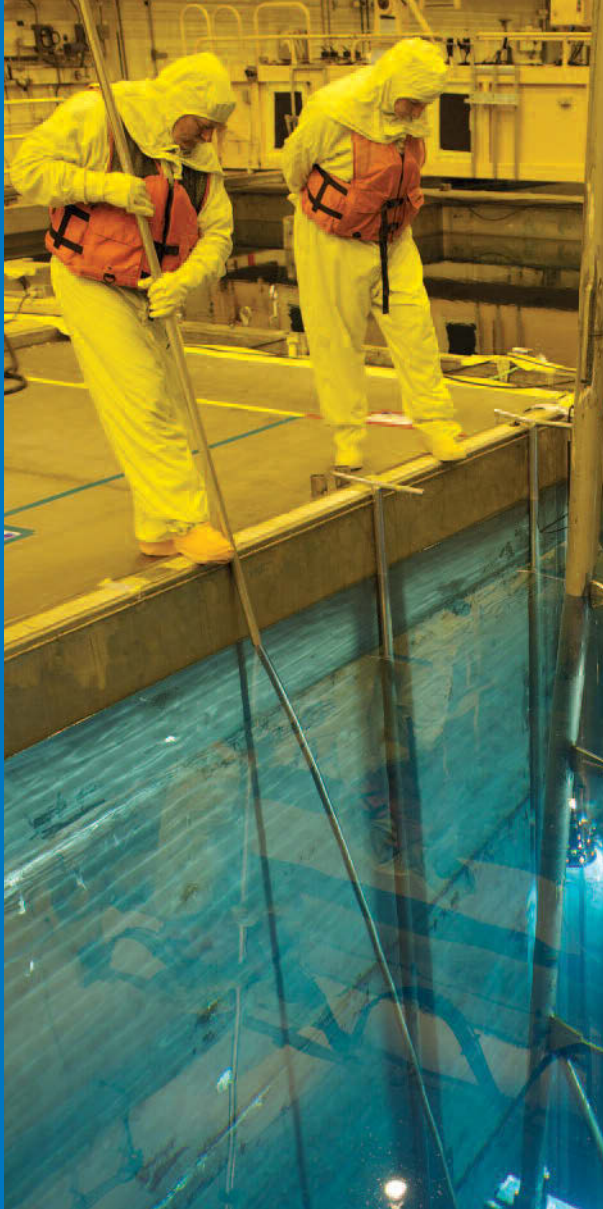
Currently, based on a charge of one-tenth of a cent per kilowatt-hour of nuclear-generated electricity, the DOE collects about \$750 million annually from nuclear power companies for deposit into the NWF. It is estimated that the NWF, which was established to pay for the government's taking possession of used nuclear fuel for disposal at Yucca Mountain, has a current value of over \$28 billion. In agreeing with the National Association of Regulatory Utility Commissioners and the Nuclear Energy Institute, the petitioners in *NARUC v. DOE*, the court said, "So long as the government has no viable alternative to Yucca Mountain as a depository for nuclear waste, [nuclear power plant operators] should not be charged an annual fee to cover the cost of that disposal."

In ordering the suspension of the fee, the court found that the DOE failed to provide a sufficient assessment of the adequacy of the NWF fees as required by the NWPA. In January 2013, then energy secretary Steven Chu claimed that no adjustment of the fee was necessary because it could not be determined whether current fees are either insufficient or excessive. The court, however, called this a "nondetermination," saying that the secretary "may not comply with his statutory obligation by 'concluding' that a conclusion was impossible."



# CH2MHILL®

Delivering Safety, Results, and Performance Excellence



## World-class Program Management & Delivery

Employee-owned **CH2M HILL** is a global leader in full-service program management, engineering, construction, and operations for government, civil, industrial and energy clients. With \$7 billion in revenue and more than 26,000 employees, we are a **FORTUNE 500 firm** and an industry-leading program management, construction management and design firm, as ranked by *Engineering News-Record*.

**CH2M HILL** specializes in the management of complex nuclear programs and projects around the globe. Our experience includes more than two decades of managing and operating nuclear facilities and providing innovative clean-up and environmental remediation for commercial and government facilities and sites. We are one of the few firms with the experience necessary to manage large nuclear projects with inherent radiological, chemical, and industrial safety challenges.

**CH2M HILL** provides innovative clean up and closure solutions for the most contaminated sites in the U.S. DOE nuclear weapons complex and in UK Nuclear Decommissioning sites, while successfully and safely delivering projects ahead of schedule and under budget. In addition, we ensure the decommissioning, waste management, waste fuel strategies, and support service operations at civilian nuclear research sites in the United Kingdom and the United States result in reduced costs and improved schedule performance, quality, and safety standards.

### WORLD HEADQUARTERS

9191 South Jamaica St.  
Englewood, CO 80112  
303.771.0900  
Karen Wiemelt  
Senior Vice President, Global Business  
Development and Strategy  
karen.wiemelt@ch2m.com

[www.ch2m.com](http://www.ch2m.com)



[facebook.com/CH2MHILL](https://facebook.com/CH2MHILL)



[twitter.com/CH2MHILL](https://twitter.com/CH2MHILL)



[youtube.com/CH2MHILLpr](https://youtube.com/CH2MHILLpr)

In a statement, NEI General Counsel Ellen Ginsberg said, “The court’s decision should prompt Congress to reform the government’s nuclear waste disposal program. We strongly encourage Congress to establish a new waste management entity and endow it with the powers and funding necessary to achieve the goals originally established in the Nuclear Waste Policy Act.”

- The Department of Energy’s failure to comply with the NWPA was at the heart of \$235-million court award to three New England nuclear power companies on November 14. For failing to take possession of used nuclear fuel as required by the NWPA, the U.S. Court of Federal Claims ordered the DOE to pay damages to Connecticut Yankee Atomic Power Company, Yankee Atomic Electric Company, and Maine Yankee Atomic Power Company.

The companies are owners of three former nuclear power plants that have been fully decommissioned, with only the used nuclear fuel and greater-than-Class-C waste remaining on site in independent spent fuel storage installations. To recover costs for storing the used fuel and waste, the companies successfully sued the DOE in 1998 for breach of the NWPA, and this latest award is for costs the companies incurred between January 1, 2002, and December 31, 2008. The court found that Connecticut Yankee is entitled to the recovery of \$126.34 million; Yankee Atomic, \$73.3 million; and Maine Yankee, \$35.76 million.

### **EPA to approve changes in WIPP’s panel closure design**

The Environmental Protection Agency is proposing a rule change to allow the Department of Energy to use a different method for sealing waste-filled panels at the Waste Isolation Pilot Plant (WIPP) than was previously approved. Notice of the proposed rule change and an opportunity for public comment was published in the December 3 *Federal Register*.

Located near Carlsbad, N.M., WIPP is a disposal facility for defense-related transuranic radioactive waste built into an underground salt formation. The waste is placed in groups of mined rooms called panels. Once the panels are filled, they will be sealed using engineered structures that are intended to prevent access to the filled panels and to protect site workers while the facility is still operating, and to limit the release of radionuclides after it is permanently closed.

As included in its compliance certification application for WIPP, the DOE originally intended to seal the panels with concrete block walls and poured concrete monoliths. In September 2011, the DOE sought EPA approval to change this design and close the panels using 100 feet of mined salt placed between two steel bulkheads. Over time, as the surrounding salt fills in the open areas, the loosely packed salt will compress into a state resembling intact salt.

The EPA said that it has completed its technical review of the design change and has concluded that the new design will not have a significant impact on the long-term performance of the disposal system. Furthermore, according to the agency, “There is no evidence to suggest that the panel closure has a disproportionate ability to impact long-term performance when compared to other design features of the repository.” The EPA added, however, that this does not mean that the DOE can change the panel closure design at will; a departure from the approved design must be submitted to the EPA for approval.

Comments on the proposed rule change were to be accepted through February 3, 2014.

- The DOE’s Carlsbad Field Office, which oversees the WIPP repository, participated in the second meeting of the OECD Nuclear Energy Agency’s (NEA) Salt Club and the 4th U.S.-German Workshop on Salt Repository Research, Design, and Operation, which were held in Berlin, Germany, in September, the DOE announced on November 26.

Represented by the Carlsbad Field Office’s international programs and policy advisor, Abe Van Luik, the DOE joined Salt Club members and workshop participants in discussing their research and experiences from the operation of salt-based repositories for nuclear waste. The Salt Club includes representatives from NEA member countries, primarily the United States, Germany, Poland, and the Netherlands, who are studying the use of salt formations as a host rock for deep geologic nuclear repositories.

According to the DOE, as subject experts in salt repository science, the meeting participants shared plans for future work and received almost immediate peer review as they strengthened their professional relationships and promoted best practices. The workshop, meanwhile, enhanced the coordination of U.S.-German research and development in the field, with presentations on many aspects of salt repository science and engineering. Representatives from the U.S. government, the Carlsbad Field Office, Sandia National Laboratories, and Los Alamos National Lab-



# F&J SPECIALTY PRODUCTS, INC.

*The Nucleus of Quality Air Monitoring Programs*

## F&J Advanced-Technology Instruments



**GAS-60810D Series**  
Ambient Air Monitoring System



**WC-VFD**  
World Calibrator



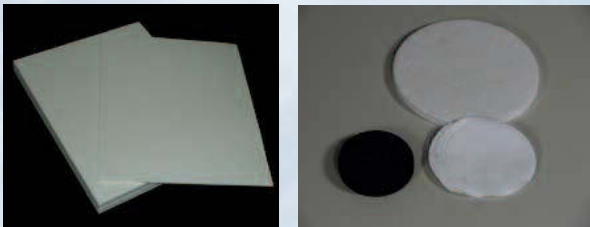
**DF-EDL-1 Series**  
ELITE DIGITAL LIGHT (EDL)  
Air Sampler



ISO 9001: 2008  
Quality Management  
System



**DF-AB-40L**  
Emergency Response Air Sampler



**Filter Media**  
MCE Membrane Assortment, Glass Fiber,  
Qualitative and Quantitative Media



Radioiodine Collection Filter Cartridges

### Contact:

tel: 352.680.1177 / fax: 352.680.1454 / [fandj@fjspecialty.com](mailto:fandj@fjspecialty.com) / [www.fjspecialty.com](http://www.fjspecialty.com)

oratory participated in the technical exchanges on the U.S. side, the DOE said.

“German representatives offered lessons learned from their extensive heat testing in salt,” Van Luik said in a news release. “These lessons will help EM [the DOE’s Office of Environmental Management] more efficiently design its currently planned research on the long-term performance of salt for disposal of heat-bearing radioactive wastes.”

Participants also had the opportunity to tour the Asse and Morsleben repository sites in Germany, which, like WIPP, use rock salt as the host repository medium. According to the DOE, Van Luik visited the closed Morsleben site to better understand the work involved in closing and sealing the repository, which will provide the Carlsbad Field Office with information to consider as it plans for the future closing and sealing of WIPP.

### SRS employee recognized for innovative ideas

A contractor employee at the Department of Energy’s Savannah River Site in South Carolina has received two awards for developing new methods for managing transuranic (TRU) waste, the DOE announced on October 30. Ernie Williams, a manager in Savannah River Nuclear Solutions’ Radiological Protection Department, received silver awards in two categories during Ideas America’s recent conference, held in Orlando, Fla. Ideas America is a non-profit association serving professional managers and administrators of employee suggestion, innovation, and involvement programs.

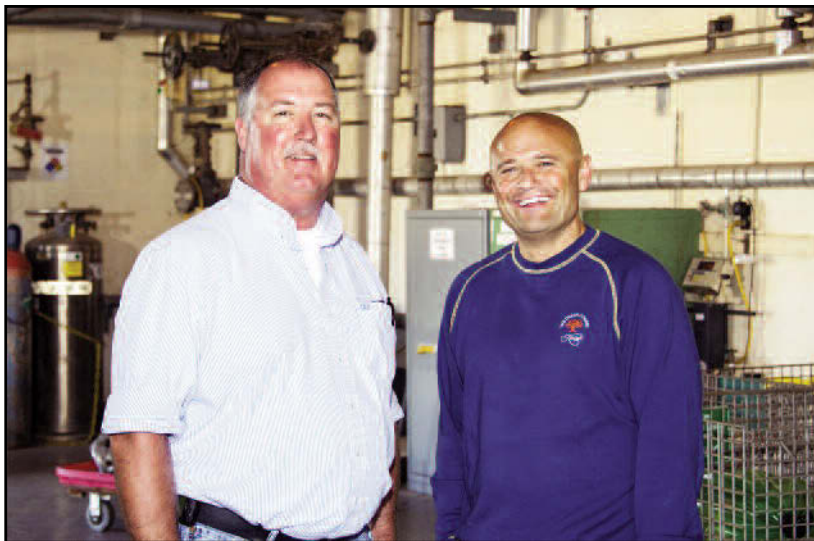
In the Idea of the Year category, Williams received the award for using a borescope camera for inspecting highly contaminated TRU waste boxes prior to shipment to the Waste Isolation Pilot Plant in Carlsbad, N.M. Previously, the boxes were cut open for inspection and the removal of prohibited items, which was time-consuming and exposed workers to safety and exposure hazards. The borescope camera

can be inserted into the boxes through a small hole, and if no prohibited items are found, the box does not have to be cut open.

Williams also won an award in the Safety Idea of the Year category for using a commercially available mesh bag to contain the absorption media that is used to absorb liquids found in TRU waste storage boxes. Instead of spreading the loose material over the liquid to soak it up and then removing it by hand, as was previously done, workers put the absorbent in the mesh bags before placing it over the liquid. Once the liquid is absorbed, the bags can be removed remotely with a crane, eliminating numerous safety and radiological exposure hazards for employees.

“There are about 20 coworkers of mine at SRNS who contributed in some way to this achievement,” Williams said in a news release. “Without them, it wouldn’t have happened. This really was a team effort.”

This is the first time that SRNS has participated in Ideas America’s Idea of the Year Awards, the company said. Ideas America presented 12 awards in four categories: safety, green (environmental), team, and individual. Gold, silver, and bronze awards were presented in each category.



SRNS employee Ernie Williams, left, received two internationally recognized awards for new ideas in handling transuranic waste. Williams’ manager, Johnny Lott, right, accepted the awards—which were presented during the 71st annual Ideas America Training Summit, held in Orlando, Fla.—for Williams, who was unable to attend. (Photo: DOE)

# POWERFUL INNOVATION PROVEN EXPERIENCE



**Lifting Experts  
for more than**

**YEARS**



**Your complete source for specialized  
Nuclear Material Handling Solutions  
for current plant needs and the next  
generation of nuclear power plants.**

From complex custom equipment to standard equipment, components and parts, American Crane can meet all your material handling needs. Visit our new online catalogue at [Store.AmericanCrane.com](http://Store.AmericanCrane.com) for comprehensive online parts and standard equipment featuring **Al-Vac, Yale, Shaw-Box, Budgit, Little Mule, CM, Chester Hoist, Coffing Hoist, Munck** and more.

## **SERVICES:**

- ▶ Nuclear Quality Custom Equipment and Components (10 CFR 50 App. B & NQA-1)
- ▶ QA Program & Testing (10 CFR 50 App. B and NQA-1)
- ▶ Engineering Solutions including Seismic Analysis & Design
- ▶ In-House Manufacturing & Machining
- ▶ Installation, Site Services, Outage Services & Parts
- ▶ Upgrades & Rebuilds of Our Equipment & OEMs

YOUR CRITICAL LIFT EXPERTS

ACECO  **American  
CRANE**  
& EQUIPMENT CORPORATION

**877-877-6778, ext. 224 • AmericanCrane.com**

## U-233 to be shipped from ORNL to Nevada National Security Site

The Department of Energy's inventory of uranium-233 will be shipped from its storage place at Oak Ridge, Tenn., to Nevada starting early this year, the *Las Vegas Sun* reported on November 12. According to the report, the DOE said in a press call that it would begin shipping 403 canisters containing U-233 to Nevada for shallow burial at the Nevada National Security Site. The U-233 was generated as part of a research program at the Nuclear Fuel Services plant in West Valley, N.Y., in 1968, and was later transferred to Oak Ridge National Laboratory in Tennessee for storage and potential future use.

Early last year, Nevada Gov. Brian Sandoval and other state officials, including Sen. Harry Reid, came out in opposition to the shipments after the DOE's disposal plans were reported in the media. In an effort to overcome the impasse, Sandoval and Energy Secretary Ernest Moniz formed a working group in August 2013 to discuss possible resolutions. Following the *Las Vegas Sun* report, both Sandoval and Reid said they remain opposed to the shipments.

## D&D Updates

- A review of decommissioning funding status (DFS) reports by the Nuclear Regulatory Commission staff found that as of December 31, 2012, U.S. nuclear power plant licensees had accumulated a total of \$45.7 billion for decommissioning work, and that all licensees were able to provide assurance that adequate funds were available to safely decommission their facilities.

The NRC requires nuclear power plant licensees to report on the status of their decommissioning funds at least once every two years, or annually within five years of the plant's planned shutdown and once the plant ceases operation. The NRC staff's review of the 2013 DFS reports for operating power reactors (SECY-13-0105) was posted to the NRC's online ADAMS library on October 24.

The NRC reviewed the DFS reports for all 104 nuclear power reactors that were operating in 2012 and found that all but four of the reactors had more than the minimum prescribed amount of decommissioning funds available. The four reactors for which the full amount was not initially available were FirstEnergy's Beaver Valley-1 and Perry, which had shortfalls of \$14.6 million and \$13 million, respectively; Entergy's Palisades, with a \$10.3-million shortfall; and NextEra Energy's Point Beach-2, with

a \$2.5-million shortfall.

The shortfalls were resolved by the licensees by October, according to the NRC report. FirstEnergy committed to increase the amount of its supplemental parent company guarantees for Beaver Valley and Perry, while Entergy and NextEra increased their decommissioning trust funds to meet the minimum requirements. The NRC also said that it was able to resolve an outstanding 2011 shortfall for Exelon Generation's Limerick-1 reactor.

The four reactors that have since ceased operations—San Onofre-2 and -3, Crystal River-3, and Kewaunee—as well as Vermont Yankee, which Entergy plans to close in 2014, all reported decommissioning fund surpluses.

The NRC staff also noted that the quality of the information many of the licensees provided in their 2013 decommissioning funding reports had improved. "In particular, the NRC staff required fewer requests for additional information in evaluating the 2013 DFS reports," the staff said in its report.

- The K-25 building, which was located at the Department of Energy's Oak Ridge site in Tennessee and was once the world's largest building under one roof, is no longer. The DOE's Office of Environmental Management announced on December 19 that it completed demolition of the remaining section of the gaseous diffusion building, ending a five-year demolition project ahead of schedule. All shipments of debris from the building are expected to be completed in this spring.

"Today marks a tremendous accomplishment for the American people—advancing our commitment to the safe and complete cleanup of former Manhattan Project sites," Deputy Secretary of Energy Daniel Poneman said in a news release. "While there is still important cleanup work to do, completing the demolition of the K-25 gaseous diffusion building and doing so ahead of schedule and under budget is a testament to the outstanding Oak Ridge workforce."

Once a massive U-shaped structure, the K-25 building was built in 1943 as part of the Manhattan Project and originally contained 1.64 million square feet of floor space and occupied more than 40 acres near the center of the East Tennessee Technology Park, formerly the Oak Ridge Gaseous Diffusion Plant. Until 1964, the building was used to enrich uranium for defense and commercial purposes.

Demolition of K-25 began in 2008, and by September 2012 demolition of the west wing and most of the east wing was completed. Removal of the building's north end, which was the smallest of K-25's three sections and formed the base of its distinctive U shape, was finished in

# BROKK 100

## 100% Performance



TUNNELING

CEMENT

PROCESS

NUCLEAR

CONSTRUCTION

MINING

### INTRODUCING THE ALL NEW BROKK 100 – “THE NEXT GENERATION BROKK”

The all new “Next Generation” Brokk 100 is the latest addition to the Brokk family of machines. Lighter and yet 35% more productive and more capable than our best selling Brokk 90 model, the Brokk 100 features a host of upgrades resulting from operational experience gained on the world’s most challenging projects. Our all new 2-way wireless control and monitoring system delivers unmatched capability, this enables operators to remotely perform the most demanding tasks in complete safety.

Brokk is the proven industry leader for safe, powerful, rugged, reliable, high performance, remotely operated equipment. With 10 available Brokk machine size options, there is a machine available to suit each application without compromise. Add to that over 30 years of Brokk deployment experience, comprehensive in-house engineering and technical support staff, full after-sales support and it is clear that we can fully support our customers, including their most complex and challenging applications.

Brokk also offers hundreds of standard and custom designed attachments for our machines. With the standard “Quick Hitch” or our optional fully remote “NQH” tool change interface, a single Brokk machine can perform multiple tasks in hazardous environments with the operator working in complete safety.

[www.brokk.com/100/](http://www.brokk.com/100/)

Original Demolition Power™

# **BROKK**®

January 2013. Remaining were portions of the east wing that required further decontamination due to technetium-99 contamination. URS-CH2M Oak Ridge (UCOR), the DOE's primary site cleanup contractor, finished removing those sections in December.

"I'm proud to have been part of this historic achievement," said Leo Sain, UCOR president and project manager. "This project was a massive undertaking involving many people. We are pleased that UCOR, working hand-in-hand with DOE, was able to safely complete the demolition and bring this project full circle."

While the demolition of K-25 is complete, the building's concrete base slabs will remain in place as a reminder of the facility's footprint. The DOE and local historic preservation agencies also have agreed to take steps to preserve the historic contributions of the K-25 complex.

Under a 2012 agreement with the Tennessee State Historic Preservation Office, the Advisory Council on Historic Preservation, the city of Oak Ridge, the East Tennessee Preservation Alliance, and other consulting parties, the DOE will construct a three-story equipment building that recreates a scale representation of the gaseous diffusion technology and contains authentic equipment used in the original facility. A nearby K-25 history center, meanwhile, will display equipment, artifacts, oral histories, photographs and videos related to the plant's history. Also, the DOE provided a \$500,000 grant to preserve the Alexander Inn, a historic structure in Oak Ridge where visiting scientists and dignitaries stayed during their visits to the area.

- Washington River Protection Solutions, the Department of Energy contractor tasked with managing radioactive and chemical tank waste at the Hanford Site, has completed the transfer of sludge and other nonliquid waste from Tank C-110, a single-shell tank, to a more stable double-shell tank, the DOE announced on October 24. The retrieval of waste from Tank C-110 marks the 11th single-shell tank retrieval at the site to date. Hanford, the site of plutonium production during the Cold War, has 149 single-shell tanks and 28 double-shell tanks containing about 56 million gallons of radioactive and chemical waste.

According to the DOE, an engineering evaluation of Tank C-110 shows that less than 360 ft<sup>3</sup> of waste remains in the tank, which meets regulatory requirements. Video of the inside of the 530,000-gallon-capacity tank shows that a large percentage of the tank floor is now visible.

Emptying the tank involved the removal of an estimated 178,000 gallons of sludge using modified sluicing, which left about 17,200 gallons of hard-heel waste on the tank

floor. A remotely operated, track-mounted tool called the Foldtrack was used to remove the hard-heel waste.

"Foldtrack had its most-successful deployment, which was crucial in completing the retrieval of this tank," said Joanne Grindstaff, a DOE project director, in a DOE news release. "The Foldtrack has a plow blade, two on-board water jet systems, three high-pressure turbo nozzles, and a sluicing cannon that operators use to break down the difficult-to-remove waste and move the tank waste closer to the pump, making it easier to transfer waste to the double-shell tank."

The Tank C-110 retrieval operation was the first at Hanford's C Tank Farm to use a hot-water skid, which produces 100 gallons per minute of 120 °F water to accelerate the dissolution of any water-soluble sludge waste, the DOE said.

- An advisory panel is urging that Vermont Yankee be decommissioned soon after it closes next year. On October 30, the Vermont State Nuclear Advisory Panel passed a resolution urging state officials to pursue a strategy that would lead to the prompt dismantlement of the Vermont Yankee nuclear power plant in Vernon, Vt., the *Burlington Free Press* reported. Entergy announced in August that it would close the 617-MWe boiling water reactor next fall, at the end of the current fuel cycle, and that it intends to place the reactor in SAFSTOR condition to allow time for residual radioactivity to decay to safer levels. While the final decision on Vermont Yankee's decommissioning rests with the Nuclear Regulatory Commission, the state could pursue the matter in U.S. courts, as it has in the past in its efforts to close the plant.

- Homestake Mining has requested a license amendment for its Grants Reclamation Project, a former uranium processing mill near Milan, N.M., that would allow it to change the background monitoring location used to measure concentrations of radon-222 in the air. Homestake Mining Company of California said that the current background monitoring location does not best represent background conditions for the site, and it is recommending a location north of the site as an alternative. In the October 29 *Federal Register*, the Nuclear Regulatory Commission published an opportunity to request a hearing and to petition for leave to intervene in the license amendment request by December 30. Information regarding the amendment request, including instructions on filing electronic submissions, can be found on the Federal Rulemaking website, at <[www.regulations.gov](http://www.regulations.gov)>, with a search for Docket ID NRC-2013-0138.

- The Nuclear Regulatory Commission is granting US Ecology a licensing exemption to dispose of low-activity



# NUCON<sup>®</sup> Products and Services

10CFR50 Appendix B and NQA-1 QA Program  
Licensed Radioisotope Laboratory - ASME Section VIII

## AIR & GAS TREATMENT SYSTEMS AND COMPONENTS

- Complete ESF and non-ESF Air Treatment Systems
- Portable Air Cleaning Units (P-NATS)
- Type II, III and IV Adsorber Cells
- Adsorber Refilling Services
- Gaseous Radwaste and Off-Gas Systems
- Target Dissolver Off-Gas Systems
- Mercury Control Equipment and Systems for Mixed Waste Disposal Operations
- Acid Gas Removal Equipment and Systems
- Gas & Liquid Phase Treatment Systems

## TESTING INSTRUMENTS

- Tracer Gas Detectors and Generators (R-11, R-12, R-112 & R-112A, HCFC-123, R-134a, 1-bromobutane)
- Aerosol Detectors and Generators (DOP, PAO, DOS, etc.)
- Pressure Detectors (Portable)
- Calibration Services; (Halide & Aerosol Instruments, Airflow, Pressure and Temperature Measurement Instruments)

## ADSORBENTS

- Radioiodine Removal Carbons (NUSORB<sup>®</sup> KITEG II<sup>™</sup>, TEG<sup>™</sup> & KIG<sup>™</sup>)
- Noble Gas Delay Bed Carbons
- Mercury Removal Adsorbents (MERSORB<sup>®</sup> series)
- Acid Gas Removal (NUSORB<sup>®</sup> KINA<sup>™</sup> series) and Systems
- VOC Removal (NUSORB<sup>®</sup> GC<sup>™</sup> series)

## RADIOISOTOPE LABORATORY SERVICES

- Radioiodine Removal Performance Testing of New and Used Carbons per USNRC Regulatory Guides, 1.52 (all revisions) & 1.140 (all revisions) and ASTM D3803, RDT-M16-1T, and DIN & DNR
- <sup>133</sup>Xe / <sup>85</sup>Kr Dynamic "K" Testing
- Various Testing Using Radioisotope Tracers

## ON-SITE TESTING AND CONSULTING

- In-place Leak Testing (ASME: N510 & N511 and AG-1)
- Control Room Envelope In Leakage Testing (ASTM E741-2000)
- Acceptance Testing (ASME N510 and AG-1)
- Air Balancing
- Duct and Housing Leakage Testing
- Compliance Review of ESF Air Cleaning Systems
- Personnel Training (ANSI/ASME and ASME AG-1)

## LABORATORY AND ENGINEERING SERVICES

- Control Room Habitability Improvements and Upgrades
- Radioisotope "Heat Decay" Studies
- Chemical Effects Studies (on adsorbants)
- Treatment Technology Development and Design



# NUCON<sup>®</sup> International, Inc

7000 Huntley Road  
Columbus, OH 43229  
Phone: 614-846-5710 - Fax: 614-431-0858  
Web Site: [www.nucon-int.com](http://www.nucon-int.com)

## Industry news ▼

waste from an Environmental Protection Agency Superfund site in Pennsylvania at the company's disposal facility near Grand View, Idaho. An environmental assessment and finding of no significant impact for the license exemption was issued by the NRC and published in the October 31 *Federal Register*. The exemption will allow US Ecology to receive and dispose of about 7640 m<sup>3</sup> of hazardous and low-activity waste from Safety Light Corporation's (SLC) site in Bloomsburg, Pa. The waste material, which consists of bulk debris and materials from the demolition of structures on the SLC site, contains radionuclides originating from the production of luminous materials and other commercial products. According to the NRC, the radionuclide concentrations are not expected to exceed acceptance limits for the US Ecology Idaho facility.

● A decommissioning plan for the Crystal River-3 nuclear power plant has been submitted to the Nuclear Regulatory Commission, Duke Energy announced on De-

cember 10. In February 2013, Duke announced that it was ending its efforts to repair the damaged 860-MWe pressurized water reactor north of Tampa, Fla., and would permanently close the plant. Duke has chosen the SAFSTOR decommissioning option, whereby the plant will remain in a safe, stable condition for 60 years until decommissioning work is completed in 2074. The estimated cost of decommissioning Crystal River-3 is \$1.18 billion in 2013 dollars, and Duke said that it believes the company's existing nuclear decommissioning trust fund, plus the fund's future growth, coupled with funds from the plant's nine other minority owners, will be sufficient to decommission the plant. The plant's used nuclear fuel will remain in the existing on-site fuel pool until a new independent spent fuel storage installation is built on the site. Duke said that it expects to begin implementing the tasks outlined in the decommissioning plan in 2014. Crystal River-3 operated from 1977 to 2009. ■



## One Source for All Your Radioactive Material Processing Needs



### Assure Regulatory Compliance

Contaminated Equipment Storage  
Motor and Pump Refurbishment  
Equipment Decontamination  
Waste Handling and Disposal  
Service Level I Coatings

Hot Shop Repair  
Facility Access  
Contaminated Electronics Recycling  
Contaminated Metals Recycling  
Large Component Processing

Lead Shielding Recycling  
Truck to Rail Transload  
Special Projects  
Asset Recovery

**Veolia's Alaron Nuclear Services**  
2138 State Route 18  
Wampum, PA 16157  
United States

**Contact us today! 724.535.5777 | [www.VeoliaES.com](http://www.VeoliaES.com)**

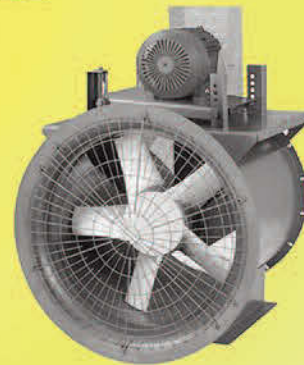
Turning Waste into a Resource

# Supplying the Nuclear Industry for Over 40 Years

Experience & Integrity



Continuous experience in the evolving nuclear industry enables us to provide you with qualified, custom products specific to your needs, on time & within budget.



## Complete HVAC Product Line

All Products are designed, qualified  
& fabricated in accordance with  
ASME AG-1 & NQA-1

**Fans:** Centrifugal, Axial, High Pressure Exhaust • **Variable Frequency Drives** • **Air Handling Units:** HEPA Filter Units, Charcoal Absorbers, Heating & Cooling Coils • **Dampers:** Bubbletight, HELB, Tornado, Control, Fire, Smoke, Balancing • **Ductwork & Accessories:** Supports, Access Doors, Flex Connections • **Actuators** • **Instruments & Controls** • **Grilles, Registers & Diffusers** • **Services:** Installation, Testing, Field Engineers, Product Design

SSM INDUSTRIES, INC.  
3401 Grand Avenue  
Pittsburgh, Pa 15225-1507  
Visit us on the Web: <http://www.ssmi.biz>  
Phone: (412) 777-5101 Email: [powerdiv@ssmi.biz](mailto:powerdiv@ssmi.biz)

THE NEW YORK BLOWER COMPANY  
7660 Quincy Street  
Willowbrook IL, 60527-5530  
Visit us on the Web: <http://www.nyb.com>  
Phone: (800) 208-7918 Email: [nyb@nyb.com](mailto:nyb@nyb.com)

# EVALUATION OF DIRECT DISPOSAL OF SPENT FUEL IN EXISTING DUAL-PURPOSE CANISTERS

*Costs, worker dose, and complexity of fuel management operations could possibly be reduced through direct disposal of DPCs.*

By E. L. Hardin, D. J. Clayton, R. L. Howard, J. Clarity, J. M. Scaglione, J. T. Carter, W. M. Nutt, and R. W. Clark

The U.S. nuclear power industry is accumulating spent nuclear fuel (SNF) in dry storage at the rate of approximately 2,000 metric tons (t) per year. Dry storage sites are associated with both operating and decommissioned power plants. Currently, there are more than 1,700 dry casks in use containing more than 17,000 t of SNF (as heavy metal; Wagner et al. 2013). Projections show that by the year 2025 there will be more than 3,000 such casks in use (Fig. 1) and that sometime before 2040 more than half of the SNF in the United States will be in dry storage (Hardin et al. 2013a). The disposition of this SNF will become a major part of back-end fuel management strategy.

For most dry storage systems, SNF is loaded and sealed into welded, stainless steel canisters which are then transferred to stationary dry storage casks. Exceptions include a few self-shielded, transportable casks that contain bare fuel assemblies. Canisters that can also be loaded into licensed transportation casks are referred to as dual-purpose canisters (DPC). The majority of SNF in existing dry storage in the United States is in DPCs, and nearly all new dry storage transfers are to DPCs. These canisters typically hold as many as 32 pressurized water reactor fuel assemblies (or equivalent boiling water reactor fuel) and recent designs hold even more.

The possibility for direct disposal of these DPCs without cutting them open and repackaging the SNF is attractive because it would potentially save money, reduce the complexity of fuel management operations, and likely result in less cumulative worker dose (from fewer handling and packaging operations) at the time of actual disposal in a geologic repository. This paper gives a technical description of some promising direct disposal con-

cepts, and then discusses preliminary analyses of technical feasibility (post-emplacement thermal and criticality analyses), and a preliminary analysis of the timing and cost for disposing of all SNF from U.S. commercial power plants in DPCs.

The preliminary results presented here indicate that DPC direct disposal could be technically feasible, at least for certain disposal concepts. Preliminary analysis also suggests that cost savings might be realized compared to repackaging DPCs, although further analysis is needed to understand economic consequences associated with the many possible scenarios.

The concept of using a common canister design for the storage, transport, and disposal of SNF originated in the 1990s as dry-storage systems were being deployed by the U.S. utility industry. The potential advantages of standardized canisters were recognized, giving rise to multi-purpose canister (MPC) concepts developed for the U.S. Department of Energy (DOE 1994). After completing preliminary studies, the DOE made a decision not to pursue the MPC concept. Later, when the Yucca Mountain repository license application was being prepared, another study specifically addressed the disposal of existing DPCs at the proposed repository (BSC 2003). It deter-

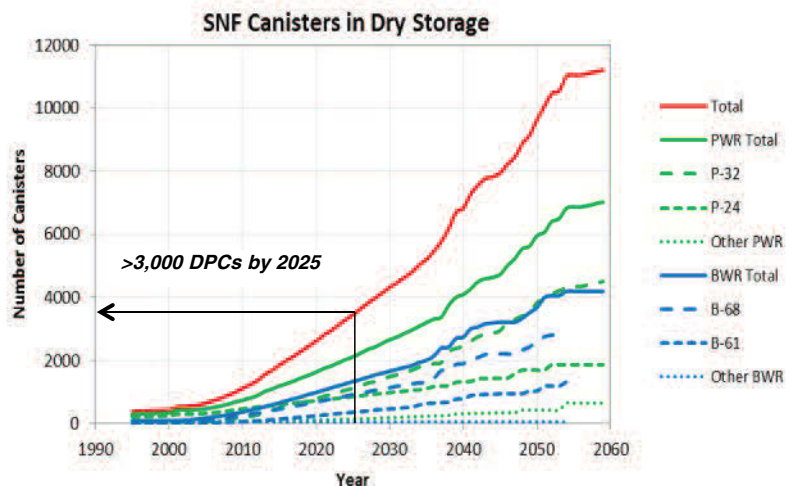


Fig. 1. Dry storage canister projection for the United States, using the TSL-CALVIN simulator and assuming existing power reactors are operated with life-extension licenses.

# Imagine!

## Imagine disposing of your Exempt Waste...

At a single site that can treat, store and dispose of all of your waste (Class A, B, C, TSCA, RCRA)

## Imagine disposing of your Exempt Waste...

At pre-approved levels without waiting up to two years for NRC approval.

## Imagine disposing of your Exempt Waste...

Having the segregation and characterization done for you.

## Imagine disposing of your Exempt Waste...

In our RCRA landfill instead of in an unlicensed industrial landfill.

## Imagine disposing of your Exempt Waste...

Without using an intermediate facility for segregation and survey and eliminating the extra cost and risk of added transportation and handling.

## Imagine disposing of your Exempt Waste...

At a site whose characteristics were confirmed through a low-level radioactive waste licensing process.

## Imagine disposing of your Exempt Waste...

Sooner than you thought possible, for less than you might expect.

# Imagine NO more...

**WCS is now licensed to dispose of low activity (exempt) waste in our RCRA landfill – Exempt disposal at enhanced levels.**



To simplify your life, WCS provides total disposal solutions that are price competitive and uniquely suited for your particular waste. You may say we're dreamers, but isn't that what it's all about?

**Simple. Permanent. Solutions. WCS.**

*Imagine the possibilities...*



*Come see us at booth 1107*

## THE TEXAS SOLUTION

**DALLAS OFFICE:**

Three Lincoln Centre, 5430 LBJ Freeway, Suite 1700, Dallas, Texas 75240-2697

**(972)715-9800**

**ANDREWS SITE:**

9998 West State Highway 176, Andrews, Texas 79714

**(888) 789-2783**



Constraints and Assumptions Used in DPC Disposal Concept Development	
Canister capacity	24- and 32-PWR sizes (or BWR equivalent) are typical. Newer designs such as the Magnastor (NAC International) and MPC-37 (Holtec International) systems may hold 37 or more PWR assemblies.
Fuel burnup	$\leq 60$ GWd/t (for PWR and BWR fuel, bracketing the range with 5 percent enrichment)
Transportability	SNF in DPCs can be safely transported to the repository for disposal, for at least 50 years and for as long as 100 years after reactor discharge.
Age of fuel at repository (or panel) closure	Less than 150 years (for any canister, the combined duration of decay storage before emplacement plus pre-closure cooling in a repository)
Post-closure reactivity limit	$k_{\text{eff}} < 1.0$ after repository closure
Underground handling and emplacement operations	Shielded for all operations until emplacement (self-shielded waste packages are also an option).
Basis for waste isolation performance	Assume future regulations will incorporate the probabilistic approaches from 40 CFR 197 and 10 CFR 63.
Host rock peak temperature targets:	
Salt	$\leq 200$ °C
Crystalline (“hard” rock)	$\leq 200$ °C
Argillaceous (e.g., claystone, shale, etc.)	$\leq 100$ °C
Cladding temperature limit after emplacement	$\leq 350$ °C
Clay-based engineered material peak temperature target	$\leq 100$ °C

mined that post-emplacement criticality was the most important technical issue, and that fuel burnup data from reactor operations could be used to demonstrate subcriticality for a fraction of the DPC inventory.

Direct disposal of existing DPCs (up to 32-PWR size) was also examined by the Electric Power Research Institute (EPRI 2008a; 2008b), which looked at thermal and criticality issues and found no technical impediment to direct disposal for the repository concept being studied by the DOE at the time. More recently, a German team has proposed direct disposal of the CASTOR-V storage/transportation cask containing approximately 10 t of SNF in a salt repository (Graf et al. 2012).

This paper summarizes current activities in the DOE’s Used Fuel Disposition Program to examine the feasibility of DPC direct disposal. This updated analysis has considered the canister systems currently being used in the United States, the available geologic settings (no site or geology has been selected), and the projected characteristics of SNF that will be placed in dry storage over the next several decades.

#### OBJECTIVES FOR DIRECT DISPOSAL

The objectives for direct disposal of SNF in DPCs are the same as for any geologic repository: the safety of workers and the public, and long-term isolation of the radioactive materials from the biosphere. Achieving these objectives will involve 1) respecting temperature limits for

the fuel and the repository, 2) mitigating the potential for criticality after waste emplacement, 3) engineering feasibility of underground construction and operations, and 4) achieving acceptance by regulators and the public. Some of the technical constraints and assumptions that could help to ensure that these objectives are met are summarized in the accompanying table.

The present evaluation has focused on the feasibility of repository closure at or before the time when SNF in DPCs reaches 150 years of age out of reactor. It is further assumed that the DPCs can be safely transported to the repository as soon as 50 years after reactor discharge, or at up to 100 years after discharge as appropriate.

Canister capacity and fuel burnup assumptions bracket the DPCs currently in storage, and also address the projected larger canisters and higher SNF burnup. The 150-year time limit on storage and disposal operations avoids more protracted, longer-term commitment to waste management activities (other than monitoring and other activities that may be required).

The assumed reactivity limit ( $k_{\text{eff}} < 1.0$ ) is less conservative than values used for storage and transportation safety analyses, but reflects the gradually changing nature of conditions affecting the potential for criticality in a repository. Also, such a criticality event would have to occur in a disposal system with multiple, redundant barriers to waste migration (Hardin et al. 2013d, Section 6). In any event, post-closure criticality is very unlikely in disposal environments where moderating water is scarce, and/or where there is sufficient natural neutron absorption, as

discussed below.

The assumption of shielded underground transport and emplacement operations could provide additional assurance that worker dose would be limited for normal operations and a range of possible accidents during repository operations. Post-closure waste isolation safety would be evaluated using probabilistic assessments to demonstrate compliance with regulatory performance objectives (see table). Given the generic (non-site-specific) nature of this examination, this paper provides qualitative safety arguments, comparing direct disposal with alternative disposal concepts that involve repackaging SNF in purpose-built canisters.

The peak temperature target, or limit, for salt would limit decomposition of hydrous minerals that are often found with halite in salt formations. It would also prevent decrepitation that can occur at temperatures above approximately 250 °C. Whereas these mechanisms would occur only locally, and neither would necessarily compromise the waste isolation integrity of a host salt formation, they could add complexity to the disposal safety case. In any case, the 200 °C target is already high enough to facilitate direct disposal of DPCs.

For crystalline rock such as granite, or “hard” rock such as welded volcanic tuff, or metamorphic rock, the 200 °C target would limit micro-cracking and weakening from differential thermal expansion of mineral grains (Hardin et al. 1997). Again, the effect would be localized and would not necessarily compromise waste isolation, but it could add complexity to the safety case, and the 200 °C target is already high enough to facilitate direct disposal of DPCs.

Peak temperature targets for argillaceous host media and engineered clay-based materials (see table) are based on current understanding from international repository development programs. Alteration of clay-based materials generally involves dissolution, aqueous transport, and precipitation (e.g., silica precipitate). Temperature limits are imposed because alteration could degrade swelling pressure, promote fracturing, and potentially decrease sorption of released radionuclides. For example, the Swedish program has adopted a peak buffer temperature of 100 °C (after swelling; SKB 2011, Section 5.5.1). This study uses a target maximum temperature of 100 °C for clay buffer and clay-based backfill materials, recognizing that this is the focus of ongoing research and development and may change in the future.

Natural clay-bearing formations are subject to the same alteration processes as engineered clay-based materials, and may also contain significant amounts of impurities such as potassium, which can react to form nonswelling illite clay. Temperature limits would be similar to, and possibly lower than, those for engineered materials. Andra, France’s National Radioactive Waste Management Agency, has proposed a 90 °C limit for the argillaceous host medium surrounding waste packages in the proposed repository in Callovo-Oxfordian argillite (Andra 2005, Section 1.2.3.4). This study uses a target maximum temperature of 100 °C for argillaceous media, by analogy to clay-based engineered materials, recognizing that this, too, is the focus of ongoing R&D and may change in the future.

The host rock and engineered material peak temperature targets in the table are specified for the waste package surface or surrounding material. Past thermal analy-

ses have shown that if the package surface meets these limits, then the temperature of fuel within the package will meet the 350 °C limit intended to limit Zircaloy cladding creep rupture, by a wide margin (BSC 2008). Thus, the temperature of the fuel is not expected to directly constrain the disposal of DPCs.

## DISPOSAL CONCEPTS AND THERMAL MANAGEMENT

Prospective geologic disposal concepts are readily divided into “enclosed” and “open” modes of waste package emplacement (Hardin et al. 2012). The enclosed modes involve emplacing packages directly into contact with engineered materials, or host rock, which have inherent thermal limits. The open modes maintain air space around each package that can be ventilated to remove heat prior to the permanent closure of the repository. These spaces may also remain open and continue to be involved in heat dissipation after closure. Open emplacement concepts combine the functions of decay storage (e.g., dry storage) with geologic disposal in the same underground facility. An open-mode repository could be constructed and operated much sooner than enclosed concepts that require decay storage of 100 years or longer (Hardin et al. 2012). Earlier emplacement of SNF waste could allow much of the cost for the disposal of SNF in the United States to be incurred at the same time that currently operating nuclear power plants are being shut down (i.e., while contributions to the Nuclear Waste Fund continue).

Most international high-level waste and SNF disposal programs are focused on enclosed modes in argillaceous or crystalline host rock types, with inherent limits on heat generation and SNF capacity for waste packages. Only the salt concept and the open emplacement modes in other media are suited for relatively large DPC waste packages with heat output of 10 kW or more at emplacement. A disposal solution using larger packages is attractive for the United States, which currently faces the disposal of more than twice as much SNF as any other nation among those that do not have the means of reprocessing their SNF.

Disposal overpacks would be used with any disposal concept. A range of overpacks could be designed to accommodate the different types of DPCs, which differ with respect to dimensions and external handling features. Overpacks would be the interface between different types of DPCs and other elements of the disposal system, such as transporters, emplacement equipment, other engineered barriers, and the host rock. DPCs are typically constructed from relatively thin stainless steel plate, and overpacks could provide additional, robust mechanical strength for handling and transport, and for repository closure operations such as backfilling. The weight of fully loaded DPCs ranges up to approximately 50 t depending on capacity, and a 5-cm-thick steel overpack would add approximately 20 t. The overall diameter of waste packages containing DPCs would be just under 2 m, with a length of 5 m or slightly more depending on fuel type.

Robust overpacks could also help to ensure containment for a range of potential accidents or disruptive events during repository operations. Overpacks made from low-alloy steel with wall thickness of a few centimeters have been proposed for various disposal concepts (Hansen et

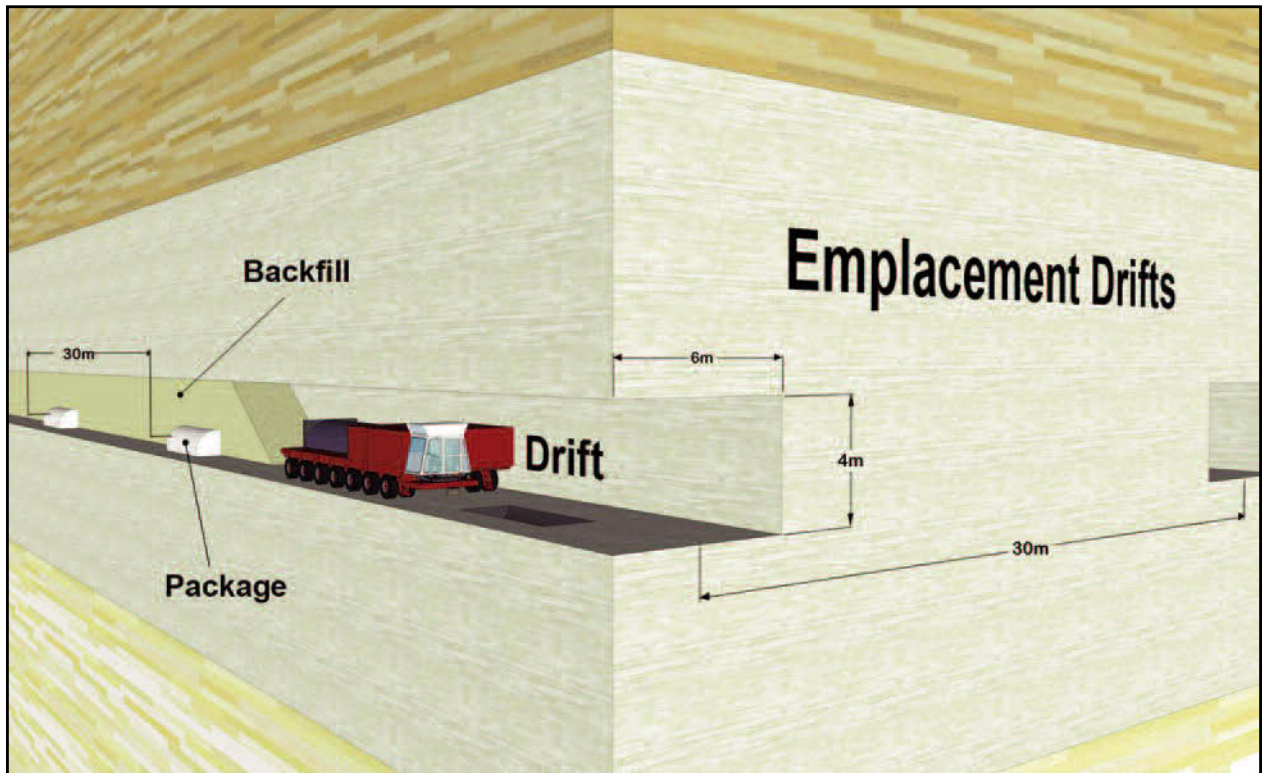


Fig. 2. Repository concept for dual-purpose canister waste packages in bedded salt.

al. 2010; Sevougian et al. 2012). The materials used and the methods for fabrication and treatment would likely be selected for performance in the disposal environment, as has been demonstrated for a range of disposal concepts internationally (DOE 2008; SKB 2011; Andra 2005).

### Salt Concept

A repository in salt was proposed for heat-generating HLW based on lessons learned from the Waste Isolation Pilot Plant (WIPP) and salt investigations at Asse and Morsleben, in Germany (Hansen and Leigh 2011). The concept (Fig. 2) was then extended to SNF (Hardin et al. 2013b). Excavation and construction would likely be similar to WIPP, an operating geologic repository for transuranic (TRU) waste located in southeastern New Mexico. The repository could be excavated using standard mining practices. Floors could be bare rock suitable for rubber-tired equipment, and ground support could consist only of rock bolts in traffic areas. Both bedded salt and salt domes could be suitable, differing mainly in lateral extent and moisture content. Less moisture in domal salt means less potential for brine to accumulate, but both types of formations offer very low brine mobility and no radionuclide releases under normal, undisturbed conditions (Vaughn et al. 2012). Accumulation of brine at waste packages might be important in criticality analysis for certain conditions, but 75 percent of natural chlorine is Cl-35, a thermal neutron absorber.

DPC disposal overpacks could consist of low-alloy steel or other low-cost structural material, sufficient to maintain containment through handling and for at least 50 years after emplacement (e.g., to facilitate possible retrieval). Steel wall thickness of 5 cm could impart ample

mechanical strength for handling and transport, and some allowance for corrosion as well. The limited abundance of moisture in a salt repository would limit the extent of corrosion damage (water is consumed by corrosion reactions), so the overpack could remain intact and available as a redundant isolation barrier for much longer than 50 years. Emplacement drifts would be backfilled immediately, so that subsequent nearby repository monitoring or closure operations could be performed without additional shielding. Nonemplacement access openings would be backfilled with crushed salt prior to closure.

Waste packages could be handled underground in the horizontal orientation to limit the height of excavations. To limit handling operations underground, they could also be transported from the surface in horizontal orientation. Transport of DPC packages would require a ramp from the surface, or a shaft hoist such as that tested at Gorleben and scaled up to sufficient capacity (175-t payload). This capacity is roughly twice the 85-t capacity tested at Gorleben in the 1990s, which was demonstrated then to be technically feasible. The larger capacity (175 t) has been proposed in connection with the German DIREGT concept for direct disposal (Graf et al. 2012). It is important to note that site-specific factors may constrain possibilities for shaft or ramp construction. For example, the existence of an aquifer in the geologic section above the host formation could favor vertical shafts if they are considered to be safer to construct or simpler to seal at repository closure. Not all potential host formations are associated with aquifers, however, and bedded salt formations or salt domes may offer both shaft access from above and ramp access through adjacent rock strata.

Salt has thermal properties that facilitate disposal of larger, hotter waste packages. Thermal conductivity is higher than many other rock types, and salt can tolerate a



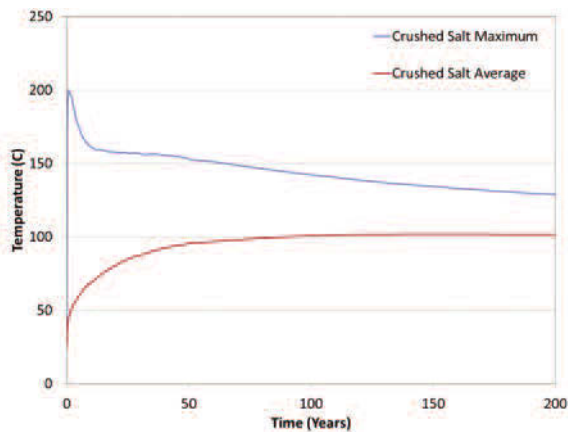


Fig. 3. Temperature histories for a 32-PWR package with 60 GWd/t spent nuclear fuel burnup, stored 70 years before emplacement in salt (at zero time; from Hardin et al. 2013c).

peak temperature of 200 °C. Finite-element thermal-mechanical analysis of the disposal of large packages (32-PWR size) using the salt concept was reported previously (Hardin et al. 2012). Temperature histories (e.g., Fig. 3) show that the salt peak temperature target can be met with DPC decay storage of 50 to 70 years.

While salt does creep, it does so under stress conditions imparted by overburden pressure, not from the much smaller weight of waste packages. Stresses from reaction loads near emplaced waste packages are small compared to stress redistribution caused by excavation. Even thermally activated salt deformation in response to waste package weight is minor, as demonstrated by coupled thermal-mechanical simulations (Clayton et al. 2013) us-

ing constitutive laws for salt that were developed from laboratory data and validated against field-scale observations (summarized by Hansen and Leigh 2011). Salt constitutive behavior at low stresses and low strain rates typical of long-term waste package behavior in the salt concept is an area of continuing investigation in the Used Fuel Disposition Program.

### *Hard Rock (Crystalline) Unsaturated, Unbackfilled Repository*

In this open-mode concept, waste packages would be emplaced axially in open drifts, and ventilated for up to 100 years to remove heat (Fig. 4). The concept could use a corrosion-resistant package and other redundant engineered barriers as needed for defense-in-depth. Other barriers could include water diversion features such as drip shields, or multiple corrosion-resistant packaging materials such as titanium or nickel alloys. This concept is similar to previous work (DOE 2008) and to a previous proposal for direct disposal of DPCs (EPRI 2008b).

Hard rock (e.g., igneous or metamorphic, and crystalline) offers better long-term opening stability and typically has greater thermal conductivity and higher temperature tolerance (to approximately 200 °C) than rock types containing significant clay or other hydrous minerals. Virtually all hard rock types have some fracturing, so mitigating rock permeability is potentially important. If the host rock is unsaturated, the existence of sufficient permeability will make it free-draining. With drainage there is little possibility of focused groundwater flow along repository openings, so plugging, sealing, or backfilling of emplacement and access drifts may not be need-

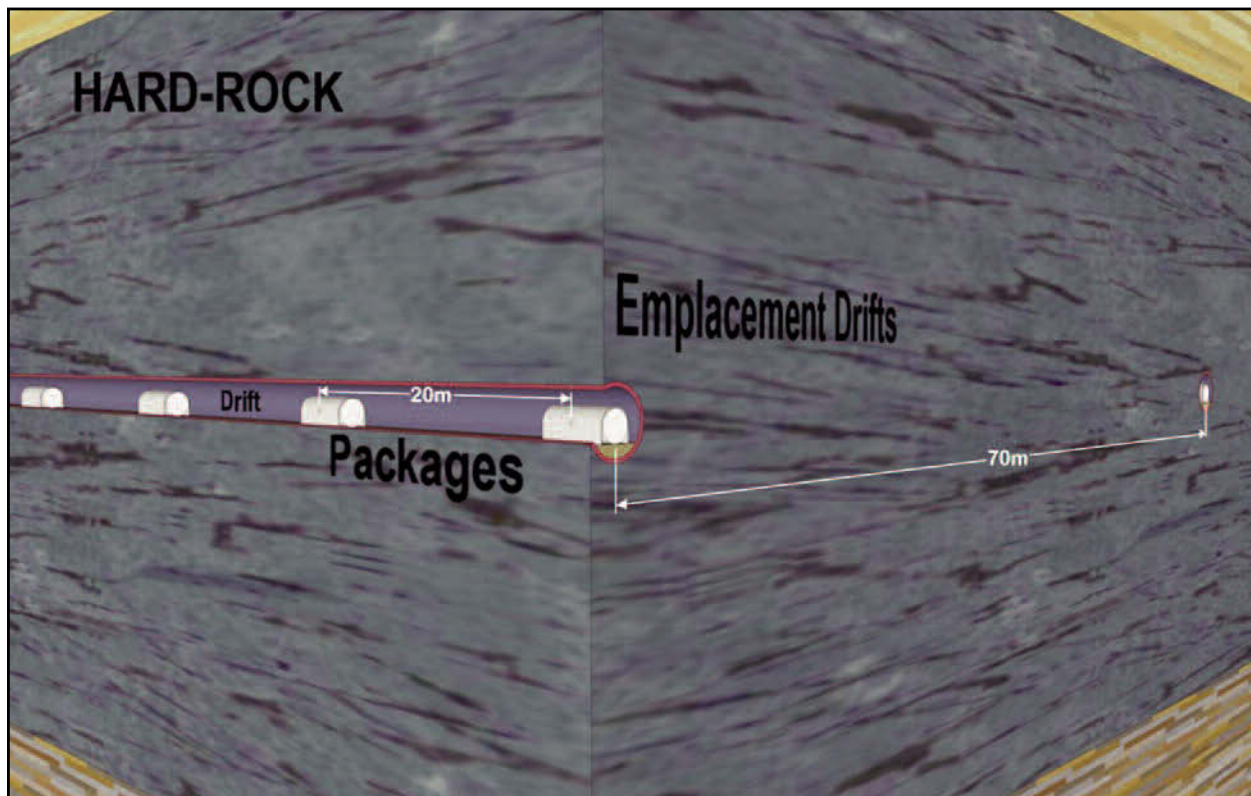


Fig. 4. Repository concept for dual-purpose canister waste packages in hard rock (crystalline), with extended repository ventilation and without backfill.

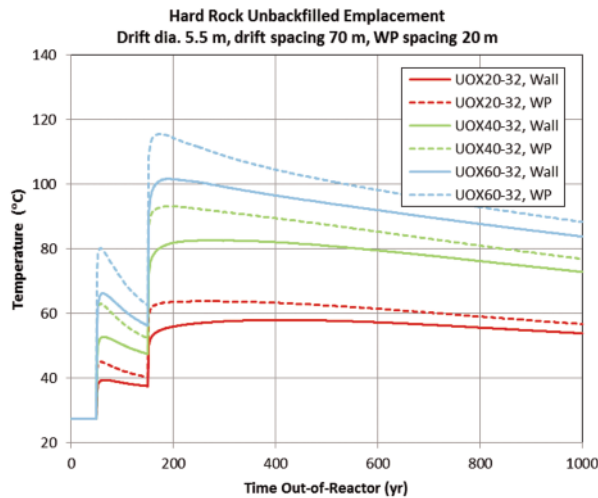


Fig. 5. Temperature histories for a 32-PWR waste package with 60 GWd/t burnup, stored 50 years and then emplaced in an unbackfilled hard rock (crystalline) repository and ventilated for an additional 100 years (from Hardin et al. 2013c).

ed. In saturated settings, a low-permeability backfill could be installed at the time of repository closure. Thermal calculations (Fig. 5) show that a 200 °C host rock peak temperature target could be readily met for SNF with high burnup, with fewer than 150 years of combined decay storage plus ventilation. The results shown in Fig. 5 suggest that the repository layout could be optimized with respect to drift and waste package spacings, and shorter durations for decay storage and ventilation.

### Other Disposal Concepts

The other concepts amenable to DPC direct disposal would use backfill, installed at closure, in argillaceous or crystalline host media. A range of alternative concepts for DPC direct disposal was examined by Hardin and Voegelé (2013) in a study that focused on how to meet peak temperature targets in various geologic settings: argillaceous rock types (with thermal properties typical of indurated mudstone, claystone, or shale); hard rock (properties of typical granite or tuff); and salt (bedded or domal). As noted above, with the exception of disposal in salt, DPC disposal concepts need to be “open” for ventilation to remove heat until repository closure. For DPC disposal, the alternatives to open emplacement or to disposal in salt would be “enclosed” concepts in which buffer and/or backfill materials would be installed at emplacement. Such enclosed emplacement modes could require many hundreds of years of surface decay storage before disposal (Hardin et al. 2012).

Some of the open concepts that have been identified might remain open if unbackfilled after repository closure, which could improve heat dissipation, until eventual collapse of the emplacement openings. Drift collapse, however, would increase the radial extent of the disturbed rock zone (DRZ) in the rock around the openings. While this could be inconsequential in unsaturated hydrologic settings, in saturated settings the collapse rubble and the DRZ could later act as pathways for groundwater flow and possible transport of radionuclides. Thus, backfill would be needed in saturated settings to mechanically sta-

bilize the host rock, minimize the DRZ, and control groundwater flow. Further, isolation of adjacent waste packages from one another using low-permeability backfill could be advantageous in the analysis of future inadvertent human intrusion (Hardin et al. 2013d).

Granular backfill materials generally have relatively low thermal conductivity (e.g., 0.6 to 1.2 W/m-K (watts/meter-Kelvin), which subjects those materials and the waste package to higher peak temperatures (Hardin et al. 2012). This would generally not be a problem for waste packages, which can withstand surface temperatures approaching 300 °C without significant damage to the SNF contained within (or to the packaging, depending on the selection of material and the chemical environment, and the post-closure safety function assigned to the package; see BSC 2008). Nor is the installation of backfill likely to significantly affect temperature in the host rock. Elevated temperature in the backfill, however, could have an impact on the properties of the backfill itself, and, in particular, alter clays that are used to produce swelling behavior and low permeability. Scoping calculations show that backfill material capable of withstanding 150 °C peak temperature (plus the associated thermal history) could make the use of backfill a viable option in DPC direct disposal (Hardin and Voegelé 2013). This possibility is the objective of ongoing materials research in the Used Fuel Disposition Program, intended to develop and maintain options for disposal in a broad range of geologic settings.

Argillaceous (containing clay) host media typically have lower thermal conductivity than salt or crystalline media, which presents an additional challenge for repository thermal management. There is some flexibility in selecting repository dimensions to limit temperature rise in such media. The dimensional variables are emplacement drift diameter, the spacing between packages, and the spacing between drifts. These variables trade against one another to some extent, and they determine excavation volume and repository layout size. Repository layouts have been described (Greenberg and Wen 2013) that limit host rock peak temperature in argillaceous media, while limiting excavation volume and repository size. To accommodate direct disposal of moderate- to high-burnup SNF in DPCs, repository layout size (and the extent of tunneling needed) would be approximately doubled in argillaceous media as compared to salt or hard rock. Scoping studies have also shown that allowing slightly higher peak host rock temperature could significantly reduce the repository layout size. The peak temperatures and other thermal criteria appropriate for various argillaceous host media are another area of ongoing research in the Used Fuel Disposition Program.

### SAFETY OF DPC DIRECT DISPOSAL

Generic demonstration of waste isolation performance could be achieved by evaluating the potential differences between direct disposal of DPCs and disposal of the same SNF in packaging (including canisters) designed specifically for disposal, in the same geologic setting. Repackaging could produce smaller packages for use with enclosed disposal concepts, or it could produce packaging similar to DPCs in size, with features specific to disposal. Gener-

ic safety analysis for DPC direct disposal, and generic safety analysis in general, are currently under development. The approach taken here focuses on qualitative differences, pointing out important ways that DPC direct disposal could differ from other disposal concepts involving repackaging:

- *Emplacement mode and engineered barrier system design*—DPC disposal concepts that could be implemented in 150 years include open emplacement modes that use ventilation to remove heat, and the salt concept, which could be closed immediately after emplacement. Backfill emplaced remotely at closure (in a thermal and radiological environment) would likely have less density and uniformity than material emplaced before waste emplacement. Hence, comparisons of open-mode DPC direct disposal with concepts that involve repackaging should include effects associated with greater permeability and the potential for groundwater flow and advective radionuclide transport in the near field. If transport of radionuclides through the far field to the biosphere is diffusion-controlled, such differences may be insignificant.

- *Thermal effects (DPC disposal vs. large purpose-built packages)*—DPCs are not necessarily much larger than purpose-built disposal canisters would be—for example, a previously designed transport/aging/disposal (TAD) canister would hold 21 PWR assemblies (DOE 2008). Peak temperatures for larger packages could be controlled with decay storage and repository ventilation, but post-peak temperature would be higher for DPC-based packages than for smaller packages, for hundreds of years. Aging attenuates short-lived fission products, but larger packages contain more heat-generating nuclides with intermediate half-lives that are not as amenable to aging, such as americium-241. Thus, elevated temperature in the near-field host rock and backfill could persist longer with larger packages. The consequences could be minimal if host rock and backfill transport characteristics are relatively insensitive to thermal exposure (e.g., as for the salt concept).

- *Thermal effects (DPC disposal vs. enclosed modes and small packages)*—Enclosed emplacement modes in argillaceous and crystalline rock types were shown to require 4-PWR size waste packages to limit peak temperature to less than 100 °C, with disposal at up to 150 years (Hardin et al. 2012). DPCs would need decay storage for many hundreds of years to meet this temperature limit. Both the peak temperature and the duration of elevated temperature would be greater for in-drift disposal of DPC-based packages (with decades of repository ventilation) compared to smaller packages used with enclosed emplacement modes (and no ventilation). The waste isolation performance of enclosed modes would resemble that analyzed for the Swedish (SKB 2011) and French (Andra 2005) SNF disposal concepts, whereas performance of DPC direct disposal would likely place more emphasis on backfill and the geologic setting (particularly in the far field that is relatively unaffected by waste heating).

A notable exception to the need for small packages is the salt concept, which could accommodate SNF waste packages up to 32-PWR size or larger. Radionuclide transport characteristics of salt backfill and host rock are insensitive to temperature, or are improved through thermally accelerated creep consolidation. The package thermal power limit for the salt concept could be met by

32-PWR size packages after decay storage of approximately 70 years or less (Hardin and Voegele 2013).

- *Quantity of SNF*—If a waste package breach were to occur, more SNF would be exposed to the disposal environment with DPCs than with smaller containers. The difference would be greatest in comparing DPCs with the small canisters (e.g., 4-PWR size) needed for enclosed emplacement modes in argillaceous or crystalline media. This difference could potentially result in a reduction in waste isolation performance for DPC disposal as compared to smaller canisters, depending on the dominant transport mechanism controlling radionuclide transport from the disposal package to and through the host rock. This potential reduction in performance would tend to be more significant for settings where transport is dominated by advection. The importance of advective transport is the most important factor of interest in the long-term safety of DPC direct disposal related to the quantity of SNF per package.

- *Inner canister design*—Canisters purpose-built for disposal could have features not found in existing DPCs, such as inserts (in lieu of baskets); thicker shells, plates, and/or spacers to extend structural lifetime in corrosion environments; more corrosion-resistant materials; thicker neutron-absorbing elements that can function after >10<sup>4</sup> years of exposure to groundwater; and fillers that can exclude moderating groundwater after a package breach. Existing DPCs cannot include any of these features (assuming they cannot be reopened), and so post-closure criticality is an issue for DPC direct disposal. As discussed below, the potential for criticality can be mitigated by moderator exclusion and by chloride in groundwater, and by measures to address conservatism in the reactivity analysis.

To summarize, for generic (non-site-specific) comparison of DPC direct disposal with disposal of the same waste repackaged in purpose-built containers, important factors that help to ensure post-closure disposal safety include: 1) diffusion-controlled transport, 2) near-field transport properties that are insensitive to temperature, 3) backfill and natural-barrier contributions (particularly the far field less affected by heat), and 4) mechanisms that limit potential post-closure criticality. These are general disposal system attributes that could benefit any geologic repository, whether it involves DPC disposal or repackaging. Eventually, the availability of site-specific data will support more resolution of differences in post-closure safety performance associated with DPC direct disposal.

### POST-CLOSURE CRITICALITY SCOPING ANALYSIS

Canisters licensed for transportation are typically analyzed for reactivity when fully flooded with fresh water (maximum reactivity) after accidental breach (10 CFR 71.55). In such analyses, the neutron absorbers and basket geometry are assumed to function as designed. By contrast, the analysis of post-closure criticality must consider the potential for the degradation of neutron-absorbing features, and the possibility for collapse of the basket holding the fuel assemblies, in addition to flooding. These mechanisms may be important for 10,000 years (§10 CFR 63.114) or longer, which is likely sufficient for

the chemical breakdown of aluminum-based absorber materials—such as Boral, currently being used in DPC construction—when exposed to water.

For the TAD canister discussed above (DOE 2008), degradation was addressed in the design by fabricating absorber plates from borated Type 304 stainless steel, and all other components of the canister from nuclear-grade Type 316 stainless steel, with sufficient thicknesses for corrosion allowance. The accumulation of corrosion damage to structural and absorber components over 10,000 years of exposure to groundwater was bounded based on the extrapolation of laboratory test data, with acceptable margins on load-bearing and neutron absorption properties. These features are not available on the current inventory of DPCs. Hence, the challenge for post-closure criticality analysis for existing DPCs is to account fully for other factors mitigating the potential for criticality, including as-loaded margin analysis, burnup credit, flooding with brine (for certain geologic settings), and moderator exclusion. Note that if water is excluded from the repository or from entering waste packages, there is no potential for criticality.

Existing DPCs have been loaded using conservative assumptions—for example, in accordance with specifications based on analysis with unirradiated fresh fuel. Detailed information about the reactor in-service history of each SNF assembly, along with actual cask-specific loading arrangements, can be used to exploit this type of reactivity margin. Scoping calculations of reactivity for two representative DPC systems (Clarity and Scaglione 2013) demonstrate this approach: the Transportable Storage Canister (TSC-24) from NAC International and the Multi-Purpose Canister (MPC-32) from Holtec International. Detailed analyses were conducted for the TSC-24 and MPC-32 canisters in use at two storage sites. These two DPC systems were selected because they are reasonably representative of the overall population of DPCs. As of June 2013, there are 185 MPC-32 canisters and 220 TSC-24 canisters currently loaded in dry storage in the United States. Actual DPC loading specifications and assembly in-service history information used in these calculations were provided by the operating companies.

The SCALE (ORNL 2011) CSAS6 criticality analysis sequence was used to perform criticality calculations for loaded fuel canisters with the KENO-VI Monte Carlo code, with the continuous energy ENDF/B-VII cross-section library to determine the effective neutron multiplication factor ( $k_{\text{eff}}$ ). Depletion calculations were performed using the TRITON two-dimensional depletion sequence to generate used fuel isotopic compositions (Clarity and Scaglione 2013).

Initial scoping calculations were performed for three representative configurations: 1) as-loaded, with all canister internals represented in original condition; 2) complete loss of neutron absorber panels (replacement by groundwater), but assembly-to-assembly spacing unchanged; and 3) complete degradation of basket structure (and loss of neutron absorber), resulting in minimal assembly spacing and the collapse of assemblies into a cylindrical arrangement. These configurations are stylized and may be unrealistic, but they do show the potential benefit from more detailed analyses of post-closure criticality.

Fuel assemblies were represented as fully intact in each

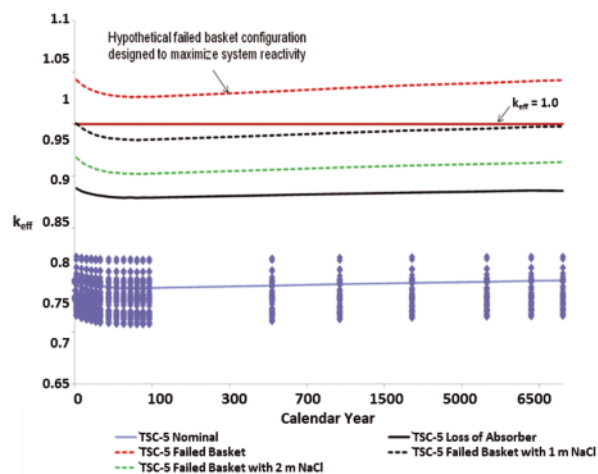


Fig. 6. Reactivity vs. time calculations for TSC-24 canisters, and degraded cases for representative canister TSC-5 (as loaded).

configuration, allowing penetration by groundwater. Burnup credit included actinides and fission products (i.e., uranium-234, -235, -236, and -238; neptunium-237; plutonium-238, -239, -240, -241, and -242; americium-241 and -243; molybdenum-95; technetium-99; ruthenium-101; rhodium-103; silver-109; cesium-133; neodymium-143 and -145; samarium-147, -149, -150, -151, and -152; europium-151 and -153; and gadolinium-155). To account for computation bias and uncertainty, a +0.02 ( $\Delta k_{\text{eff}}$ ) margin was added.

The NAC TSC-24 canister calculations (Fig. 6) show that when actinide and fission product burnup credit is taken in conjunction with canister-specific loading, calculated  $k_{\text{eff}}$  ranges from 0.61 to 0.81 for the 37 canisters evaluated, when flooded with pure water. For a representative canister (called TSC-5), the absorber loss and basket degradation cases resulted in reactivity increases on the order of +0.17 and +0.38 ( $\Delta k_{\text{eff}}$ ), respectively. Additional evaluations of the degraded basket case were performed to see if chloride present in groundwater could control system reactivity (Cl-35 has a thermal neutron capture cross-section of about 44 barns). For the TSC-5 canister, flooded with a 1-molal NaCl brine, reactivity decreased moderately ( $\Delta k_{\text{eff}} \sim -0.08$ ). Similar reduction was calculated for 2-molal NaCl. The concentration of NaCl in seawater is about 0.5 molal, but brines present in some crystalline rocks are more concentrated than seawater, and brines in salt formations have a chloride concentration on the order of 6 molal.

Canister and basket materials may continue to function for thousands of years in some disposal environments. Further investigation into the geochemical behavior of canister materials and their interaction with groundwater could determine whether the degraded basket case is needed, and how basket degradation would vary for different canister and disposal overpack designs. For example, the basket used in the NAC TSC-24 canisters evaluated includes 0.5-in.-thick stainless steel spacer discs, and aluminum heat transfer discs that maintain assembly-to-assembly spacing. These discs would need to degrade faster than the fuel assemblies for the degraded basket configuration to develop.

Calculations for the Holtec MPC-32 system (Fig. 7)

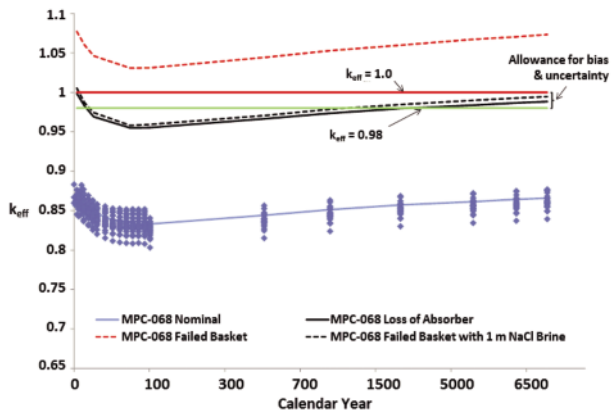


Fig. 7. Reactivity vs. time calculations for MPC-32 canisters, and degraded cases for representative canister MPC-068 (as loaded).

show that when actinide and fission product burnup credit is taken in conjunction with canister-specific loading, calculated  $k_{\text{eff}}$  values range from 0.80 to 0.88 for the 26 casks evaluated, when flooded with pure water. For a representative canister (MPC-068), absorber loss and basket degradation resulted in reactivity increases on the order of +0.12 and +0.20 ( $\Delta k_{\text{eff}}$ ), respectively.

Discharged burnable poison rod assemblies (BPRA) are actually present in these MPC-32 canisters but were not represented in the calculations. Discharged BPRAs could be credited for moderator displacement, and typically decrease  $k_{\text{eff}}$  by -0.02 to -0.03 ( $\Delta k_{\text{eff}}$ ) or more. With burnup credit, canister-specific loading, and moderator displacement credit for discharged BPRAs, all of the MPC-32 canisters evaluated would be subcritical for the absorber loss case. For the basket degradation case, reactivity increased significantly for all canisters, and the effect was much greater than the decrease available from burnup credit and canister-specific loading. For the basket degradation case, flooding with 1-molal NaCl decreased reactivity by approximately -0.07 ( $\Delta k_{\text{eff}}$ ), and 2-molal NaCl showed another similar decrease in reactivity.

### TIMING AND RELATIVE COST OF DPC DISPOSAL

The TSL-CALVIN transportation-storage-logistics simulator (Nutt et al. 2012) was used to determine when DPCs loaded by the existing fleet of nuclear reactors could be sufficiently cool to meet repository emplacement thermal power limits. The simulator logic explicitly links DPC shipments to the repository from reactor sites, or from a centralized storage facility (CSF), to a thermal power limit for emplacement in the repository. All dry storage canisters and casks are assumed to be transportable either to a CSF (subject to transport cask limits) or to a repository (subject to the thermal power limit for disposal). For this analysis, DPCs are assumed to include all welded dry storage canisters and bolted dry storage casks.

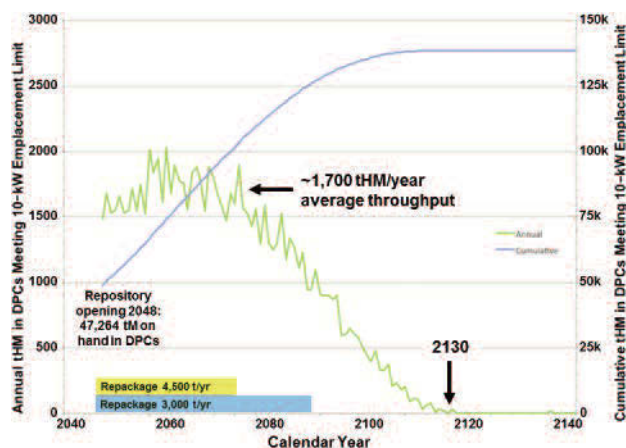
Forecasts of when DPCs could be cool enough for disposal were made for a range of thermal limits (Hardin et al. 2013d). For this paper, the results for the 10-kW limit are shown (Fig. 8). This limit is appropriate to represent disposal of any DPC, with either the salt concept

(Hardin et al. 2012) or the hard rock (crystalline) unsaturated, unbackfilled concept (Hardin 2013). The simulation is based on a set of assumptions including the following:

- SNF will be generated at all currently operating power plants, with 20-year life extensions, and gradual increases in burnup (approaching what can be achieved with 5 percent enrichment). As power plants are decommissioned, all SNF will be put into dry storage.
- A CSF would serve as the principal surface decay storage facility for DPCs (in addition to at-reactor storage prior to shipment). The shipment of DPCs from reactor sites to a CSF would begin in 2025, at a rate of either 3,000 or 4,500 tHM per year.
- A repository would open and begin to package and emplace DPCs underground in 2048. The inventory of SNF in the CSF at that time would be 69,000 tHM or 103,500 tHM, depending on the assumed CSF receipt rate (3,000 or 4,500 tHM per year).
- Once the repository is operating, DPCs cool enough for disposal would be shipped directly from reactor sites, or from the CSF if DPCs at the reactor sites are not cool enough.
- Shipments to the CSF would continue after 2048, as needed, to transfer fuel from decommissioned plants (subject to CSF receipt rate limits).

The CSF and repository starting dates are consistent with the current high-level strategy of the DOE (DOE 2013).

The simulator tracks the amount of SNF that becomes available each year for disposal, the amount emplaced in a repository, and the status of SNF in storage at reactor sites and at a CSF. The incremental cost for storing DPCs at a CSF until they are cool enough for disposal is estimated and compared with the cost of repackaging into smaller containers for disposal. Results (Figs. 8 and 9) show that emplacement could be substantially complete by calendar year 2130 for the 10-kW thermal limit (with a few outlying, high-burnup canisters). For the salt concept, closure could soon follow, while for the hard rock (crystalline) unsaturated, unbackfilled concept, a few decades of repository ventilation would be needed before closure. For comparison, disposal schedules for other



Note: Color bars are timelines for repository emplacement of the full inventory of 140,000 tHM, at the indicated throughput levels, starting in 2048.

Fig. 8. TSL-CALVIN forecasts for dual-purpose canisters cooling to a 10-kW thermal limit in 2048 and each following year, expressed as quantity of spent nuclear fuel.

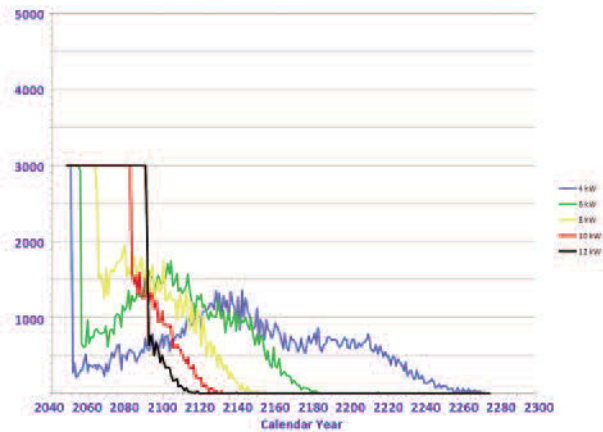


Fig. 9. Projected annual repository dual-purpose canister acceptance rates for 3,000 tHM/yr throughput limit, for various thermal limit values.

thermal-limit values are also shown (Fig. 9). An optimal disposal acceptance rate of approximately 1,700 tHM/year was calculated for the 10-kW case, to complete disposal by 2130 (Hardin et al. 2013d). In other words, repository throughput capacity of only 1,700 tHM/year could complete DPC emplacement in the same time as a 3,000-tHM/year facility.

The incremental CSF life-cycle cost of additional decay storage needed to implement the 10-kW disposal schedule was estimated to be \$5.4 billion (Hardin et al. 2013d). For comparison, the life-cycle cost of a 3,000 tHM/year repackaging facility was estimated to range from approximately \$6.5 billion to \$14.5 billion, depending on the size of the disposal canister, with smaller canisters resulting in higher cost. This repackaging cost estimate is only for canistering fuel at a CSF, and does not include disposal.

Higher disposal costs would result from the use of smaller waste packages because more disposal overpacks would be needed, along with more handling operations and larger underground facilities. For example, Kalinina and Hardin (2012) compared the disposal of 140,000 tHM in a salt repository with 4-PWR- and 12-PWR-size waste packages (or BWR equivalent) requiring 86,049 and 28,648 packages, respectively. The analysis assumed that waste would be received at the repository already in canisters appropriate for disposal. The additional 57,401 packages added more than \$30 billion to the estimated disposal cost, just for the procurement, loading, and sealing of disposal overpacks. Thus, when disposal costs are taken into account, the repackaging of SNF in DPCs into smaller containers could add on the order of \$10 billion (and possibly several times that) to the total disposal cost for commercial SNF in the United States if the option to use smaller waste packages were selected for disposal.

### ENGINEERING FEASIBILITY

The handling and packaging of large DPCs in surface facilities at the repository or at upstream installations are well within the state of current practice. The operations needed to transfer each DPC to a suitable disposal overpack are essentially the same as those used for initial DPC

loading, storage, and transportation. Handling and packaging would be very similar for any DPC direct disposal concept, no matter where the repository is located or in what geologic host medium. Thus, there are no significant feasibility questions associated with repository operations until the waste is transported underground.

Options for surface-to-underground transport of the heavy loads associated with DPC-based waste include vertical shafts, shallow ramps with tire-mounted vehicles, and steep ramps with rail-mounted conveyance (Fairhurst 2012). Note that a complete transporter that includes the waste package, additional shielding, wheel mechanisms, and motive power could weigh 250 t or more, but a minimum configuration of waste package, shielding, and transport cart could weigh 175 t or less.

A shaft friction hoist with 175-t capacity could be built following principles tested at the Gorleben repository facility, in Germany, for 85-t capacity (Englemann et al. 1993). Alternatively, such loads could be transported in ramps at up to 10 percent grade with a rubber-tire, self-powered transporter such as the Cometto system tested by the Swedish repository program (90-t capacity). Transport in steeper ramps (up to 45 degrees) could be engineered using a funicular system with a counter-balanced friction hoist and conveyance riding on a steel track, as is being considered for France's repository (Fairhurst 2012). Shallow ramps (with a grade of approximately 2 percent or less) can be served using more conventional rail equipment (e.g., DOE 2008). Each of these options has redundant safety features, and different considerations for safety analysis. The choice of which option to use for waste transport may be influenced by site-specific geology and local experience. All are technically feasible, although the shaft hoist or funicular could be the largest of its kind. Any underground repository would be accessed by shafts for construction, men and materials, utilities, ventilation, and other functions except possibly for waste transport.

Handling underground presents a different set of engineering challenges. The disposal concepts described here use in-drift emplacement, whereby waste packages would be placed on the floor in open drifts (or onto low pedestals). Rubber-tire transporters could deliver waste packages from the surface all the way to emplacement drifts, providing shielding for all operations except final emplacement, which could be done by remote control. These transporters are hydraulically driven and can kneel, thereby accommodating travel over rough surfaces, and simple loading/unloading.

Other transport options might require an underground transfer station, and specialized equipment for underground transport and emplacement. One such rail-mounted machine for vertical borehole emplacement (including package up-ending) was demonstrated at full scale in Sweden (Mützel et al. 2001). The machine developed for this test included many components that were standard in other applications, but improvements in the areas of measurement and control were identified as being needed. Machines for in-drift emplacement could be simpler with potentially less demanding tolerances. Engineering development and testing for underground handling and emplacement, as well as licensing to verify safety, would be needed, but technical feasibility is a relatively minor issue.

## Preliminary Results

Preliminary results indicate that DPC direct disposal could be technically feasible, at least for certain disposal concepts. Preliminary analysis also suggests that cost savings might be realized compared to repackaging DPCs, although further analysis is needed. The results can be summarized as follows:

- **Disposal Concepts**—DPC direct disposal could be implemented in a range of geologic settings, while meeting thermal limits and with a reasonable expectation of needed stability of mined openings. Disposal options range from the salt concept, to disposal in argillaceous or crystalline rock. All options could use in-drift emplacement to simplify the handling of large, heavy packages. Low-permeability backfill could be used for all concepts, although unbackfilled variants could be viable depending on site-specific characteristics of the host medium and the geologic setting. The need to backfill at closure could be accommodated in the repository design.

- **Thermal Management**—The salt concept and hard rock (crystalline) unsaturated, unbackfilled concept described here could readily meet peak temperature targets because both types of media can tolerate temperatures of 200 °C (or higher), and have relatively high thermal conductivity. The salt concept could be backfilled immediately after emplacement, while openings in hard rock could be backfilled at closure after a few decades of repository ventilation. Hard rock (i.e., crystalline) formations exist that could have excellent long-term stability.

Argillaceous (containing clay) media could have lower temperature limits in order to limit alteration of the clay, and such media have relatively low thermal conductivity. Accordingly, longer duration of surface decay storage and repository ventilation, or larger repository layouts, could be needed. Argillaceous media typically exhibit less long-term stability than hard rock, and this could be important for a repository with more than 100 km of drifts.

- **Safety**—Important factors that could help to ensure post-closure disposal safety include 1) diffusion-controlled transport in the engineered barrier system and/or the natural barrier system, 2) near-field transport properties that are relatively insensitive to temperature, 3) limited radionuclide transport in backfill and the host rock (particularly in the far field), and 4) attributes that limit potential post-closure criticality. These general factors would benefit any geologic repository. When prospective repository sites are identified, site-specific data will support more resolution of differences in post-closure safety associated with DPC direct disposal.

- **Engineering Feasibility**—Waste handling and transportation for DPC direct disposal would be essentially the same as current practice, with no associated engineering feasibility questions until the DPC-based waste packages are to be transported underground. Several options exist for surface-to-underground waste package transport in shafts or ramps, including shaft hoists, funiculars, and tire-mounted or rail-mounted ramp transporters. These transport options are technically feasible, although some systems would be the largest of their kind. The choice would likely depend on site-specific geology and local experience. Additional engineering would be needed to develop systems for underground transport and emplacement, but such systems have been demonstrated for the Swedish repository concept using existing technology.

- **Criticality**—Control of criticality for at least 10,000 years after disposal is an important factor in the case for DPC direct disposal. Preliminary analysis indicates that many, although not all, existing DPCs would be subcritical even if chemically and mechanically degraded in the disposal environment. An additional reactivity margin is available for many existing DPCs by using as-loaded assembly information and updated burnup credit. With further analysis, existing DPCs could be categorized according to the potential for criticality in different disposal environments (i.e., with different groundwater availability and composition).

- **Acceptance**—Once technical feasibility, safety, and cost have been evaluated, it is important to communicate analysis findings, collaborate with industry, discuss safety with regulatory bodies, and promote reviews by external stakeholders. The ongoing study—for which preliminary results are described here—represents the beginning of that process. ■

## REFERENCES

- Andra 2005. *Dossier 2005 argile—architecture and management of a geological disposal system*. December 2005. <http://www.Andra.fr/international/download/Andra-international-en/document/editions/268va.pdf>.
- BSC (Bechtel-SAIC Co.) 2003. *The Potential of Using Commercial Dual-Purpose Canisters for Direct Disposal*. TDR-CRW-SE-000030 Rev. 00. Office of Civilian Radioactive Waste Management. Las Vegas, Nev.
- BSC (Bechtel-SAIC Co.) 2008. *Postclosure Analysis of the Range of Design Thermal Loadings*. U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ANL-NBS-HS-000057 Rev. 00. Jan. 2008.
- Clarity, J. B. and J. M. Scaglione 2013. *Feasibility of Direct Disposal of Dual-Purpose Canisters—Criticality Evaluations*. ORNL/LTR-2013/213. Oak Ridge National Laboratory, Oak Ridge, Tenn. June 2013.
- Clayton, D. J., M. J. Martinez, and E. L. Hardin 2013. *Potential Vertical Movement of Large Heat-Generating Waste Packages in Salt*. SAND2013-3596. Sandia National Laboratories. Albuquerque, N.M.
- DOE (U.S. Department of Energy) 1994. *Multi-Purpose Canister System Evaluation*. DOE/RW-0445. Office of Civilian Radioactive Waste Management. Washington, D.C.
- DOE (U.S. Department of Energy) 2008. *Yucca Mountain Repository License Application for Construction Authorization*. DOE/RW-0573. Washington, D.C.: U.S. Department of Energy.
- DOE (U.S. Department of Energy) 2013. *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*. Jan. 2013.
- Engelmann, H. J., W. Filbert and C. Schrimpf 1993. “Demonstration Tests for the Simulation of Shaft Transport.” *Waste Management 1993*. American Nuclear Society. Tucson, Arizona, February 28–March 4.
- EPRI (Electric Power Research Institute) 2008a. *Feasibility of Direct Disposal of Dual-Purpose Canisters in a High-Level Waste Repository*. 1018051. Palo Alto, Calif.

- EPRI (Electric Power Research Institute) 2008b. *Feasibility of Direct Disposal of Dual-Purpose Canisters: Options for Assuring Criticality Control*. 1016629. Palo Alto, Calif.
- Fairhurst, C. 2012. *Current Approaches to Surface-Underground Transfer of High-Level Nuclear Waste*. Itasca Consulting Group Inc. Minneapolis, Minn. Oct. 2012.
- Graf, R., K.-J. Brammer, and W. Filbert 2012 (in German). "Direkte Endlagerung von Transport- und Lagerbehältern—ein umsetzbares technisches Konzept." *Jahrestagung Kerntechnik 2012*. Stuttgart. May 2012.
- Hansen, F. D., E. L. Hardin, R. P. Rechar, G. A. Freeze, D. C. Sassani, P. V. Brady, C. M. Stone, M. J. Martinez, J. F. Holland, T. Dewers, K. N. Gaither, S. R. Sobolik, and R. T. Cygan 2010. *Shale disposal of U.S. high-level radioactive waste*. SAND2010-2843. Sandia National Laboratories. Albuquerque, N.M. May 2010.
- Hansen, F. D. and C. D. Leigh 2011. *Salt Disposal of Heat-Generating Nuclear Waste*. SAND2011-0161. Sandia National Laboratories. Albuquerque, N.M.
- Hardin, E. 2013. *Temperature-Package Power Correlations for Open-Mode Geologic Disposal Concepts*. SAND2013-1425. Sandia National Laboratories. Albuquerque, N.M. Feb. 2013.
- Hardin, E., C. Stockman, E. Kalinina and E. J. Bonano 2013a. "Integrating Long-Term Storage with Disposal." *OECD/NEA International Workshop on Safety of Long Term Interim Storage Facilities*. Munich, Germany. May 21–23, 2013.
- Hardin, E., D. Clayton, J. Scaglione, R. Howard, J. Carter, and J. Blink 2013b. "DPC Direct Disposal Feasibility Evaluation: Concept Development and Analysis." *Nuclear Energy Institute Used Fuel Management Conference*. St. Petersburg, Fla. May 7–9, 2013.
- Hardin, E., T. Hadgu, D. Clayton, R. Howard, H. Greenberg, J. Blink, M. Sharma, M. Sutton, J. Carter, M. Dupont, and P. Rodwell 2013c. "SNF Disposal Concepts for Small and Large Waste Packages." *Proc. 14<sup>th</sup> Intl. High-Level Rad. Waste Mgmt. Conf.* Albuquerque, N.M. April 28–May 2, 2013. American Nuclear Society.
- Hardin, E. L., D. J. Clayton, R. L. Howard, J. M. Scaglione, E. Pierce, K. Banerjee, M. D. Voegele, H. R. Greenberg, J. Wen, T. A. Buscheck, J. T. Carter, T. Severynse, and W. M. Nutt 2013d. *Preliminary Report on Dual-Purpose Canister Disposal Alternatives (FY13)*. Aug. 2013. U.S. Department of Energy, Used Fuel Disposition R&D Campaign.
- Hardin, E., T. Hadgu, D. Clayton, R. Howard, H. Greenberg, J. Blink, M. Sharma, M. Sutton, J. Carter, M. Dupont, and P. Rodwell 2012. *Repository Reference Disposal Concepts and Thermal Management Analysis*. FCRD-USED-2012-000219 Rev. 2. Nov. 2012. U.S. Department of Energy, Used Fuel Disposition R&D Campaign.
- Hardin, E. L., D. A. Chesnut, T. J. Kneafsey, K. Pruess, J. J. Roberts, and W. Lin 1997. *Synthesis report on thermally driven coupled processes*. UCRL-ID-128495. Livermore, Calif.: Lawrence Livermore National Laboratory. Oct. 15, 1997. OSTI ID: 16624.
- Kalinina E. A. and E. Hardin 2012. *Logistical Simulation of Spent Nuclear Fuel Disposal in a Salt Repository with Low Temperature Limits*. SAND2012-8109. Sandia National Laboratories. Albuquerque, N.M. Sept. 2012.
- Mützel, W., E. Huth, R. Brausam, J. Keller, S. Pettersson, R. Bäck, and H. Jendenius 2001. *Demonstration deposition machine for canisters: Description and experience from design and test operation*. SKB-IPR-01-038. Swedish Nuclear Fuel and Waste Management Co. July 2001.
- Nutt, W. M., E. Morris, F. Puig, E. Kalinina, and S. Gillespie 2012. *Transportation Storage Logistics Model—CALVIN (TSL-CALVIN) Manual*. FCRD-NFST-2012-000424. Oct. 2012. U.S. Department of Energy, Nuclear Fuel Storage and Transportation Planning Project.
- Nutt, W. M. 2013. *Preliminary System Analysis of Direct Dual Purpose Canister Disposal*. FCRD-UFD-2013-000184 Rev. 0. July 2013. U.S. Department of Energy, Used Fuel Disposition R&D Campaign.
- ORNL (Oak Ridge National Laboratory) 2011. *SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design*. ORNL/TM-2005/39, Version 6.1. June 2011. Available from Radiation Safety Information Computational Center at Oak Ridge National Laboratory as CCC-785.
- Sevougian, S. D., G. A. Freeze, M. B. Gross, J. Lee, C. D. Leigh, P. Mariner, R. J. MacKinnon, and P. Vaughn 2012. *GTSPA Model Development and Sensitivity Analysis of Processes Affecting Performance of a Salt Repository for Disposal of Heat-Generating Nuclear Waste*. FCRD-USED-2012-000320, Rev. 0. U.S. Department of Energy, Office of Used Fuel Disposition.
- SKB (Swedish Nuclear Fuel and Waste Management Co.) 2011. *Long-term safety for the final repository for spent nuclear fuel at Forsmark: Main report of the SR-Site project, Volume I*. Technical Report TR-11-01.
- Vaughn, P., M. D. Voegele, W. M. Nutt, G. A. Freeze, J. L. Prouty, E. L. Hardin, S. D. Sevougian, and R.F. Weiner 2012. *Draft Generic Deep Geologic Disposal Safety Case*. FCRD-UFD-2012-000146 Rev. 0. June 2012. U.S. Department of Energy, Used Fuel Disposition R&D Campaign.
- Wagner, J. C., J. L. Peterson, D. E. Mueller, J. C. Gehin, A. Worrall, T. Taiwo, W. M. Nutt, M. A. Williamson, M. Todosow, R. Wigeland, W. G. Halsey, R. P. Omberg, P. N. Swift, and J. T. Carter 2013. "Assessment of Used Nuclear Fuel Inventory Relative to Disposition Options." *Proc. 14<sup>th</sup> Intl. High-Level Rad. Waste Mgmt. Conf.* Albuquerque, N.M. April 28–May 2, 2013. American Nuclear Society. ■
- E. L. Hardin works in Applied Systems Analysis and Research and D. J. Clayton works in Advanced Nuclear Fuel Cycle Technologies, both in Advanced Nuclear Energy Programs at Sandia National Laboratories; R. L. Howard and J. M. Scaglione are in the Used Fuel Systems Group, and J. B. Clarity is in the Nuclear Data and Criticality Safety Group, all in the Reactor and Nuclear Systems Division at Oak Ridge National Laboratory; J. T. Carter is in the Clean Energy Directorate at Savannah River National Laboratory; W. M. Nutt is in the Nuclear Engineering Division at Argonne National Laboratory; and R. W. Clark is in the Office of Used Nuclear Fuel Disposition at the Department of Energy. For addition-*



al information, contact Hardin at ehardin@sandia.gov.

### Acknowledgments

The authors wish to thank the additional contributors, reviewers, and administrative staff who assisted with the study reported here, including Tom Cotton, Bob Jubin, Michael Voegele, Tom Severynse, Jim Blink, Harris Greenberg, and Laura Connolly. This paper is approved for unclassified, unlimited release (SAND2013-6854J). Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

### Disclaimer

This information was prepared as an account of work sponsored by an agency of the U.S. government. Neither the U.S. government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness, of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. government or any agency thereof.

This is a technical paper that does not take into account the contractual limitations under the Standard Contract. Under the provisions of the Standard Contract, DOE does not consider spent fuel in canisters to be an acceptable waste form, absent a mutually agreed to contract modification. To ensure the ability to transfer the spent fuel to the government under the Standard Contract, the individual spent fuel assemblies must be retrievable for packaging into a DOE-supplied transportation cask.

# PACTEC

We manufacture packaging. We engineer solutions.

### PROVEN

Over 25,000 IP-1 and IP-2 LiftPacs used for VLLW and LLW transport, storage, and disposal in the USA, UK, and Japan

### TESTED

Unsurpassed product testing both in the lab and on-site

### QUALITY

ISO 9001:2008 certified manufacturing facilities throughout the world

### RAILCAR LINERS



### LSA/SCO OVERPACKS



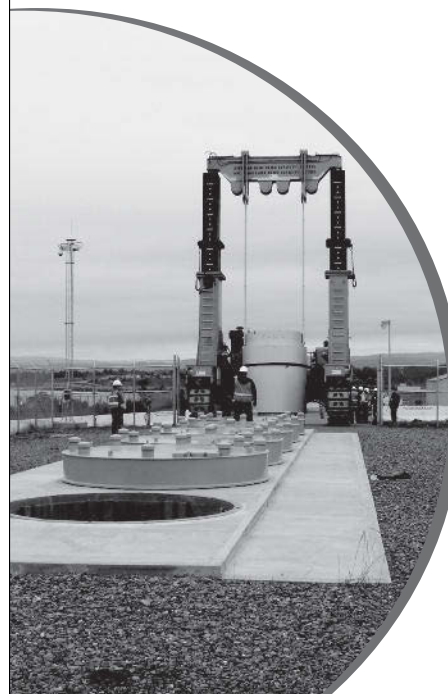
Connect with Us!  
(877) 554-2541 | [pactecinc.com](http://pactecinc.com)

**NDA**  
2013 SUPPLY CHAIN  
AWARD WINNER

Over 630 Holtec dry storage and transport systems are in use by nuclear power plants worldwide.

CALL US  
**1.856.797.0900**

## Nuclear Fuel and Waste Management



- ✓ **Dry Spent Fuel Storage and Transport Systems**
- ✓ **Dry Storage Services** including civil/architectural design, site construction, supply of systems, and fuel loading
- ✓ **Non-Fuel Waste Storage Systems**
- ✓ **Wet Fuel Storage Systems**
- ✓ **Wet Storage Services** including rack installation

**HOLTEC**  
INTERNATIONAL

[www.holtec.com](http://www.holtec.com)

# Predicting Stress Corrosion Cracking in the Canisters of Used Nuclear Fuel Dry Cask Storage Systems

*A research initiative at the Massachusetts Institute of Technology's H. H. Uhlig Corrosion Laboratory aims to determine the role of stress corrosion cracking in predicting the life span of dry cask storage canisters.*

By Sara Ferry, Ronald Ballinger, Isabel Crystal, Dominic Solis, and Bradley Black

**A**s 2014 begins, the ultimate fate of used nuclear fuel in the United States remains uncertain. For the foreseeable future, used nuclear fuel will remain in spent fuel pools and in dry cask storage. The number of loaded dry storage casks in the United States is increasing each year. According to *StoreFUEL*, a total of 1130 loaded casks as of 2009 grew to a total of 1570 casks in 2012 across 45 independent spent fuel storage installation (ISFSI) sites [1-2].

It is difficult to predict the total length of time these dry cask storage systems will remain at the ISFSI sites, where they are exposed to variable weather and local, in-canister environments. It is even more difficult to predict when a decision on the final destination of used nuclear fuel will be made and implemented. The possibility that used fuel may remain in aboveground storage for decades, or even up to a century, is increasingly likely.

The general design of a dry cask storage system consists of a stainless steel canister that contains spent fuel assemblies that have been removed from wet storage and dried. This canister is then bolted or welded shut before being enclosed in a thick concrete overpack. These sturdy canister-and-overpack systems were designed to withstand all manner of natural and man-made disasters, but they were also intended only as interim storage for a period of approximately 20 years. It was not anticipated that the used fuel might remain at ISFSI sites for periods that may now approach 100 years.

It is known that the dry cask storage systems can withstand earthquakes, aircraft impacts, and flooding. The dry storage facility at the Fukushima Daiichi site withstood not only the earthquake but also the subsequent tsunami with no damage. But how well can the dry storage canisters weather the slower, less dramatic processes of environmental degradation? This article will detail a description of the MIT H. H. Uhlig Corrosion Laboratory's research initiative, funded by the Department of Energy's Nuclear Engineering University Program to understand the likelihood of one of the key degradation processes in particular: stress corrosion cracking (SCC) in the stainless

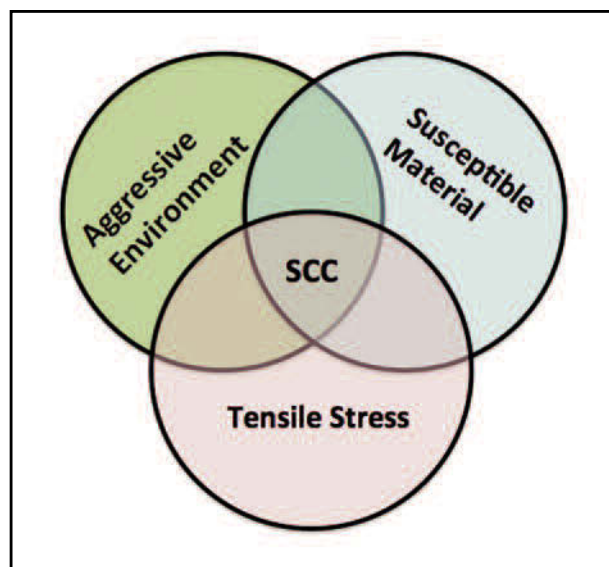


Fig. 1. Diagram showing the three criteria that must exist for stress corrosion cracking (SCC) to occur.

steel canisters that contain the used nuclear fuel assemblies [3].

Anyone who has read about SCC in the past is likely to be familiar with the diagram in Fig. 1. For SCC to occur, three criteria must be met: An aggressive (usually aqueous) environment must exist, the material in question must be susceptible to SCC in that specific environment, and tensile stress (either residual in the material or applied) must be present at a sufficient “threshold” level [4]. This complicated phenomenon is difficult to predict because of the complex, nonlinear interplay among these three factors. Change the material composition slightly, and the same environment that once caused SCC no longer poses a threat. Vary the chemistry of the environment, and suddenly, a material that was performing admirably begins to suffer pitting and cracking that leads to failure. Insofar as used nuclear fuel storage at ISFSI sites is concerned, the question then becomes: Given the canister material, the stresses therein, and the environment without, what is the possibility—or, more appropriately, the probability—that SCC could damage the stainless steel

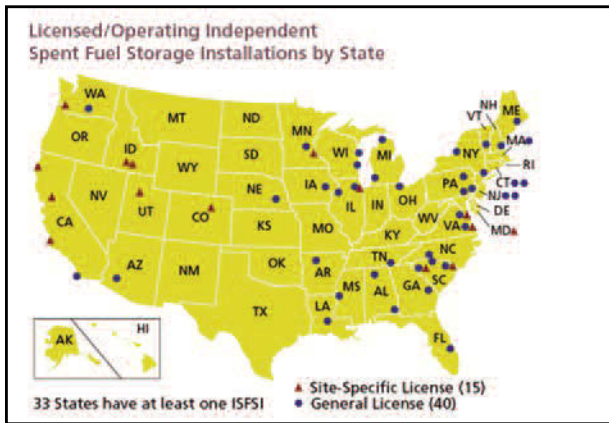


Fig. 2. U.S. Nuclear Regulatory Commission map of ISFSI sites in the United States [5].

canisters in a dry cask storage system?

The canisters used in U.S. dry cask storage systems are fabricated of welded austenitic stainless steels, namely, the Type 304/304L and Type 316/316L grades. These grades of stainless steel—in particular, Type 304/304L—are known to be susceptible to pitting and transgranular SCC if they are exposed to a chloride-containing aqueous environment [4]. Therefore, a susceptible material is present, and the first criterion for SCC is met.

What of the aggressive environment, however? The term “dry cask storage” seems to eliminate entirely the possibility of an aqueous environment. But consider a typical dry cask storage system design: The stainless steel canister is inside a vented concrete overpack. The vent openings are a conduit between the canister and the outside environment, allowing for convective cooling of the canister surface. Therefore, given the right combination of canister surface temperature, humidity, and air temperature at the ISFSI site, the development of aqueous films on the outer canister wall is not an impossibility.

Of course, pure water is not expected to be problematic with regard to SCC in these steel grades, and the canister surface temperature is expected to remain quite high during storage, making condensation unlikely in the first place. But the presence of chlorides in an aqueous film on the canister surface, which would satisfy the second criterion for SCC, cannot be discounted. Maps of ISFSI sites in the United States (Fig. 2) reveal that most dry cask storage is located in lakeside or in coastal regions, where a high salt content in the air is expected. Salt can be carried through the vents in the concrete overpacks, where it can settle on the canister surface. Sodium, calcium, and magnesium salts are likely to be present.

Given the right temperature and humidity conditions in the gap between the canister and concrete overpack, these salts can deliquesce following deposition on the canister surface. During the deliquescence process, the deposited salts absorb moisture from the air until a highly saturated chloride-containing solution is formed on that surface [6]. These highly saturated salt solutions can be sustained at temperatures above 100 °C. As time progresses, two things happen: The canister surface temperature drops due to a decrease in the level of decay heat from the fuel, and the buildup of salts and other airborne particulates on the canister surface is expected to increase. The possibility that a highly concentrated film of chloride

solution will develop on the canister surface increases as the dry cask storage system ages.

Criterion three, the presence of a tensile stress at sufficient levels, is the last requirement for SCC to be possible. Consider the welds used to construct the steel canister. A common configuration involves a circumferential weld at the center of the canister, and two axial welds opposite each other in each half of the canister. In Fig. 3, a modified image of a Holtec HI-STORM canister, the canister welds are highlighted in red [7,8].

The welding process results in high thermal gradients as melting and solidification occur, causing thermal expansion and contraction of the steel. Residual stresses are consequently left behind in the canister welds and in the heat-affected zone adjacent to the welds (where local material chemistry and structure may also be altered significantly). In other applications, these residual stresses are relieved by subjecting the weld material to a postweld heat treatment (PWHT), but such a treatment can result in the sensitization of austenitic stainless steel grades such as Type 304/304L and Type 316/316L. Sensitization occurs when the steel is held for long periods at the temperatures required for successful stress relief, and precipitation of chromium carbides at the grain boundaries occurs. This precipitation causes a depletion of chromium in the region adjacent to the grain boundaries, potentially leaving the steel susceptible to intergranular corrosion attack. For this reason, PWHTs are typically avoided during canister fabrication when using stainless steels in order to circumvent intergranular corrosion degradation processes. The trade-off of this design decision is that high residual stresses remain in the canister welds and in the adjacent heat-affected zones, and increase the likelihood of transgranular SCC. The welds and heat-affected zones are expected to be

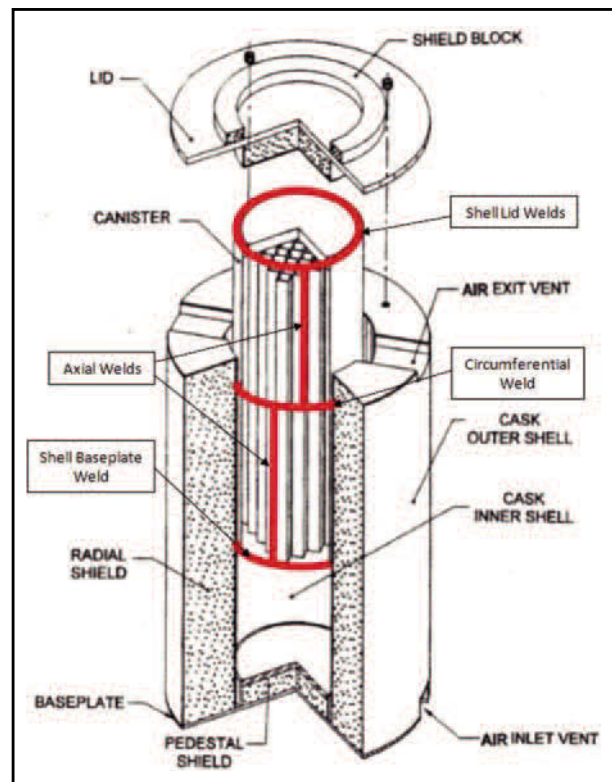


Fig. 3. A Holtec HI-STORM canister system, with the canister welds highlighted in red. [7,8]

the part of the canister most likely to experience SCC damage, since local tensile stresses are highest in those regions.

Therefore, none of the three criteria for SCC in the canisters—susceptible material, aggressive environment, and tensile stress—can be ruled out, which means that SCC cannot be ruled out either. Previous experimental research

on canister materials has also indicated that the possibility of SCC should be investigated further. For example, Mayuzumi, Tani, and Arai studied dry storage canister materials and concluded that they were unlikely to survive beyond 30 years [9]. Kosaki studied Type 304 steel in accelerated laboratory and environmental conditions and concluded that SCC penetration of an 11-mm-thick can-



Fig. 4. The as-received flat-plate welds, November 2013. A section of the flat-plate weld (inset) was cut for microstructural analysis from the end of each weld.

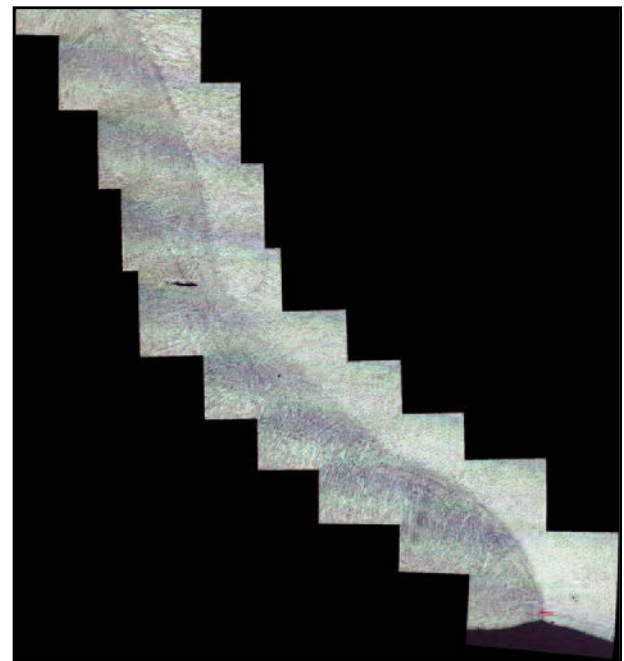
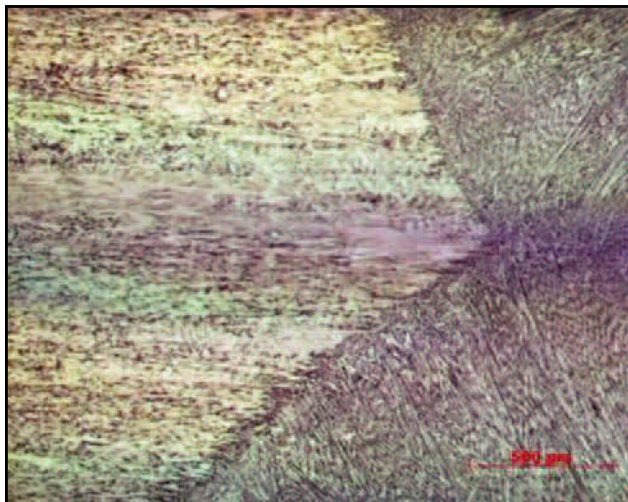


Fig. 5. Results of photographing the weld microstructure. Clockwise from top left: the full weld, as visible to the unaided eye following polishing and etching; a composite of half the fusion line between the weld and bulk material; the juncture between the two “vees” of the weld.

ister wall, which is close to the thickness typical of the canisters used in the United States, would occur in as little as 25 years when subjected to stress and a salt-containing environment [10].

The crux of this research initiative is this. Can a probabilistic mathematical model be developed that describes the likelihood of SCC in a canister, when it will initiate, and how it will propagate? Furthermore, can the uncertainty in this model be quantified to make it truly useful for canister life prediction?

## OBTAINING THE WELD MATERIAL

One of the key variables in the degradation process is the level of tensile stress present. In fact, if the stress can be reduced sufficiently, SCC can be effectively eliminated as an issue. And so, quantifying the residual stress distribution in the welds is of key importance. As a result, a main focus of the project is the quantification of these stresses.

The project team first explored the feasibility of having representative canister shells made by the three major canister vendors in the United States: Holtec International, NAC International, and Ranor Inc. (which fabricated canisters for Transnuclear).

A consideration of the cost of these shells, combined with the time and money that would be needed to experiment on each canister mock-up, quickly resulted in the realization that we would have to narrow our scope. The decision was made to focus the experiments on just one type of weld: flat-plate welds, ordered from a single vendor, that would be fabricated using the same material and welding procedures used by the chosen vendor in the fabrication of actual canisters. These welds were received in November 2013. The project's goal became the development of a predictive model for SCC that used these welds as a reference. Ideally, this model would be adaptable to canisters that utilized different weld geometries. If the residual stress distribution is critical to life prediction in this weld, it is likely important for all types of canisters.

The as-received welds are shown in Fig. 4. The bulk material is Type 304 stainless steel, and the weld is Type 308. The 6 × 4-ft (1.83 × 1.22-m) plate is 5/8-in. (1.59-cm) thick and contains two welds that run its length in order to maximize the amount of experimental material available for use. They are far enough apart that neither weld influenced the other during the fabrication of the plate.

To begin, a section of the weld was cut from the plate for microstructural analysis. Weld samples were mechanically polished and etched to reveal the microstructure (Fig. 5).

## UNDERSTANDING RESIDUAL STRESSES IN THE CANISTER WELDS

Understanding the residual stress profile in and around canister welds is a key step toward predicting SCC behavior. First, as discussed earlier, the presence of a certain threshold level of tensile stress is required for SCC to occur. There is some controversy in the materials community as to the existence of an actual threshold, but there is general agreement that at some point, SCC ceases to be an is-

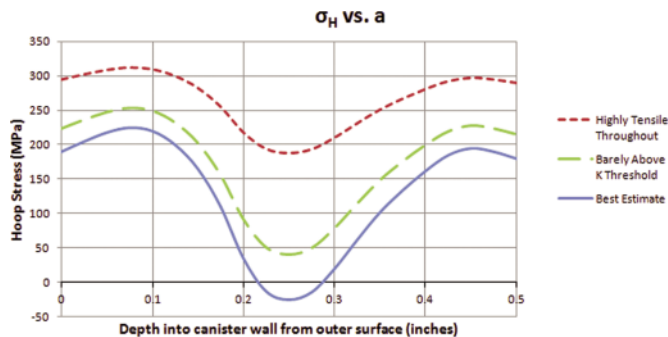


Fig. 6. Prediction of hoop stress in a typical canister wall [6].

sue as a practical matter. Knowing whether, and where, this threshold stress level is reached is a necessary initial step toward predicting the likelihood of SCC. Second, the three-dimensional residual stress profile will affect the way that SCC, once initiated, will proceed. An increase in tensile stress speeds up crack initiation time, and it will also increase crack propagation rate. Of course, even welds that are nominally “identical” are never truly exact copies of each other. Thus, residual stresses—and the likelihood and behavior of SCC—will vary throughout the welds of an individual canister, and across different canisters. Understanding the extent of this variation, therefore, is also an important aspect of predicting SCC in different canisters.

The next phase of experimentation with the flat-plate welds shown in Fig. 4 will involve measuring their residual stress profiles. While there are some finite element analysis studies that predict residual stresses in the canisters as a result of welding, there is very little information available that involves direct measurement of the residual stresses in canister welds.

In the beginning of this project, before any weld material had been obtained, an attempt was made to begin predicting the stresses that might be observed in a “prototypical” canister weld. Data were collected from published measurements of residual stresses in stainless steel welded pipes. The project then extrapolated these residual stress profiles from the literature to the residual stress profile that might be observed in a geometry selected to represent an average used nuclear fuel canister. These predictions are shown in Fig. 6 and represent three predictions: the best estimate, and then two modifications to the best estimate—one assuming that stresses were more tensile than predicted, and one assuming that the stresses always remained just above the cracking threshold, which was estimated as 4 MPa√m [6]. The best estimate predicted compressive hoop stress at the canister wall's midpoint.

It should be stressed that this technique was far from exact, but it raised a possibility that had not been previously considered: that it might be found that there was always a point at which the stresses became compressive. Would this mean that even if a crack initiated, it would always be stopped before it could propagate all the way through the wall? The need for a definitive residual stress measurement became more pressing. In addition, since the stress state is three-dimensional, it is important to consider the complete residual stress distribution and its uncertainty.

There are multiple methods for measuring residual stresses in a metal. The more common ones, however, were ruled out for use in this project. X-ray diffraction was eliminated because of the need to understand residual

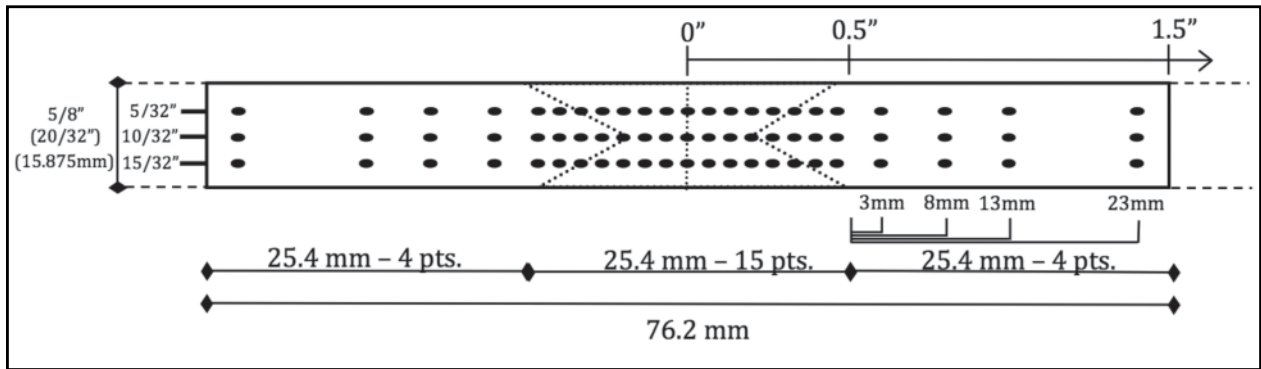


Fig. 7. This schematic shows where neutron diffraction measurements might be taken in a weld sample. The dashed diagonal lines in the center approximate the location of the “double-vee” weld. The black ellipses show proposed measurement locations. The highest resolutions are required in and near the weld, so measurement points are concentrated there.

stresses all the way through the weld sample, and X-ray diffraction measures only surface residual stress. Deep-hole drilling was eliminated as an option because the resolution of the results it provides was too coarse for the purposes of the project due to the thin plate thickness. The two other methods that were settled on were neutron diffraction and the contour method.

Neutron diffraction operates on the same basic principle as X-ray diffraction. The processes that cause residual stress—here, constrained thermal expansion and contraction during welding—distort the regularly spaced, stress-free lattice of the original material. By observing the diffraction behavior of particles or radiation that are scattered from the stressed material, the location-specific distortions in the lattice spacing of this material can be measured. From these measurements, the corresponding stress profile can be determined. An advantage of neutron diffraction is that it can measure residual stress in three dimensions up to depths of several centimeters, making it ideal for measuring residual stresses in the 5/8-in.-thick flat-plate welds.

Currently, the project team is in the process of planning neutron diffraction measurements of the weld at a neutron beam user facility. The plan is to work with researchers who have years of expertise in measuring stresses in stainless steel welds and to carry out two tests with their assistance. In the first, residual stresses will be determined in detail in a weld sample. Measurements will be taken at three depths in a weld sample and will be concentrated in the weld and material immediately adjacent to the weld, where a highly resolved stress distribution is of the most interest. Figure 7 shows one possible scheme for measurement locations in a weld sample.

In the second test, “spot” measurements will be performed at regular intervals along approximately 1.2 m of weld material. In an ideal weld, the residual stress profile through the wall would be absolutely identical at every point along the weld’s length. The goal of these spot measurements will be to quantify the extent of stress variation in an individual weld, as this will be an important source of uncertainty in the predictive model for SCC.

Using the contour method, a sample is sectioned in half, allowing the residual stresses to relax and resulting in deformation at the cut surface [9]. The extent of the deformation at each location on the surface can be mapped back to the residual stress that must have existed at that location prior to cutting. The contour method yields a two-dimensional map of residual stresses normal to the cut-

ting plane and provides higher-resolution results than neutron diffraction [10]. Ideally, at least one of the samples used in the contour method measurements will have been used previously for neutron diffraction-based measurements. This will provide a direct comparison of the results achieved by both methods.

## OBTAINING STRESS CORROSION CRACKING DATA

Currently, exposure tests utilizing the prototypic weld material are being planned. Environmental chambers will be used to expose samples to humidity and a salt-air environment. Exposure tests that mimic real-world conditions, however, pose a particular challenge. Corrosion under these conditions occurs very slowly, and the data to be collected—on pit initiation time, pit growth rates, crack initiation time, and crack growth rates—would not be available within the timescale of this project. Therefore, it is likely that these tests will be artificially accelerated, either by increasing the aggressiveness of the environment or by applying an external stress load to the weld samples, or both. Corrosion data can then be used to refine a model.

Data already available in the literature for SCC experiments in stainless steels are being collected and organized in a large data library. These data compare the parameters that can affect SCC in canister material to indicators of SCC damage. For example, the accompanying table illustrates a few of the categories of interest to the project. The collected data show how the SCC damage indicators listed in the right column are changed when an experimental input (examples are given in the three leftmost columns) is varied.

Among the objectives of the data collection effort are the following:

- *Basic validation of the predictive model.* When a parameter—such as chemistry, temperature, or stress—is varied, the model should predict a change in SCC behavior that is generally consistent with the experimental results found in the literature.
- *Use in the planning of in-lab corrosion experiments.* The plan is to identify experimental gaps in the literature for understanding SCC in steels, particularly as they relate to the conditions of interest to potential canister degradation. This will help narrow down the experiments that must be conducted as part of this project in order to sufficiently develop the predictive model without “reinventing the wheel.”

Changes in SCC Damage Indicators with Variations in Experimental Input			
Residual Stress + Strain	Chemistry + Environment	Crack Tip Effects	SCC Damage Indicators
Strain rate	Potential	Crack tip chemistry	Crack density
Applied stress	pH	Bulk chemistry	Crack growth rate
Cold work	Chloride concentration	Film composition and film mechanical properties	Area covered by SCC or corrosion damage
Weld type	Temperature	Stress at crack tip	Time to pit initiation
Material	Humidity	Strain rate at crack tip	Time to crack initiation
Time of load application	Material		Time to material fracture
Residual stress profile	Concentration of other relevant species		

**DEVELOPING A PREDICTIVE MODEL**

The ultimate goal of the project is to develop a probabilistic model that can be used to predict the occurrence and behavior of SCC in canister welds. Figure 8 illustrates the three facets of model development: modeling the formation of the aggressive environment, modeling the stages

of SCC, and accounting for experimental data. It is useful to think of this project as the development of two separate models: one describing the likelihood that an environment is sufficiently aggressive to cause SCC, and one describing the probability that SCC will progress once the threshold environment exists. The most difficult, but essential, part of the effort will be the combination of these

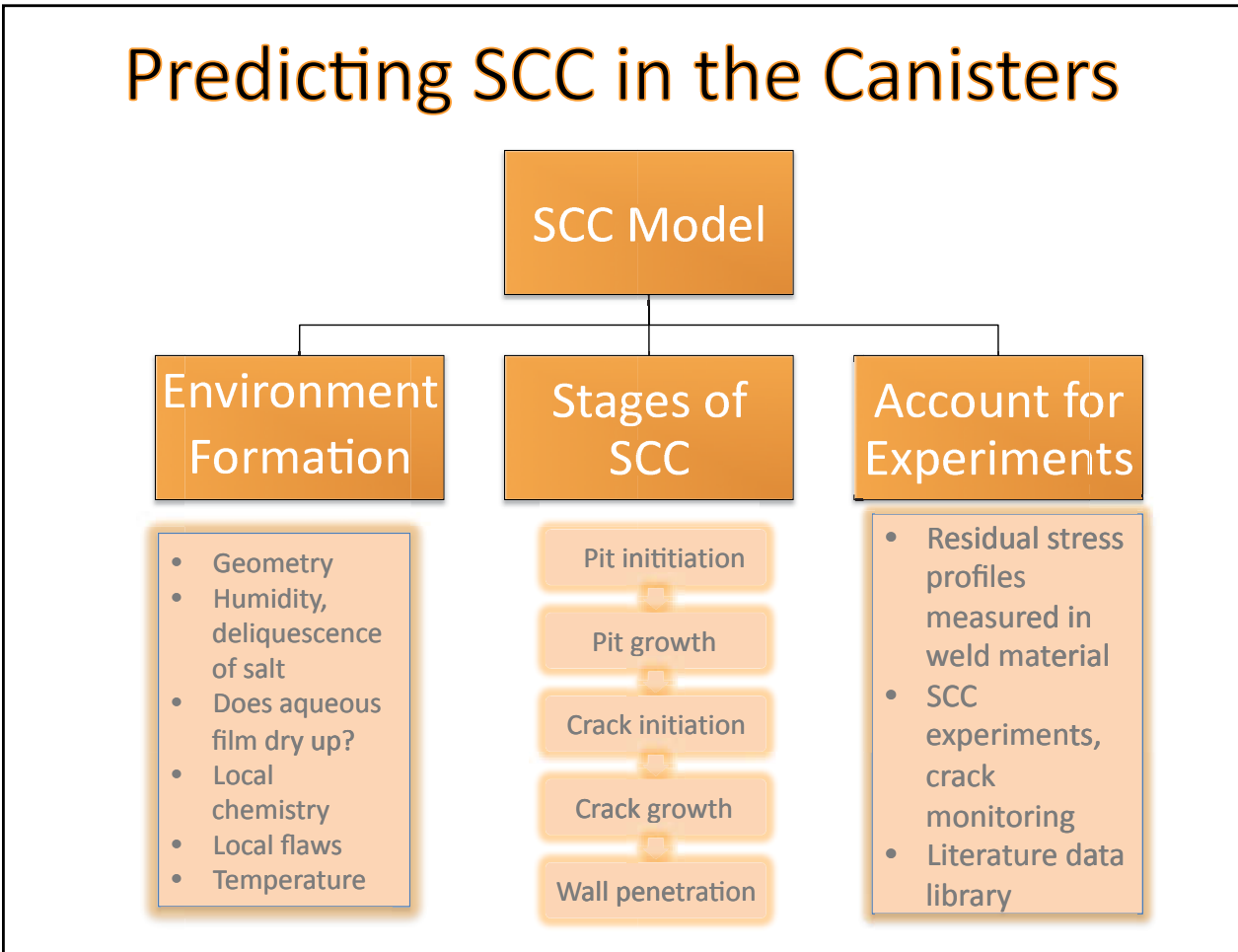


Fig. 8. This diagram illustrates the facets of the development of a probabilistic model for predicting SCC in canister welds.

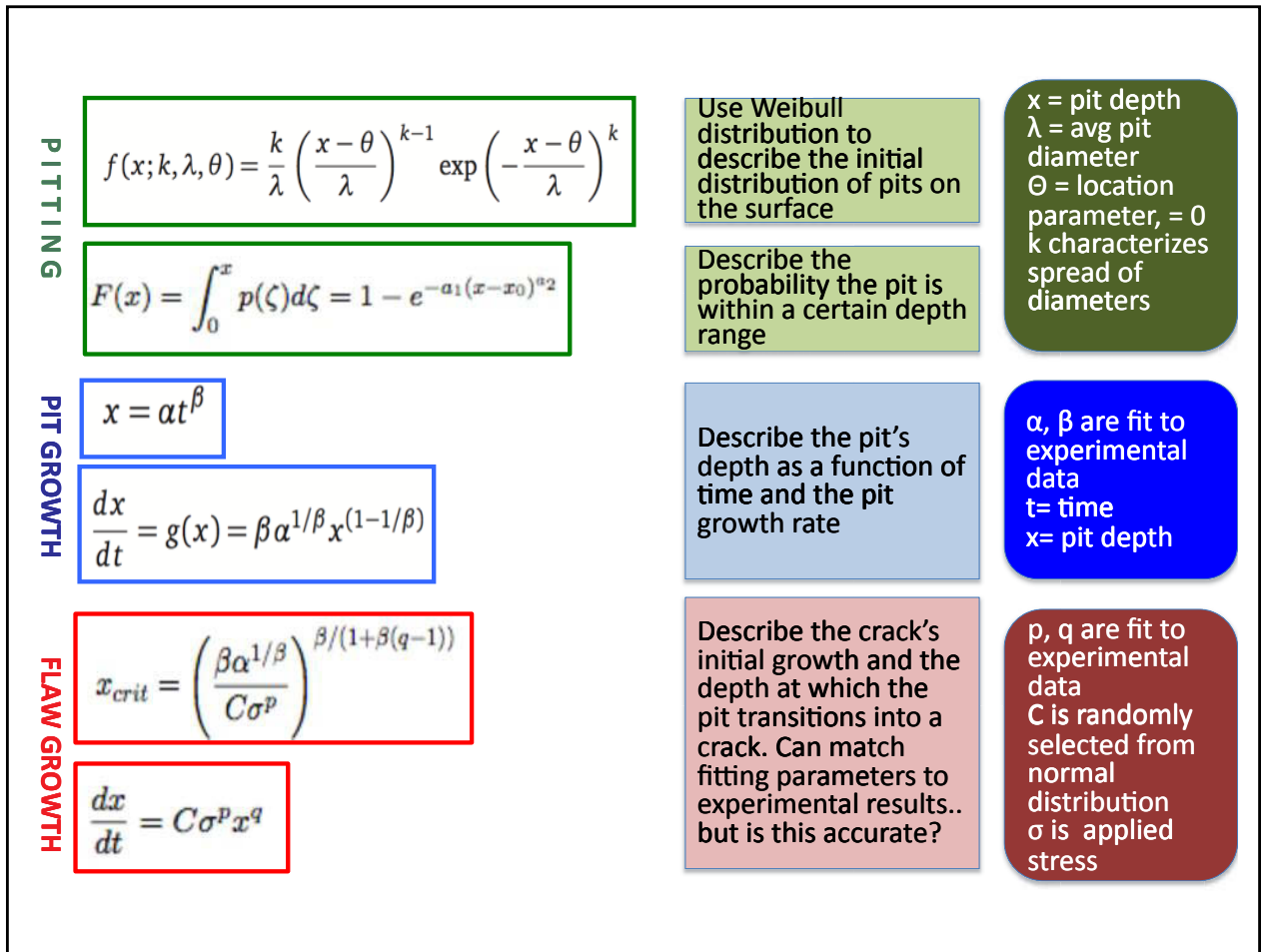


Fig. 9. Turnbull developed a probabilistic model for SCC in stainless steels that describes the distribution of pits on the surface, the growth of those pits, the initiation of cracks from the pits, and crack growth [1].

two components to account for damage accumulation and its effect on the probability of failure.

Modeling the formation of the environment will be a significant challenge, which becomes clear when one considers the sheer number of parameters that influence the outcome. Dry cask storage systems cannot be treated as identical units. Among the models available, variations exist in canister-and-overpack geometries; materials and welds; and assemblies, which have different compositions, irradiation histories, and temperature profiles. The 45 ISFSI sites at which these systems are located experience a variety of weather patterns and are subjected to different environmental chemistries. Even within the same canister, the environment considered to have “threshold aggression” will vary across the canister surface, due to variations in residual stress and temperature. The environment will change over time and salt may build up, or an aqueous film may develop due to deliquescence and then disappear as the humidity of the air adjacent to the canister changes. The task becomes one of (a) modeling the time-dependent conditions at the canister surfaces, (b) establishing whether, when, and where these conditions reach “SCC threshold” values, and (c) determining the length of time the conditions remain at or above threshold.

For the purposes and timescale of this project, the scope of environment modeling will need to be narrowed significantly. For example, we may focus on (1) identi-

fying the threshold chloride concentration in an aqueous film as a function of surface stress of Type 304 stainless steel, and (2) developing a time-dependent model for the establishment of an aqueous film and its concentration of chloride ions only as a function of relative humidity and temperature for one simplified, prototypical dry cask storage system, using weather and environment data from only a few ISFSI sites. The goal, then, would be to establish a useful framework for modeling the environment at the canister surface that can be expanded with additional research and data, rather than attempting to specifically model *all* canisters at *all* ISFSI sites.

Once the environment has been modeled, it becomes necessary to model SCC behavior itself. For this model, it will be assumed that stress corrosion cracks initiate from pits, and so, it is necessary to model pit initiation and growth first. Criteria must be established for the transition from pitting to cracking. Crack growth as a function of time must then be modeled, given the environment at the crack tip and the residual stress profile present in the weld. A crack that propagates through the canister wall constitutes a canister failure.

A comprehensive review of deterministic and probabilistic approaches to modeling SCC in stainless steels has been undertaken. This will allow for an understanding of the possible modeling approaches, the limitations and advantages of each model, and a comparison of the assumptions made in each model.



A series of decisions remains to be made: Should the model incorporate deterministic elements, or should pit initiations, pit growth rates, and crack growth rates be described purely with probabilistic distributions? Or, to rephrase the same question: Should factors such as stress and temperature be incorporated as variables in the model, or encompassed in fitting parameters? Figure 9 outlines a recent, well-known example of the later approach by Turnbull [11].

Next, what assumptions about SCC behavior in canister welds should be made? A few of the common assumptions made in the SCC modeling literature include the following:

1. Pits are perfectly hemispherical.
2. Cracks initiate at the pit base and grow normal to the surface.
3. Pit growth rates (PGR) and crack growth rates (CGR) can be expressed as functions of stress.
4. Crack initiation occurs at the point where  $PGR = CGR$  [11-12].

Experimental evidence to contradict all four assumptions exists, but making simplifying assumptions such as these will be a necessary step in model construction.

Finally, the model must account for experiments—both those conducted in-lab and those from the literature whose results were collected for the data library. The model's predictions should be consistent with the trends observed in data from SCC experiments. The data will also allow us to identify sources of uncertainty (with stress variation in a weld being one example cited here), and to quantify uncertainty in the model.

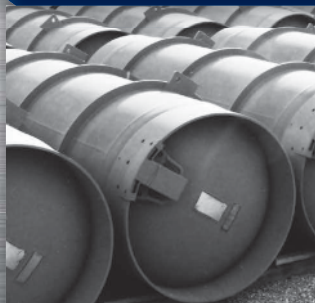
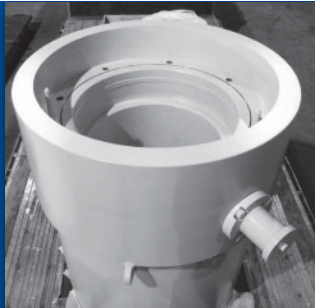
## THE IMPORTANCE OF THIS RESEARCH

Investigating the possibility of SCC in the canisters of used nuclear fuel dry storage systems is of significant current interest to the nuclear engineering community. Dry cask storage was originally intended as a temporary storage solution at sites whose wet-storage capacity had been reached while preparations for transfer of all used nuclear fuel to an ultimate storage site were under way. As it stands today, however, ISFSIs are becoming a long-term, rather than a temporary, storage solution. Until the ultimate fate of used nuclear fuel in the United States is decided, they are *the* storage solution. The expected lifetime of dry cask storage systems will exceed their original design lifetime. It was never expected that dry storage casks would be stored at ISFSI sites for so long that outer canister surface temperatures would drop to levels that could support a deliquesced salt film, or long enough for such a film to possibly develop and to yield SCC damage.

This research initiative aims to answer the following questions:

1. What is the probability of failure resulting from SCC as a function of time?
2. What is the uncertainty in this prediction?

The intent is that this research will provide the nuclear industry with guidance as to whether preventive measures must be taken to preclude SCC in the canisters, and to provide a robust initial framework for understanding and modeling SCC behavior in the canisters that can be expanded and improved by future research endeavors.



- Nuclear Subassemblies
- Radwaste Containers
- Material Certifications
- Reactor Components
- Pressure Vessels
- Heat Exchangers

	NA, N, N3, NS NPT, PP, U	ISO 9001:2008, NQA-1 10 CFR 50 APPENDIX B ASME SECTION III & VIII	
---	-----------------------------	---	---

All nuclear certifications are currently held with Westerman Inc.

PHONE 800-338-8265 WEB [www.worthingtoncylinders.com](http://www.worthingtoncylinders.com)

2013 Worthington Industries, Inc.

## REFERENCES

1. Ux Consulting, *StoreFUEL* and Decommissioning Report, 11(127), 2009.
2. Ux Consulting, *StoreFUEL* and Decommissioning Report, 13(164), 2012.
3. R. G. Ballinger, "Life Prediction of Spent Fuel Canister Material," NEUP R&D Award Abstracts, 2011, available online at [https://inlportal.inl.gov/portal/server.pt/community/neup\\_home/600/2011\\_r\\_d\\_awards\\_archive](https://inlportal.inl.gov/portal/server.pt/community/neup_home/600/2011_r_d_awards_archive).
4. D. A. Jones, *Principles and Prevention of Corrosion*, Upper Saddle River, N.J.: Prentice Hall, 1996.
5. U. S Nuclear Regulatory Commission, "Locations of Independent Spent Fuel Storage Installations," <http://www.nrc.gov/waste/spent-fuel-storage/locations.html>, accessed December 2013.
6. Gordon, G. M. "F. N. Speller Award Lecture: Corrosion Considerations Related to Permanent Disposal of High-Level Radioactive Waste." *Corrosion*, 58(10), 2002, 811–825.
7. EPRI *Industry Spent Fuel Storage Handbook*, 2010, Fig. 4.6.
8. B. P. Black, "Effect of residual stress on the life prediction of dry storage canisters for used nuclear fuel" (S. M. Thesis), Massachusetts Institute of Technology, 2013.
9. M. Mayuzumi, J. Tani, and T. Arai, "Chloride Induced Stress Corrosion Cracking of Candidate Canister Materials for Dry Storage of Spent Fuel," *Nuc. Eng. and Design* 238 (2008), 1227–1232.
10. A. Kosaki, "Evaluation Method of Corrosion Lifetime of Conventional Stainless Steel Canister Under Oceanic Air Environment," *Nuc. Eng. and Design* 238 (2008), 1233–1240.
11. G. S. Schajer, ed., *Practical Residual Stress Measurement Methods*, Wiley, 2013.
12. P. J. Withers et al., "Recent advances in residual stress measurement," *International Journal of Pressure Vessels and Piping*, 85(3), 2008, 118–127.
13. A. Turnbull, L. N. McCartney, and S. Zhou, "A model to predict the evolution of pitting corrosion and the pit-to-crack transition incorporating statistically distributed input parameters," *Corrosion Science*, 48(8), 2006, 2084–2105.
14. Y. Kondo, "Prediction of fatigue crack initiation life based on pit growth," *Corrosion*, 45(1), 1989, 7–11. ■

*Sara Ferry is a doctoral candidate at the Massachusetts Institute of Technology; Ronald Ballinger is a professor at MIT and principal investigator; Isabel Crystal and Dominic Solis are undergraduate research associates at MIT; and Bradley Black was an MIT master's student who was involved in this project and whose master's thesis was on some of the work presented here. Acknowledgment is also made to the contributions of Sebastien Tesseyre—a research scientist at the Idaho National Laboratory—to the research presented in this article. For additional information, contact Ferry at [seferry@gmail.com](mailto:seferry@gmail.com).*

*The MIT H. H. Uhlig Corrosion Laboratory's research initiative is funded by the U.S. Department of Energy's Nuclear Engineering University Program under DOE NEUP Award Number DE-AC07-051D14517.*

# CTI

Container Technologies Industries, LLC



### Container Technologies Industries, LLC

375 Marcum Parkway, P.O. Box 129  
Helenwood, TN 37755

Phone: 423-569-2800 x 24  
Fax: 423-569-2806

Web: [www.containertechnologies.com](http://www.containertechnologies.com)  
Sales: [mfielden@containertechnologies.com](mailto:mfielden@containertechnologies.com)

### Qualifications and Experience

- 14 Years Experience in Metal Fabrication
- AWS – Certified Weld Inspector (CWI) on staff
- NQA-1 Nuclear Quality Program
- Certified Hub Zone Small Business
- Proven Track Record with DOE, DOD, Utilities, Labs, and Commercial Customers
- Engineer (PE), using SolidWorks engineering software with 3-D Visual and FEA capability
- Innovative Design Solutions and Customer Responsive Manufacturing within 2 day transit of eastern U.S.
- Modern Manufacturing Facility with 64,000 sq. ft. located in East Tennessee (near Knoxville)

### Products

- IP-1, IP-2, 7AF Containers built to satisfy Customer Requirements and Specifications
- ISO refurbished 20 and 40 ft. containers
- Pallets, Racks, Ballasts, Cradles, Cylinders
- 7AF 55 & 85 gallon drums
- New Facility Construction and Equipment Supply
- Ability to fabricate large components

### Certification and Testing

- Meet all DOT 49 CFR Testing Requirements
- Finite Element Analysis Computer Simulation (FEA)
- Physical Drop, Leak-tight, Stack, Vibration, Compression, Load, MPT
- Material Certification and Traceability

### Customer List (partial)

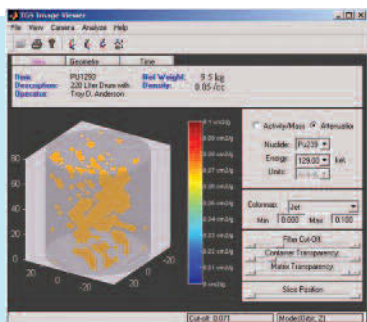
- B&W Y-12, Hanford, Savannah River (SRR, SRNS), Fluor, UCOR, CH2MHill, Candu, USEC, Bechtel, Ultra Tech, LATA, Energy Solutions, Merrick
- Labs: Sandia, Lawrence Berkeley, Los Alamos, PPL, PPPL, ORNL
- DOD: Nuclear Navy (NAVICP), NAVSUP
- Utilities: Exelon, TVA

### Corporate Data

CAGE: 1NXM7  
NAICS Codes: 332312 Steel Plate  
332313 Fabricated Structure  
DUNS: 107656014  
332439 Other Metal Containers  
332420 Metal Tanks Heavy Gauge

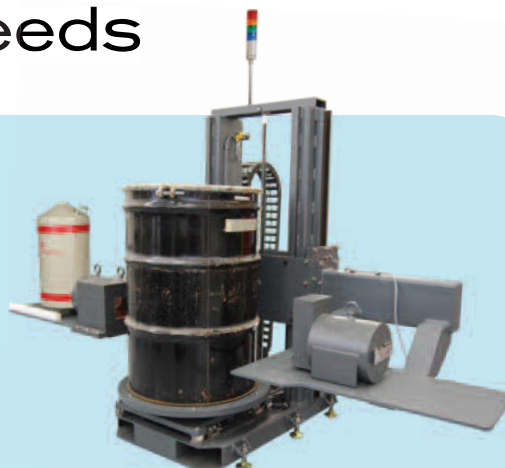
Please visit us at  
**Booth 322**

# Reliable measurements and expertise for your radioactive waste disposal needs



## » NDA 2000 Non-Destructive Assay Software

One software application for all systems (gamma and neutron); proven waste characterization with over a million assays and thousands of drums



## » Segmented Gamma Scanner

Full capability in a compact, transportable design, for standard drum measurements

## » ICIS Integrated Crate Interrogation System

High-resolution gamma systems can be calibrated using ISOCS™ mathematical efficiency software, for added flexibility of container types and quicker recertification.



## » Tomographic Gamma Scanner

Conveyor-based automation and other features reduce operator burden and intervention



**CANBERRA waste assay solutions offer accurate quantification of nuclear waste, saving you time and disposal costs.**

Solutions range from compact gross counting systems to automated active interrogation systems for full-size ISO containerized waste. With our decades of experience in designing, building and operating hundreds of waste assay systems, CANBERRA's NDA staff offer novel approaches to solve your most challenging measurement problems.

Contact CANBERRA today to learn more about our innovative waste assay solutions at [www.canberra.com/waste-assay](http://www.canberra.com/waste-assay)

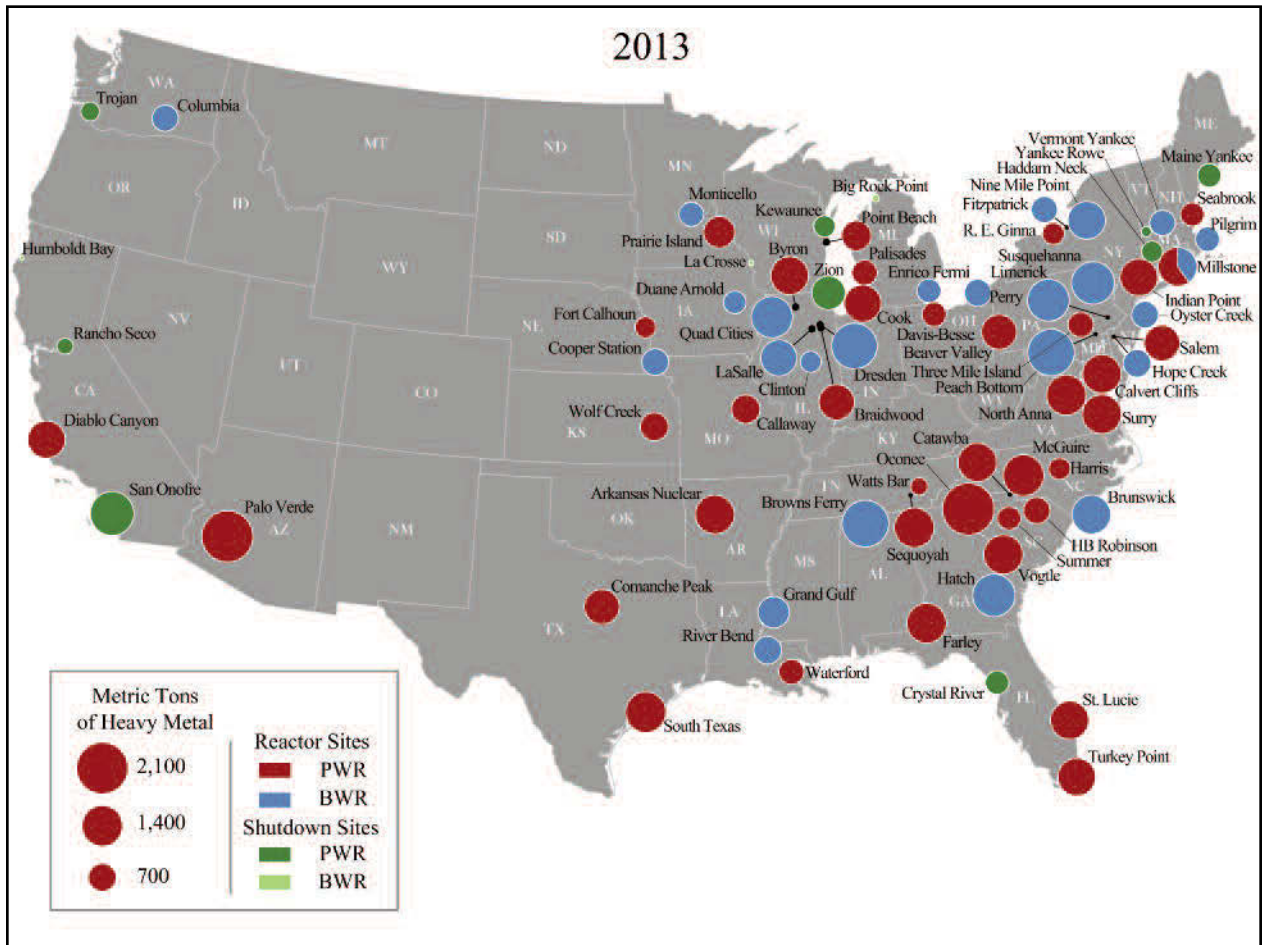


Fig. 1. Location and quantity of discharged commercial spent nuclear fuel (CSNF) at nuclear power plant sites in the United States as of 2013 (excludes gas-cooled reactor CSNF, as the quantity in THM is small in comparison to PWR and BWR CSNF inventories).

## Characteristics of Commercial Spent Nuclear Fuel: Distributed, Diverse, and Changing with Time

Understanding the current and future characteristics of commercial spent nuclear fuel is key to designing and licensing appropriate systems for its storage, transportation, handling, and disposal.

By Joshua Peterson and John Wagner

The domestic inventory of discharged commercial spent nuclear fuel (CSNF) has been and continues to be managed safely and securely. Maintaining a strong technical basis for the safe and secure storage, transportation, and disposition of CSNF is essential for the long-term sustainability of nuclear power generation in the United States. Although the Department of Energy is responsible for the ultimate disposition of CSNF, at present, the nation's long-term nuclear waste management strategy is uncertain. In the meantime, CSNF will continue to be stored at the electricity-generating reactor sites in spent fuel pools and dry storage casks.

Regardless of the various long-term strategy options, it is reasonable to expect that some portion of CSNF inventory will remain in storage for decades, followed by transportation to either an interim storage facility or a geologic repository, and subsequent acceptance and handling for ultimate disposal. The planning, preparation, and execution of the various management and disposition operations

will span several decades—possibly more than a century—and will necessitate a firm understanding of the current and future characteristics of CSNF inventory relevant to the effective design and licensing of storage, transportation, handling, and disposal systems and facilities. In recognition of this need, efforts are under way to develop, document, and maintain this information, which is being used to evaluate fuel cycle options in general and management and disposal options in particular. This article provides an overview of the key characteristics of the domestic CSNF inventory relevant to its management and disposition.

The current inventory of CSNF is distributed, diverse, and changing with time. Through 2013, there were approximately 70,000 metric tons of heavy metal (tHM) of CSNF, which corresponds to approximately 104,000 pressurized water reactor and 138,000 boiling water reactor assemblies [1] and a total of approximately 23 billion curies of long-lived radioactivity [2] stored at 75 sites in 33 states [3]. To put it into a more understandable perspective, if all of the CSNF assemblies were placed vertically side by side, they would fit within the boundaries of one and a half regulation-size football fields (78,000 ft<sup>2</sup>). During the past couple of decades, the inventory of CSNF has increased at a relatively steady rate of approximately 2,000 tHM per year [3].

CSNF assemblies vary in their design and discharge conditions and are composed of a range of actinides and fission products that can have a significant impact on the heat, activity, and reactivity of the assemblies. The diversity of types, characteristics, storage locations, and storage conditions of the current inventory of CSNF presents a variety of challenges that influence the approach to managing its safety, security, and cost, as well as disposition options.

## DISTRIBUTED

Commercial nuclear power plants have been operating in the United States since 1957,<sup>1</sup> and there are currently 100 operating nuclear power plants. Figure 1 shows the location and quantity of CSNF in the United States. The wide distribution of the nuclear power plants throughout the nation adds a layer of complexity to CSNF management in technical areas such as security, storage, transportation, and disposition.

Spent nuclear fuel from these plants is stored on-site in spent fuel pools and at independent spent fuel storage installations (ISFSI). ISFSIs are in operation at the majority of reactor sites, including 11 sites in eight states that no longer have operating reactors. A variety of dry storage systems have been designed, licensed, and used, but the majority of CSNF assemblies in dry storage are in welded-metal canisters within horizon-

tal or vertical concrete storage modules or “overpacks.” The main difference between the dry storage canisters for PWR and BWR fuel assemblies is the number of fuel assemblies that are stored within each canister. PWR dry storage canisters are certified to contain 24 to 40 assemblies, whereas BWR dry storage canisters can contain between 56 and 89 assemblies.<sup>2</sup> Approximately 72 percent (about 50,000 tHM) of the total mass of CSNF is stored in spent fuel pools, and the remaining 28 percent (about 20,000 tHM) is in dry storage (Fig. 2) [1]. These proportions, however, will slowly change (see Fig. 3) as most spent fuel pools are at or near their capacity. The growing inventory of fuel in dry storage canisters presents a variety of challenges associated with CSNF management. For example, if a different container is required for disposal, then the fuel will have to be repackaged, thereby increasing the cost of disposal.

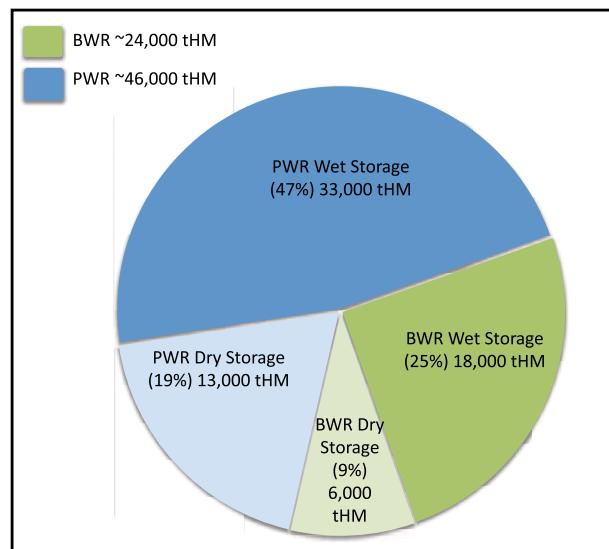


Fig. 2. Distribution of CSNF inventory in wet and dry storage (from [1]) extrapolated to 2013.

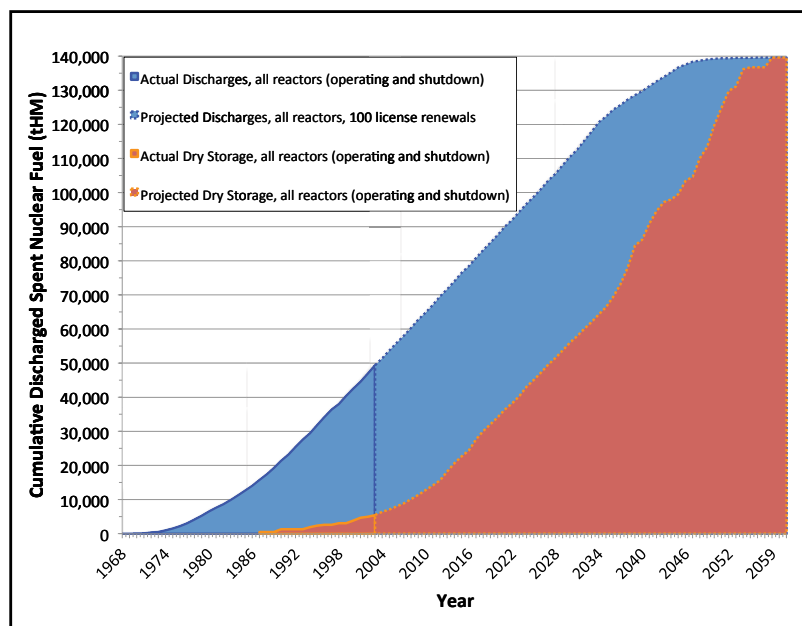


Fig. 3. Historical and projected CSNF discharges based on actual discharge data as reported in [5] and projected discharges, assuming 20-year license renewals for all operating plants.

<sup>1</sup> Note that the CSNF from the first commercial nuclear power plant, the Shippingport Atomic Power Station, is now classified as DOE-owned fuel.

<sup>2</sup> The transportation, aging, and disposal (TAD) canisters that were planned for use in a volcanic tuff repository held 21 PWR assemblies or 44 BWR assemblies. [4]

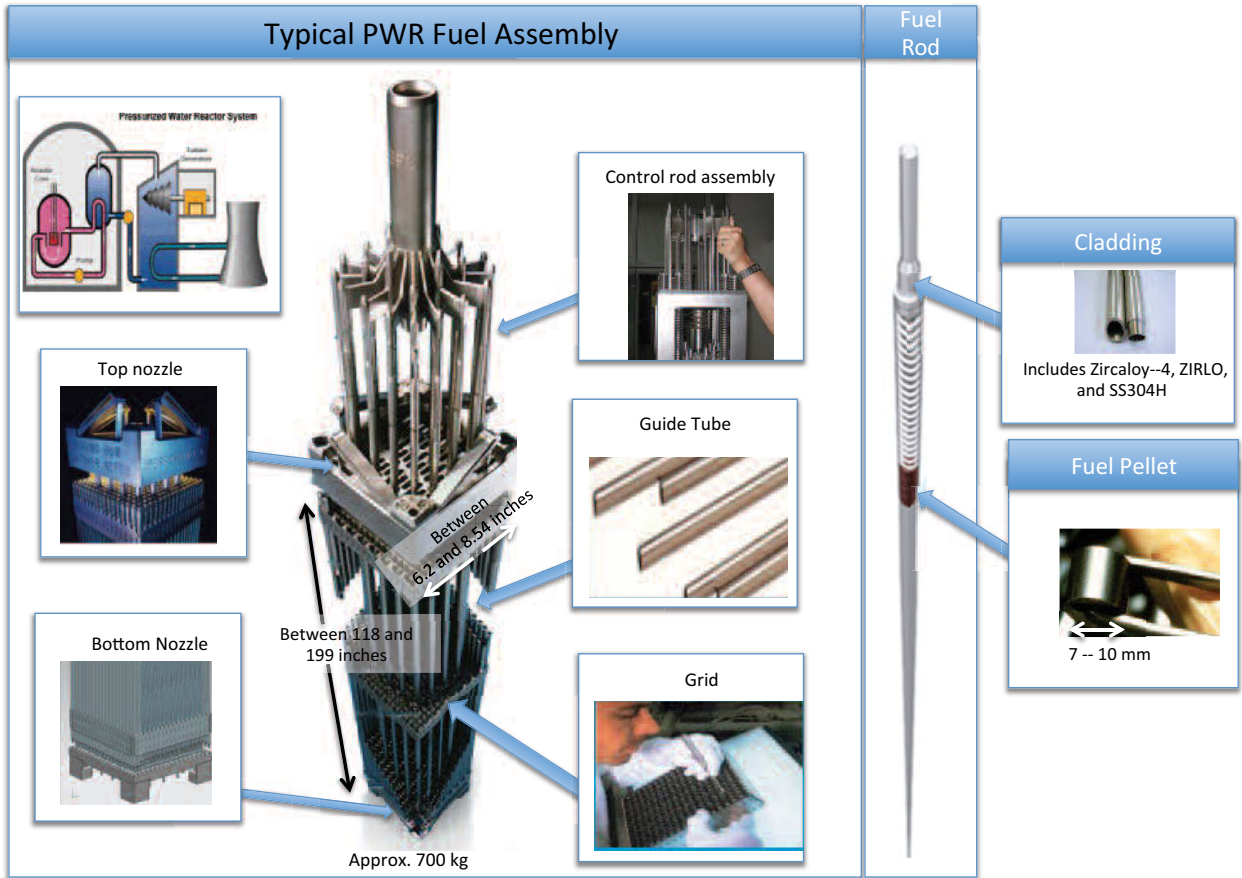


Fig. 4. Physical characteristics and components of a typical PWR fuel assembly.

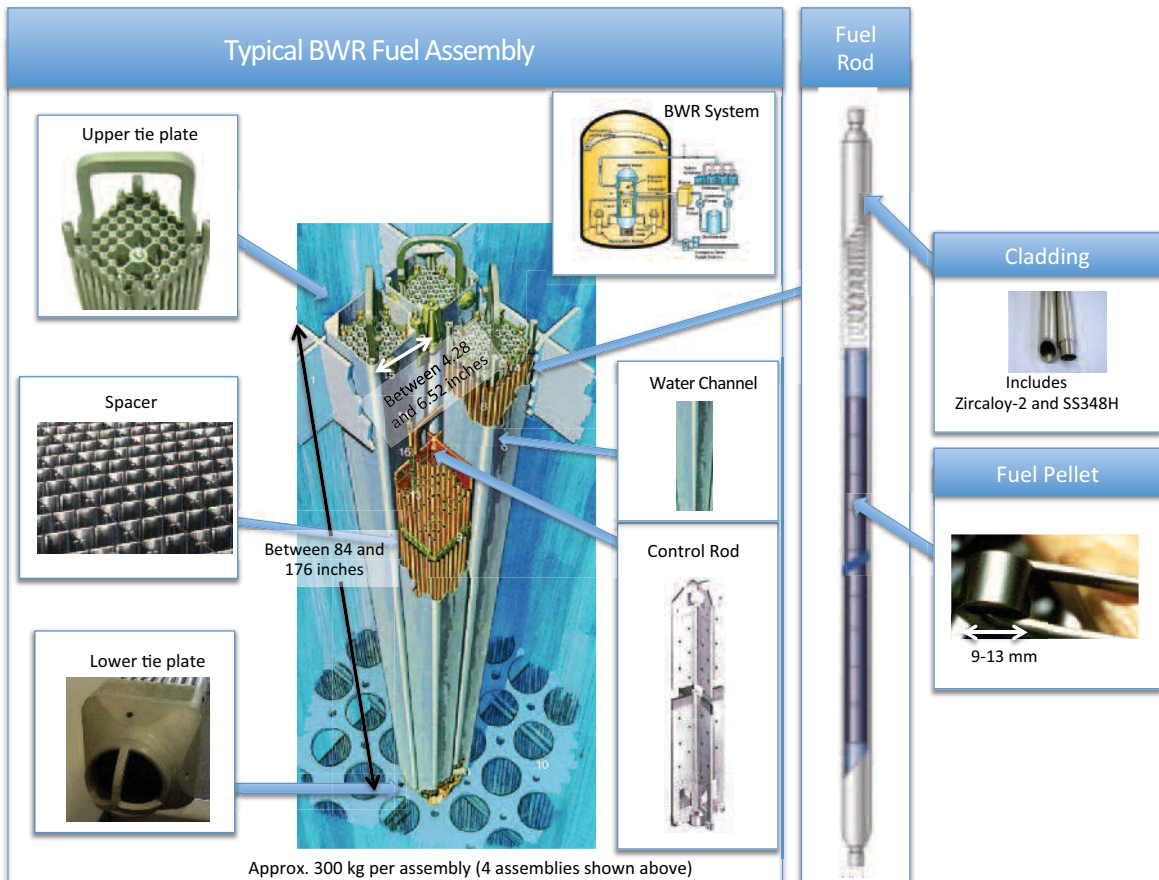


Fig. 5. Physical characteristics and components of a typical BWR fuel assembly.

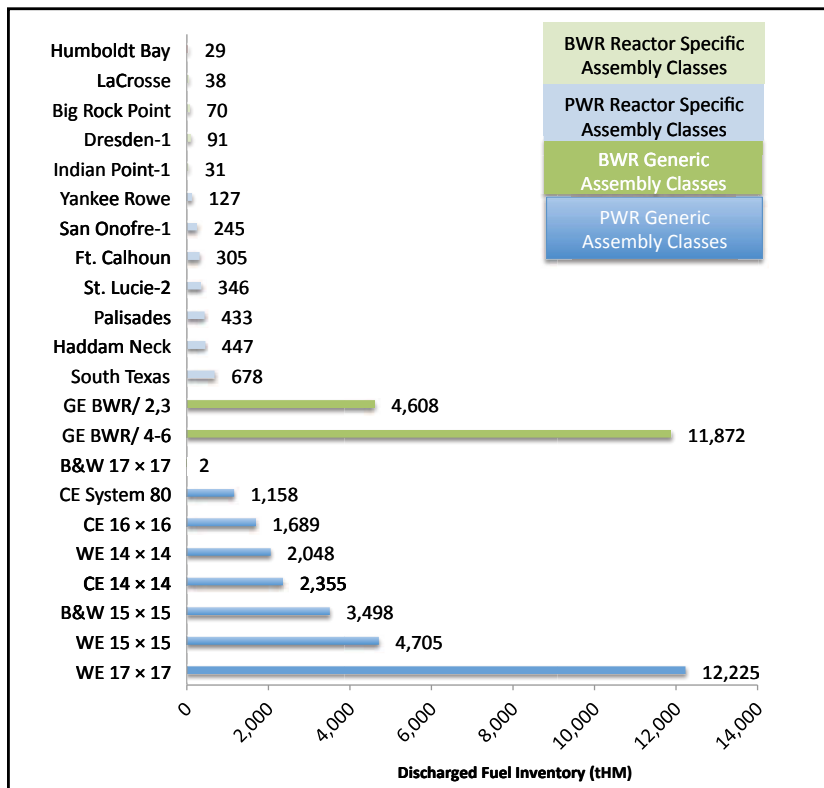


Fig. 6. Distribution of assembly classes by total mass in the CSNF inventory as of 2002. [5]

## DIVERSE

Nearly all PWR CSNF is composed of uranium dioxide ( $UO_2$ )<sup>3</sup> ceramic pellets inserted into Zircaloy cladding tubes that are bound together by a grid assembly (Fig. 4). Although new cladding materials are being developed and a small fraction of the older CSNF assemblies used SS304H, the predominant cladding materials are Zircaloy-4 and ZIRLO.<sup>4</sup> PWRs typically have used fuel assemblies arranged in 14x14, 15x15, 16x16, and 17x17 arrays of fuel pins, as well as in some asymmetrical configurations. Additional components of a PWR fuel assembly include a top nozzle, control rod guide thimble tubes, and a bottom nozzle.

BWR fuel assemblies are also composed of  $UO_2$  fuel pellets surrounded by Zircaloy cladding (Fig. 5). The cladding material for BWR fuel is typically Zircaloy-2; SS348H was used in older assembly designs. Unlike the PWR fuel assembly, the BWR fuel assembly has an outer sheath, referred to as the fuel channel, which is used to control the flow of water

through the assembly. BWR fuel assemblies are arranged in 6x6, 7x7, 8x8, 9x9, 10x10, and 11x11 arrays of fuel pins and a range of lattice variations, such as water holes and part-length rods. Additional components of the BWR fuel assembly include plenum springs, expansion springs, water rods, upper and lower tie plates, a nose piece, and the bar handle.

The different reactor types, evolutions in fuel assembly designs, and reactor operating conditions have resulted in considerable variations in the characteristics (e.g., assembly and cladding materials, initial enrichment, discharge burnup, burnable poison types, and irradiation exposure conditions) of the U.S. CSNF inventory. These variations are evident in that CSNF assemblies have been categorized [5] by physical configuration into 22 classes, 16 for PWR fuel and 6 for BWR fuel. Within each class, assembly types are of a similar size. The significant variations in the current inventory are illustrated in Fig. 6, which shows the distribution of the assembly classes. These variations present a variety of challenges for CSNF management (e.g., demonstrating compliance with storage, transportation, and disposal regulatory criteria for all the variations present in the current CSNF

<sup>3</sup> A small number of PWR and BWR assemblies contain a mixture of uranium and plutonium dioxide, referred to as mixed-oxide fuel.

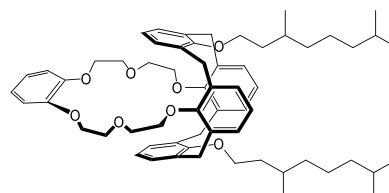
<sup>4</sup> ZIRLO is a proprietary Zircaloy alloy developed by Westinghouse.

## NUCLEAR SPECIALTIES

### CESIUM REMOVAL

Calix[4]arene-Crown Ethers

MAXCalix



### SPECIALTY SOLVENTS

Cs-7SB Modifier

FS-13

### ACTINIDE EXTRACTION & SEPARATION

CMPO

HEH[EHP]

TODGA

Bis-(o-TFMphenyl)-  
dithiophosphinic Acid

### ANALYTICAL REAGENTS

HBQS (Be)

DDCP (Pu, Am)

### DOMESTIC MANUFACTURER NQA-1

### CUSTOM SYNTHESIS & FORMULATION

### CONCEPT THROUGH COMMERCIALIZATION

**MARSHALLTON**  
RESEARCH LABORATORIES INCORPORATED

[www.marshalltonlabs.com](http://www.marshalltonlabs.com)

(336)-983-2131

[sales@marshalltonlabs.com](mailto:sales@marshalltonlabs.com)

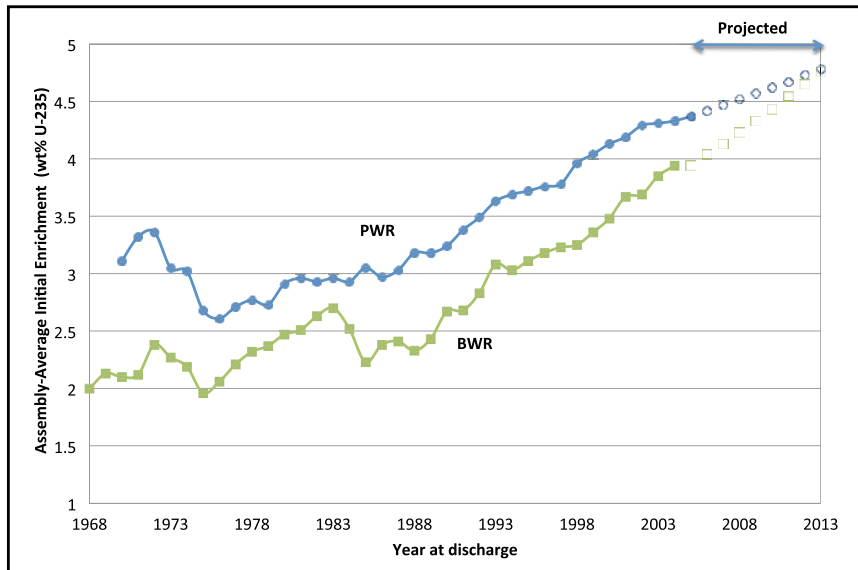


Fig. 7. Assembly-average initial enrichment as a function of time. [2]

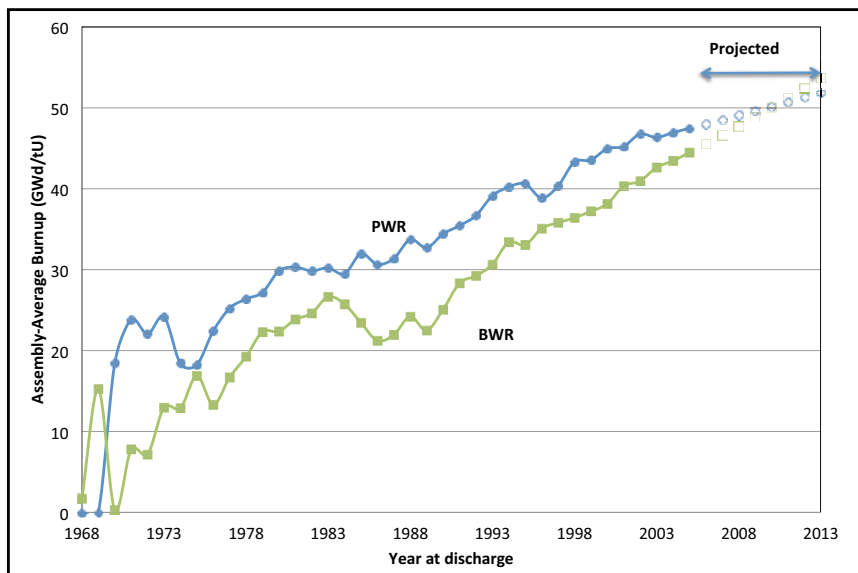


Fig. 8. Assembly-average discharge burnup as a function of time. [2]

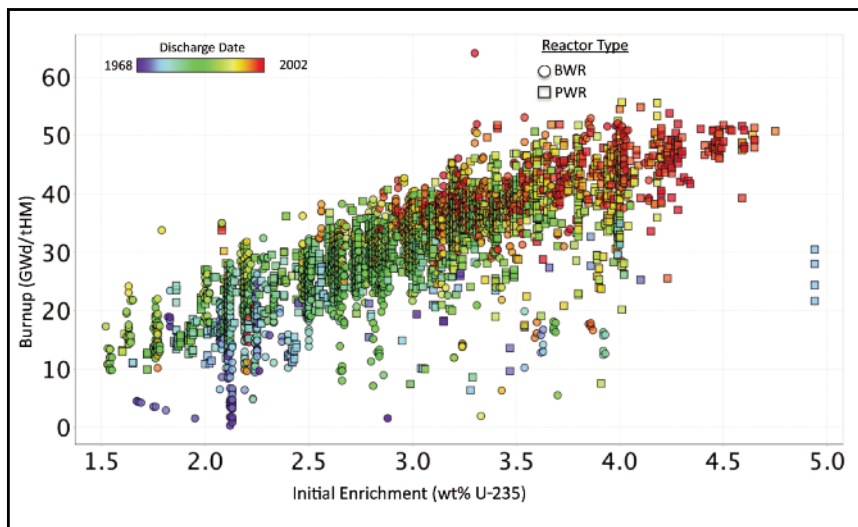


Fig. 9. Burnup as a function of enrichment for CSNF assemblies. [5]

inventory).

The distribution in the discharged CSNF inventory reflects the evolution of nuclear reactors and fuel assembly designs during the first approximately 50 years of nuclear power plant operation. An examination of discharges in recent years indicates that the variability in discharged fuel assemblies has decreased over time. For example, Fig. 7 shows how assembly-average enrichment has increased across the U.S. commercial reactor fleet and is approaching the current limit of 5 wt% uranium-235; Fig. 8 shows how burnup values have been increasing over time; and Fig. 9 shows that burnup values will ultimately be restricted by the limit on initial fuel enrichments due to the linear relationship between burnup and enrichment.<sup>5</sup> Higher burnup and enrichments have implications for all components of CSNF management, including wet and dry storage (e.g., thermal and criticality safety), transportation (e.g., thermal, dose rates, criticality safety, and fuel integrity), and disposal (e.g., thermal, criticality, emplacement dose rates, and release rates) [6].

Looking forward, less diversity in fuel assembly designs is expected as designs approach the current limit of 5 wt% U-235 for initial enrichment. In addition, discharge burnup values are becoming more uniform as they approach their upper limits, and many of the reactor-specific assembly designs are no longer being used. Also, a review of new PWR reactor designs for which combined construction and operating license applications have been submitted [7]—that is, the AP1000, the U.S. EPR, and the U.S. APWR—indicates that all of these reactor designs will use fuel with the same assembly lattice size (i.e., 17×17). This further supports the expectation that CSNF discharges in future decades will likely have more uniform characteristics than past or current CSNF discharges.

### CHANGING WITH TIME

Initially, nuclear fuel is composed of uranium consisting of 95–99.3 wt% U-238 and 0.7–5 wt% U-235. As the fuel fissions within the reactor, fission products, along with plutonium and minor actinides, are produced. After the fuel is discharged from the reactor, the majority of the CSNF is still uranium, with only a small portion composed of fission products, plutonium, and minor actinides (Fig. 10).

Due to radioactive decay, the isotopic compositions of discharged CSNF change with time, causing fluctuations in reactivity along with a reduction in activity and thermal output. Relative to reactivity, CSNF increases in reactivity for a short period of time after reactor discharge because of the decay of short-lived fission product absorbers, with the peak occurring at approximately 100 hours after discharge. After that, reactivity de-

<sup>5</sup> Note that if the current commercial reactor-licensing limit of 5.0 wt% U-235 on fuel enrichment were increased in the future, fuel design variations would be implemented to utilize higher enrichments and discharge burnup values would increase.



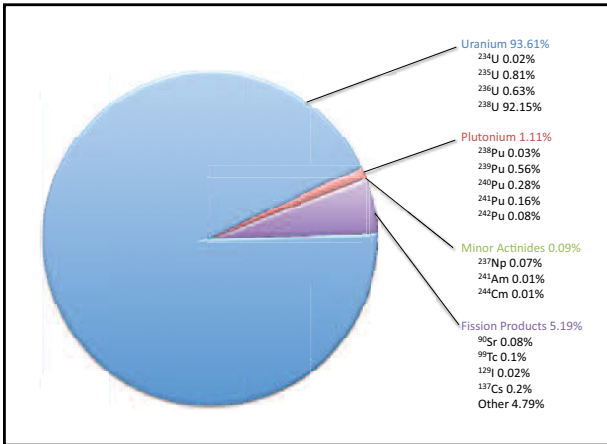


Fig. 10. Discharge isotopic composition (by mass) of a Westinghouse 17x17 assembly with initial enrichment of 4.5 wt% that has accumulated 45 GWd/tHM burnup.

creases continuously with time, out to approximately 100 years, at which time it begins to increase again. The reactivity continues to increase until a second peak at around 30,000 years (caused by the decay of two major absorbers, americium-241 and plutonium-240), after which time it begins decreasing out to approximately 100,000 years [8].

The decreased activity of CSNF many decades after discharge can be a safeguards concern when or if the dose rate from the CSNF decreases to the point that it is no longer considered “self-protecting.” Qualitatively, a CSNF assembly could be said to be self-protecting if the radiation dose rates near the assembly were high enough

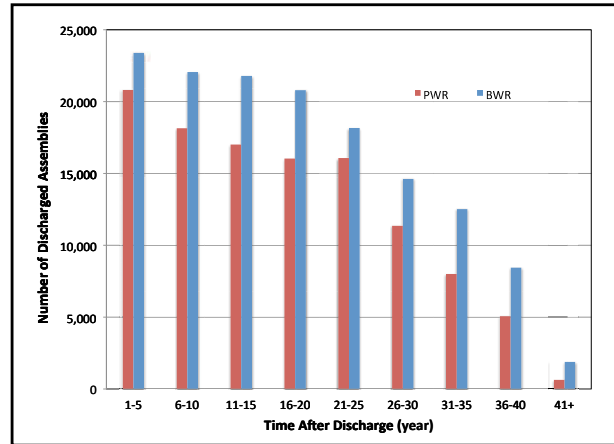


Fig. 11. The number of discharged fuel assemblies over time.

to deter a person from attempting to handle the unshielded assembly. Within the NRC regulations in 10 CFR Part 73, self-protection is attributed to CSNF, “which is not readily separable from other radioactive material and which has a total external radiation dose rate in excess of 100 rems per hour at a distance of 3 feet from any accessible surface without intervening shielding.”

Studies have shown that the dose rate for typical discharged CSNF will fall below the regulatory definition of self-protection (100 rem/h at 3 ft) between 70 and 120 years after reactor discharge [9]. Therefore, some of the CSNF assemblies may no longer be self-protecting as early as 30 years from now (Fig. 11), and at that point, additional safeguard and security measures may be needed for

# PRECISION CUSTOM COMPONENTS

TRADITION  
QUALITY  
ADVANCEMENT



Keeping the  
**Environment Clean  
& the Nation Secure**

For over 130 years PCC has manufactured high-quality custom fabricated pressure vessels, equipment, and specialty manufactured components. PCC's 250,000 square feet of precision machining, fabrication and non-destructive examination capability is dedicated to serving the Nuclear Industry.

717-848-1126 x2400  
[www.pcc-york.com](http://www.pcc-york.com)



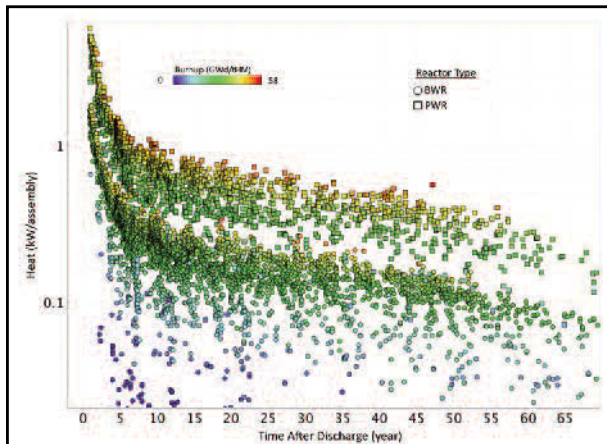


Fig. 12. Decay heat (kW) per assembly for BWR and PWR CSNF (through 2002) as a function of time after discharge (years).

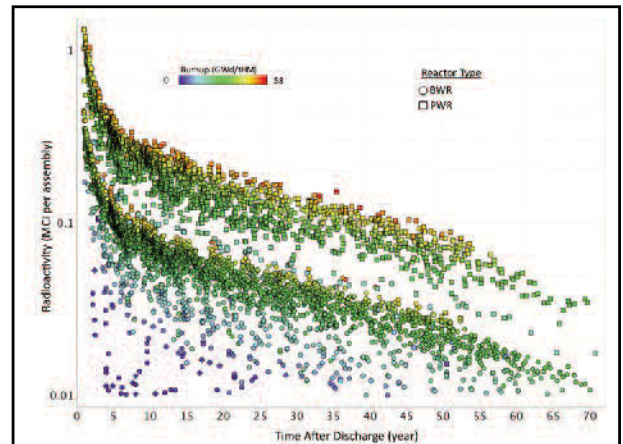


Fig. 13. Radioactivity (1 million Ci) per assembly for BWR and PWR CSNF (through 2002) as a function of time after being discharged (years).

storage and transportation purposes.

The range of discharge dates (Fig. 11), along with the diversity of the fuel characteristics discussed above, results in substantial variation in the composition, activity, and decay heat of individual fuel assemblies in the CSNF inventory, which has important implications for CSNF management. To better understand the variations in the composition, activity, and decay heat of individual fuel assemblies, the RW-859 database [5] was used in conjunction with ORIGEN in the SCALE code system [10]. The RW-859 database, created by the U.S. Energy Information Administration, contains information on all U.S.

CSNF assemblies discharged up to the year 2002 and includes information such as discharge date, burnup, initial enrichment, and assembly type. Previously generated ORIGEN cross-section libraries can be used to rapidly calculate the composition of fuel assemblies over a wide range of parameters, including enrichment, burnup, and assembly type. The information from the RW-859 database was fed into the ORIGEN computer code to calculate the discharge composition of every individual fuel assembly (numbering 160,000-plus). These results were then plotted with a data-mining tool to study the range of CSNF compositions over time. This method was applied

# GEL

# Laboratories LLC

Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

## Serving the DOE, DoD, Commercial Nuclear Utilities, and Waste Processors

- Experienced provider of analytical services supporting D&D, mixed waste, and environmental monitoring projects
- Full compliance and accreditation with numerous quality programs including DOECAP, DoD ELAP, NELAP, TNI, ISO 17025:2005, MARLAP, QSM V4.2, and NQA-1
- Customized data packages, electronic deliverables, and on-line 24-hour data access
- Certified by 38 states and federal agencies
- Single site laboratory with over 30 years of proven experience and over 200 dedicated staff

For additional information, contact GEL at [info@gel.com](mailto:info@gel.com) or 843.556.8171

[gel.com](http://gel.com)

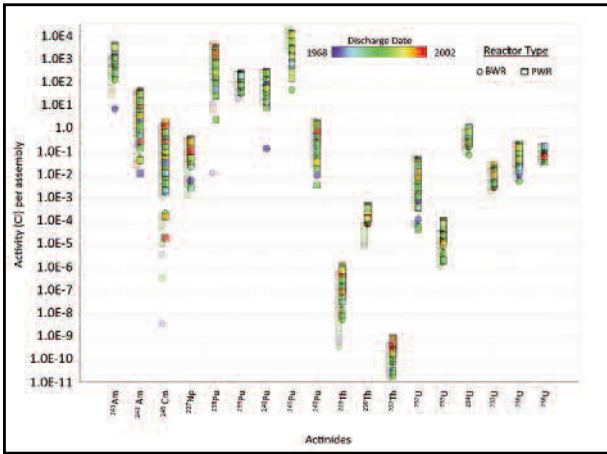


Fig. 14. Activity of selected isotopes (actinides) in CSNF (2048) for fuel discharged through 2002. (Note that the lighter data points correspond to the activity of the isotopes when the fuel was discharged.)

to calculate the total decay heat and activity of CSNF assemblies, along with the activities and masses of individual actinides and fission products within each assembly.

Figures 12 and 13 show the changing characteristics of decay heat and activity, and illustrate the large drop in decay heat and activity within the first five years following discharge. Decay heat and activity for the BWR assemblies is lower than those for PWR assemblies because BWR assemblies are smaller and contain less uranium. The high thermal output during the first few years following discharge is the reason CSNF is stored within spent fuel pools for several years prior to being transferred to dry cask storage. Both decay heat and activity affect storage, transportation, and disposal options, such as when CSNF can be placed into dry storage canisters and when those canisters can be transported off-site for disposal.

Figures 14 and 15 show the range of actinide and fission product activities in CSNF at the year of discharge (lighter data points) and the year 2048 (the strategic target date to open a geologic repository [11]). These fission products and actinides were chosen because they are significant in relation to the storage, transportation, and disposal of CSNF [12]. Their behavior will differ within different repository

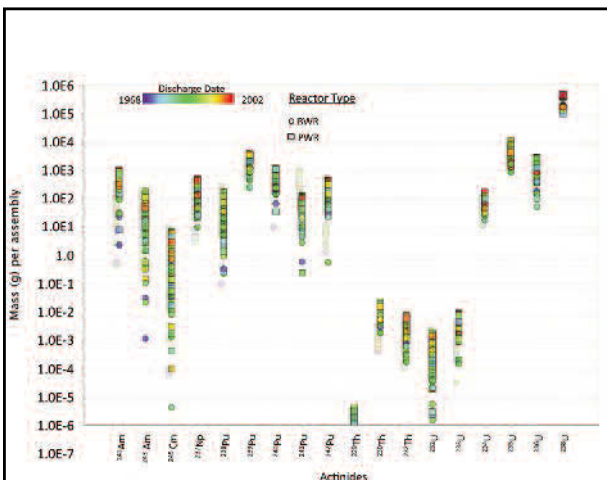


Fig. 16. Mass of selected isotopes (actinides) in CSNF (2048) for fuel discharged through 2002. (Note that the lighter data points correspond to the mass of the isotopes when the fuel was discharged.)

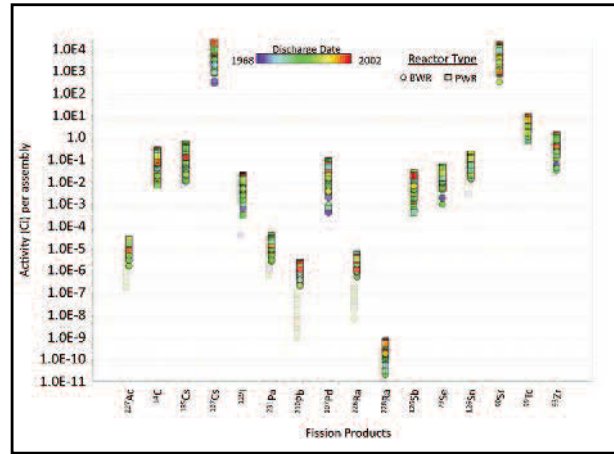


Fig. 15. Activity of selected isotopes (fission products) in CSNF (2048) for fuel discharged through 2002. (Note that the lighter data points correspond to the activity of the isotopes when the fuel was discharged.)

media, and it is important to know the potential contribution to dose from individual nuclides. Some of the nuclides with higher activity such as Pu-241, cesium-137, and strontium-90 will be a major contributor to decay heat (important during storage and transportation of CSNF) [13]. Some of the less active fission products, such as iodine-129 and selenium-79 may become the major contributors to dose after emplacement within a geological repository [14].

Figures 16 and 17 show the range of actinide and fission product compositions in CSNF also at the year of discharge (lighter data points) and at the year 2048. Knowing the quantity of these isotopes within CSNF is important for calculating values such as criticality, heat, and dose, and also for examining alternative fuel cycle options for the disposition of CSNF.

One of the alternative fuel cycle options is the recycling of CSNF for use in current reactors (for example, as mixed-oxide fuel) or advanced reactors (such as fast reactors). The individual plutonium isotopes found within the recycled fuel determine the quantity of the plutonium needed within a reactor. A comparative parameter that is useful for relating the reactivity worth of recycled fuel is known as Pu-239 equivalence (which is a function of the plutonium

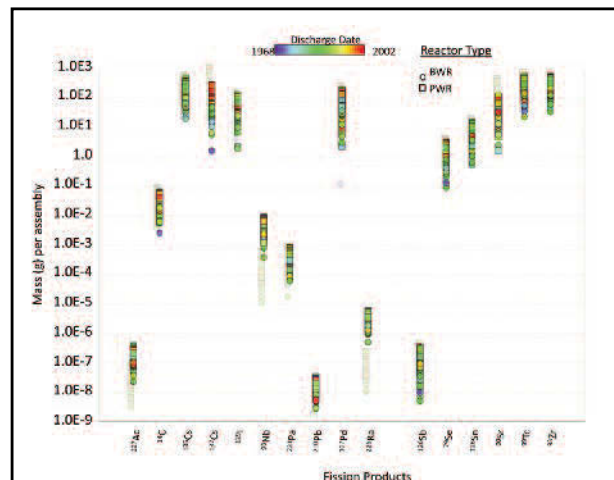


Fig. 17. Mass of selected isotopes (fission products) in CSNF (2048) for fuel discharged through 2002. (Note that the lighter data points correspond to the mass of the isotopes when the fuel was discharged.)

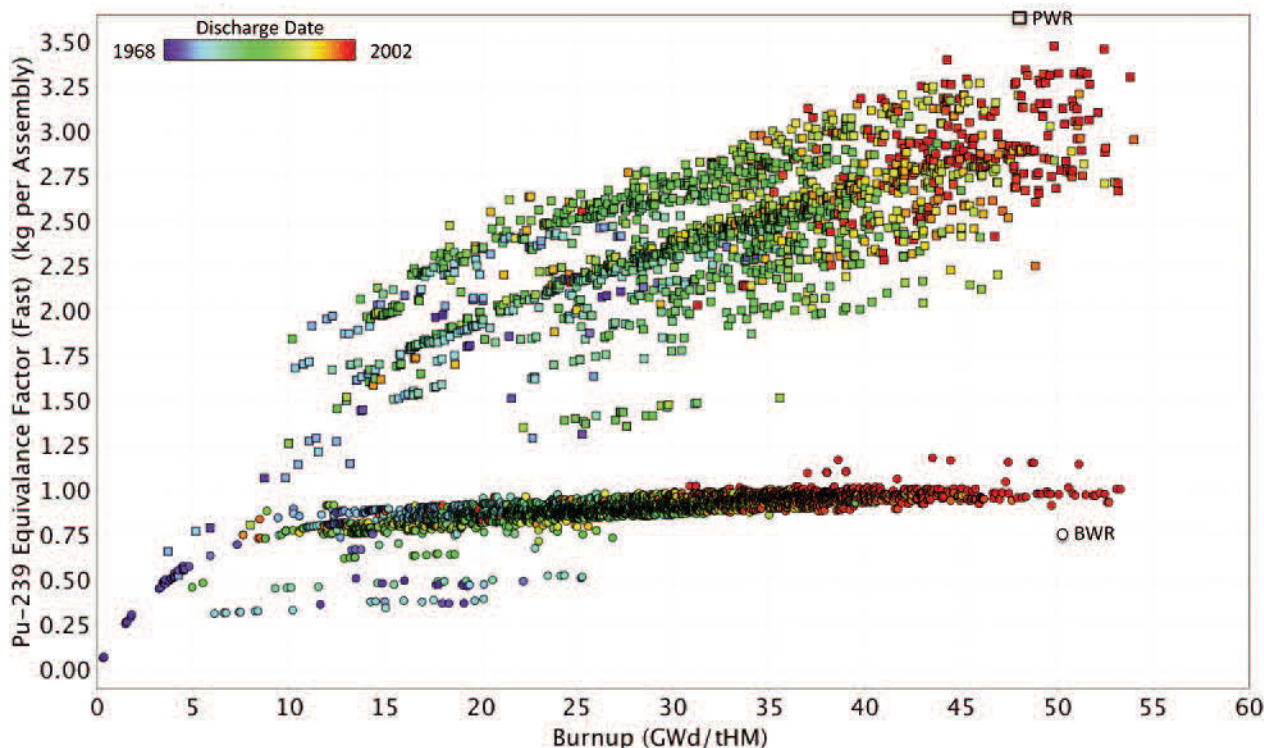


Fig. 18. Pu-239 equivalence for a fast reactor as a function of burnup, discharged date, and reactor type. [16]

isotopes) [15]. Based on this parameter, all fuel with the same Pu-239 equivalence will achieve the same reactivity lifetime and discharge burnup. Figure 18 shows the Pu-239 equivalence for a fast reactor similar to the SuperPhénix reactor, in France [15]. Figure 18 also shows that higher burnup fuels have higher Pu-239 equivalence than lower burnup fuels, making it more desirable to recycle higher burnup fuels in regard to the required quantity of plutonium.

### MAINTAINING AN UNDERSTANDING

The location, diversity, and changing characteristics of commercial spent nuclear fuel can present challenges regarding the continued security and cost of its management, and can have implications for the effective design and licensing of planned interim storage, transportation, handling, and disposition systems and facilities. Therefore, it is in the national interest to develop and maintain an understanding of the current and future characteristics of CSNF.

### REFERENCES

1. Joe Carter and D. Leduc, *Nuclear Fuels Storage and Transportation Planning Project Inventory Basis*, FCRD-NFST-2013-000263, Rev. 0, U.S. Department of Energy Nuclear Fuels Storage and Transportation Planning Project: Aug. 30, 2013.
2. J. T. Carter, A. J. Luptak, and J. Gastelum, *Fuel Cycle Potential Waste Inventory for Disposition*, FCRD-USED-2010-000031 Rev 6., U.S. Department of Energy: July 2012.
3. *Commercial Nuclear Waste: Effects of a Termination of the Yucca Mountain Repository Program and Lessons Learned*, GAO-11-229, U.S. Government Accountabil-

- ity Office: April 2011.
4. M. Popa, *Transportation, Aging, and Disposal Canister System Performance Specification Revision 1/ICN 1*, DOC ID: WMO-TADCS-000001, U.S. Department of Energy Office of Civilian Radioactive Waste Management: March 2008.
5. *RW-859 Nuclear Fuel Data*, U.S. Energy Information Administration, Washington, D.C.: Oct. 2004.
6. *Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management*, NF-T-3.8, International Atomic Energy Agency, Vienna: 2011.
7. *U.S. Nuclear Regulatory Commission website for Combined License Application of New Reactors*. Available: <http://www.nrc.gov/reactors/new-reactors/col.html>.
8. J. C. Wagner and C. V. Parks, *Recommendations on the Credit for Cooling Time in PWR Burnup Credit Analyses*, NUREG/CR-6781 (ORNL/TM-2001/272), prepared for the U.S. Nuclear Regulatory Commission by Oak Ridge National Laboratory, Oak Ridge, Tenn.: Jan. 2003.
9. F. Duran, G. Wyss, and J. Calvin, "Security Issues for Long-Term Storage of Used Fuel," presented at the ASME 2011 14th International Conference on Environmental Remediation and Radioactive Waste Management (ICEM2011), Reims, France, Sept. 25–29, 2011.
10. *SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design*, ORNL/TM-2005/39, Version 6.1, Oak Ridge National Laboratory, Oak Ridge, Tenn.: June 2011.
11. *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, Department of Energy: Jan. 2013.
12. J. F. Kerrisk, *An Assessment of the Important Radionuclides in Nuclear Waste*, LA-10414-MS, Los Alamos National Laboratory, Los Alamos, N.M.: Oct. 1985.

13. I. C. Gauld and J. C. Ryman, *Nuclide Importance to Criticality Safety, Decay Heating, and Source Terms Related to Transport and Interim Storage of High-Burnup LWR Fuel*, NUREG/CR-6700 ORNL/TM-2000/284, Oak Ridge National Laboratory, Oak Ridge, Tenn.: 2000.

14. D. Clayton, G. Freeze, T. Hadgu et al., *Generic Disposal System Modeling Fiscal Year 2011 Progress Report*, FCRD-USED-2011-000184, U.S. Department of Energy Used Fuel Disposition: 2011.

15. *Plutonium Fuel: An Assessment Report by an Expert Group*, Nuclear Energy Agency (OECD Publication and Information Center Organisation for Economic Co-operation and Development [OECD], distributor), Paris, France: 1989.

16. J. Peterson, "Data Mining to Determine Inventory Characteristics of Used Nuclear Fuel for Potential Future Recycling Campaigns," *Proceedings of the 14th International High-Level Radioactive Waste Management Conference*, Albuquerque, N.M., April 28–May 2, 2013, American Nuclear Society: 2013.

17. J. C. Wagner, J. L. Peterson, D. E. Mueller et al., *Categorization of Used Nuclear Fuel Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy*, ORNL/TM-2012/308 (FCRD-FCT-2012-000232), Oak Ridge National Laboratory, Oak Ridge, Tenn.: Dec. 2012. ■

*Joshua Peterson is reactor physics analysis engineer and John Wagner is group leader, Used Fuel Systems, at Oak Ridge National Laboratory. For additional information, contact Peterson at petersonjl@ornl.gov.*

*This article is based on a manuscript authored by the Oak Ridge National Laboratory, managed by UT-Battelle LLC under Contract No. DE-AC05-00OR22725 with the U.S. Department of Energy. The U.S. government retains, and the publisher, by accepting the article for publication, acknowledges that the U.S. government retains, a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or to allow others to do so, for U.S. government purposes.*



WHEN OTHERS AREN'T ACCEPTABLE, SPECIFY GRIFFOLYN®  
CUSTOM EQUIPMENT COVERS, BAGS & TUBING



**Ideal for construction, outage protection and maintenance**

- FIRE RETARDANT
- UV STABILIZATION
- CORROSION INHIBITORS
- HEAT SHRINKABILITY

**Customization Options**

- Engineered Configurations
- Vent, Ports & Access Panels
- D-Ring Lift & Tied Downs
- Velcro Closures
- Multi-Component Covers



TRUST THE ORIGINAL  
TRUST GRIFFOLYN®

www.griffolyn.com • 1.800.231.6074



Oak Ridge Service Center

### "Providing Solutions to the Nuclear Industry"

At the Babcock Services Oak Ridge Service Center we offer comprehensive disposition options for Low-Level Radioactive Materials and Wastes. Our solutions are both cost effective and reduce customer liabilities through decontamination, equipment reuse/salvage, recycling, and implementation of innovative radioactive material processing.

- ◇ Transportation Planning / Oversight
- ◇ Radioactive Waste Disposal Coordination
- ◇ Decontamination / Free Release / Recycle
- ◇ Tooling / Equipment Inventory Controls
- ◇ Radioactive Material Storage
- ◇ OREX® Processing
- ◇ Waste Segregation and Disposition
- ◇ Fuel Pool Management

Babcock Services, Inc.  
Oak Ridge Service Center  
P.O. Box 4925  
2323 Zirconium Way  
Oak Ridge, TN 37830  
865-574-2028  
www.babcockservices.com



Jimmy Harris, Business Development Manager • jharris@babcockservices.com • 865-438-8288

***A report from the Seventh Annual RadWaste Summit, held September 3–6, 2013, in Las Vegas, Nev.***

## Debate Continues over Part 61 Regulations

**A**t the Seventh Annual RadWaste Summit, held September 3–6, 2013, in Las Vegas, Nev., and sponsored by Exchange-Monitor Publications & Forums, approximately 200 representatives from the Department of Energy, state and local governments, and industry heard from officials and experts on a variety of topics, including the continued debate over the Nuclear Regulatory Commission's ongoing revision of its Part 61 low-level waste regulations.

The key focus of the debate centered on the appropriate period of compliance to be employed. The NRC staff's draft rulemaking would require LLW disposal sites to perform a site-specific analysis to prove that their site is protective of public health and safety for 10,000 years, down from a period of compliance of 20,000 years in previous drafts. The draft rulemaking also calls for a two-tier analysis, with the first period covering 10,000 years and the second period covering long-lived isotopes.

During a summit panel session, some questioned the viability of having a period of compliance as long as 10,000 years. In contrast, the DOE uses a period of 1,000 years in its own LLW regulations. "In the analysis that we've done in our performance assessments, we have found the 1,000-year [period] to be really the best as far as evaluating our performance assessments, and [that] evaluation of the 10,000[-year period]—because of the uncertainties that you're dealing with over that long time period—didn't really add any

value as far as looking at how I would redo the design, redo the facility itself," said Jay Rhoderick, DOE associate deputy assistant secretary for Tank Waste and Nuclear Material.

Dan Shrum, senior vice president of Regulatory Affairs for EnergySolutions, said, "It's a substantial burden to demonstrate that man-made engineered features that we typically assume [to last for] 300 to 500 years [are] going to last for 10,000 years. I don't know how I show that rebar is going to last for 10,000 years."

Scott Kirk, vice president of Licensing and Corporate Compliance for Waste Control Specialists, however, offered support for the 10,000-year period. "With regards to the 10,000-year period of performance, we think that's a very good feature, and we do so because the standard that was used in Texas to license our site went beyond that," he said. "The period of performance in Texas has a time of 1,000 years or peak dose, whichever is longer. It was a two-tier sort of process, where the first part of it is quantitative and the second part is qualitative. The standard we had to comply with really allowed us to evaluate the environmental performance of our site."

Larry Camper, the NRC's director of the Division of Waste Management and Environmental Protection, said the question of an appropriate period of compliance ultimately comes down to a policy question. "A period of compliance is a policy call, and watching policy being made in Washington is like sausage—you never want to see it being made, but it's

great to eat," he said.

From the audience, John Greeves, a consultant with Talisman International, added, "The prism you have to look at this through is the two-tier system. It's what is safe, and what is safe is for the regulatory construct to evaluate the risks. The two-tier system does that, and a policy call, whether it be 1,000 or 10,000 [years], evaluates the risks early on."

In his remarks, Camper described a 1,000-year standard—as used by the DOE—as "inadequate." "I would suggest that 1,000 years is inadequate, and it's inadequate for several reasons," he said. "First, at 1,000 years, you're only evaluating societal change, you are not evaluating technical or engineering changes. I mean, if you design the system to last for a long time, in 1,000 years you simply don't have enough change to evaluate in a meaningful way in terms of technical and engineering modifications and adjustments." Moments later, Camper clarified his remarks, noting that he meant to say that the 1,000-year standard was "insufficient" rather than "inadequate."

From the audience, though, Linda Suttora, a DOE official, disputed that the DOE measures out to only 1,000 years. "We go out to peak dose and look at it," she said. "We don't make a compliance decision directly. We don't do the 1,000 calculation and stop. We go to 1,000 and make our decisions about disposal at that point." She added, "When the error bars become so great that it doesn't make sense anymore, then we may stop our decision-making at that point."

In a statement issued after the meeting, Camper sought to further explain his remarks. “The NRC staff holds the view that 1,000 years is insufficient as a period of compliance, especially for the disposal of long-lived waste such as depleted uranium that formed the basis for the ongoing site-specific performance assessment rulemaking. During the panel discussion, I used the term ‘inadequate’ rather than ‘insufficient’ but subsequently corrected my language to say ‘insufficient’ when addressing this point,” Camper said. “I want to make it clear that I meant to say ‘insufficient’ and that in no way should my comment be misunderstood to imply that the DOE process under DOE Order 435.1, which utilizes 1,000 years, is inadequate. The DOE process must be viewed in its entirety, including the fact that the DOE also evaluates for longer terms and includes a significant role for long-term stewardship.”

“In the final analysis,” Camper added, “there is no perfect time frame to use as the period of compliance, whether it be 1,000 years, 10,000 years, 20,000 years, or some longer period of time in view of the behavior of depleted uranium over a protracted period. Any selected time frame could be subject to legitimate criticism and must be viewed in the overall context of a two-tiered system that will evaluate and document the expected long-term performance of the LLW disposal system. The NRC will make a policy determination on the assigned period of compliance for the ongoing proposed rulemaking, which must consider all of the applicable technical parameters and the various stakeholder views. As I mentioned during the panel discussion, the NRC will solicit comments on the proposed rule, and at least one public meeting will be conducted by the NRC staff to discuss the proposed rule language. Ultimately, the NRC staff will carry out the direction of the commission for the final rule language around this complicated topic.”

In a separate statement issued after the meeting, the DOE defended the length of its compliance period. Candice Trummell, spokesperson for the DOE’s Office of Environmental Management (EM), said in a statement, “DOE has provided formal comments to the NRC on its Part 61

rulemaking. EM is confident that its low-level radioactive waste (LLW) disposal management system has been, and continues to be, fully protective of human health and the environment.”

The stakeholders who will ultimately be affected by the NRC’s changes would prefer consistency between the NRC and the DOE, according to some participants at the meeting. “These rules are coming from two federal government agencies, and it would be nice if we could

have some consistency there,” Shrum said. Camper pointed to state regulations as a reason for a long period of compliance. “Three out of the four Agreement States, with the fourth on its way, have conducted safety assessments that are longer than 1,000 years, and so, from a policy standpoint, one can argue that something less than 1,000 years—given that all four of the states with operating disposal facilities have value evaluated longer than 1,000 years—would be a reduction in safety.”



THE SKILLS AND EXPERIENCE TO DELIVER NUCLEAR EXCELLENCE

When you need an experienced team with a proven process for the design, licensing and deployment of innovative technologies to store, transport and manage nuclear materials, including high level waste, you can count on NAC International Inc. and its nuclear excellence.

NAC is an industry-leading provider of engineering and dependable nuclear fuel management solutions for nuclear facility operators, nuclear fuel cycle companies and government agencies.

Trusting on its proven transport cask systems and nuclear fuel cycle experience, NAC has supported more than 200 customers worldwide, covering a diverse project portfolio from its headquarters in Atlanta to offices in London.

[www.nacintl.com](http://www.nacintl.com)

[nacinfo@nacintl.com](mailto:nacinfo@nacintl.com)



- NUCLEAR FUEL CYCLE CONSULTING
- NUCLEAR ENGINEERING SERVICES
- SPENT FUEL MANAGEMENT TECHNOLOGIES
- NUCLEAR MATERIALS TRANSPORTATION

## DOE'S EFFORTS TO SHIP U-233 TO NEVADA

Attendees at the summit also heard from the director of Nevada's Department of Conservation and Natural Resources, Leo Drozdoff, on the DOE's controversial efforts to ship a portion of its uranium-233 inventory from Oak Ridge National Laboratory to the Nevada National Security Site (NNSS) for disposal. In response to concerns from Nevada officials, the DOE established a working group with state officials to discuss the plans for the material, known as the Consolidated Edison Uranium Solidification Project (CEUSP) material. The working group, Drozdoff said, could lead to a permanent process that would provide an additional layer of review by political and policy staff for other controversial waste slated for the NNSS. "What we are endeavoring to do is not to replace anything—from a technical standpoint things work well—but we are trying to build more of a robust policy arm," he said. "That policy arm would be able to collectively work with the local governments,

work with the citizenry at large."

Given historical tensions and communication issues with the DOE, Drozdoff said, the effort could help repair relationships and provide a path forward for the future of disposal at the NNSS. "This working group will be a culmination," he said. "We are not here to say you can't bring waste here. What we are looking for is a more complete discussion about why: Why is it that it should come here? What is unique about it? Why isn't it appropriate for on-site or commercial disposal? If we figure out a way to have a process to go through that evaluation, we will be OK."

The group will be led by Brad Crowell, the DOE's acting assistant secretary for Congressional and Intergovernmental Affairs, and by Michon Martin, general counsel for Nevada Gov. Brian Sandoval. Heading the panel with political, rather than technical, experts reflects the nature of the debate in recent months. "It would be great if you [could] take politics out of the equation, but you can't," Drozdoff said. "Instead of being upset about that, let's just own it.

Let's make the process a bit more broad and inclusive." So far, the working group "has yet to be fleshed out," Drozdoff said, adding that the complete membership and a schedule for moving forward are still unclear.

Frank Marcinowski, the DOE's deputy assistant secretary for Waste Management, emphasized that the group is just starting its work. "We are in the process of having those discussions with the state, and we look forward to continue having those discussions to see if we can move forward on this. But right now we are still in the early stages," he said.

Drozdoff said that the working group will be an opportunity to develop a way to improve communications about waste under consideration for disposal in Nevada. "It's bigger than the CEUSP material," he said. "I don't think it's every waste stream . . . but we have a pretty good sense of what is a unique waste stream, and perhaps this is one we should spend a little more time on." The working group would encompass a number of different "stovepipes," Drozdoff said, including transportation, disposal, and waste review. "What this work-

## Over 500,000 square feet of world-class nuclear capabilities.

At MTM, we provide manufacturing solutions to nuclear fuel cycle challenges.

- Uranium enrichment
- Fuel fabrication
- Commercial nuclear power
- Naval nuclear power
- Next generation fission and fusion systems
- Nuclear materials transport and storage
- Reprocessing, reuse, and remediation

How can we help you?



MTM  
Nuclear

a division of Major Tool & Machine

*We know nuclear ... front to back.*

**MajorTool.com**  
sales@majortool.com  
317.636.6433



MTM's Quality Assurance Program is compliant to NQA-1, 10CFR50 Appendix B, 10CFR71 Subpart H, 10CFR72 Subpart G



ing group is endeavoring to do is at a senior level and at a policy level to make sure that these stovepipes report to something, that there is sort of a catch-all umbrella that public policy will be factored into and be informed by the various technical arms,” he said.

Drozdoff acknowledged that both sides must work on improving communications. “The state has to figure out a way to not assume the worst in every situation, whether it’s issues clouded by [the] Yucca [Mountain waste repository] or the mission of EM. The state has to get to the point where it is more comfortable where it does not assume the worst every time,” he said. But likewise, DOE’s “structured” approach to waste disposal doesn’t always sit well with local officials and citizens, he added. “They don’t like being talked to. They don’t like the script. They don’t like ‘here’s the project, here’s this, here’s our authority to do it.’ What they are looking for, part of the solution is that they are looking for a meaningful discussion,” Drozdoff said. “Sometimes they feel like they want to be heard.”

### COULD DOE TANK WASTE GO TO WIPP?

At another panel session, DOE officials and nuclear experts said that the DOE could potentially save billions of dollars by disposing of some of its tank waste at the Waste Isolation Pilot Plant (WIPP) in New Mex-

ico instead of at Yucca Mountain or another high-level waste repository. But first, legal and regulatory changes would have to occur, as WIPP is currently limited to accepting only defense-related transuranic (TRU) waste. “The original constraints on material that could be disposed of at WIPP were put in place because of concerns of the potential for poor performance of that facility,” said Per Peterson, a professor at the University of California at Berkeley and a former member of the Obama administration’s Blue Ribbon Commission on America’s Nuclear Future. “Now



**DOE officials and nuclear experts said that the DOE could potentially save billions of dollars by disposing of some of its tank waste at the Waste Isolation Pilot Plant instead of at Yucca Mountain or another high-level waste repository.**

we have a lot of operating experience with both the transportation and disposal, and many of the earlier concerns that were voiced have proved to not be correct. It’s quite logical that given this base of experience, one could go back and evaluate the long-

## Frham Safety Products, Inc. Celebrating 30 Years of Nuclear Safety Protection And Product Evolution.

Vist our new website at [www.frhamsafety.com](http://www.frhamsafety.com)  
Follow us socially via Facebook, LinkedIn and Twitter



 NASHVILLE, TN 615.254.0841  
 ROCK HILL, SC 803.366.5131  
[WWW.FRHAMSAFETY.COM](http://WWW.FRHAMSAFETY.COM)



# Tool and Metal Decontamination

## Substantial Cost Recovery

- Tool, Scaffold, & Metal Decon
- Hot Equipment Offsite Storage
- Licensed Transport Services



Precise, automated monitoring for tube, planks, and clamps



Survey, storage, and inventory

- Offsite radioactive material decontamination at eleven facilities nationwide
- Process to free release motors, water tanks, drums, HVAC, tools, scrap metal, and lead
- Rad-controlled scaffold, tool, and equipment storage
- Nationwide truck fleet

ISO 9001

ISO 14001



USA Canada Germany UK The Netherlands  
A subsidiary of UniFirst Corporation

(800) 344-3824 www.UniTechUS.com

term mission of the facility.”

Tank waste is considered HLW because of how it was created, even if it meets other criteria for disposal at WIPP. Classifying DOE waste by the risk it poses rather than by its source could take pressure off the DOE in a number of areas, including leaking tanks at the Hanford Site and the need for additional storage at the Savannah River Site (SRS) for vitrified waste.

“Part of the conversation has to be what costs can you avoid and still be protected,” said Tank Waste and Nuclear Material’s Rhoderick. For example, sending waste from some of the Hanford tanks that meet WIPP criteria could shave a year off the operating time of the Waste Treatment Plant, which is under construction at the site. “Opening up WIPP would give us opportunities to have some cost avoidance within the EM system,” he said. “Right now, we have 2,300 canisters that have been produced down at Savannah River that when you put them through the criteria, they meet the current WIPP [Waste Acceptance Criteria], but they can’t go there because they are high-level waste.”

Talk of opening up WIPP to other forms of waste has gained traction in recent years following both the shutdown of the planned Yucca Mountain repository and increased budget pressures on the DOE’s cleanup program. Examining those possibilities has been largely supported by officials from southeastern New Mexico, where WIPP is located, as part of their effort to maintain jobs in the area after the DOE wraps up TRU waste missions in the next few years. The concept has also been supported by communities at other sites eager to remove waste. Last year, SRS’s Citizens Advisory Board released several recommendations urging the DOE to take a look at disposing of the site’s vitrified tank waste canisters at WIPP. And in another step, the DOE announced that it is seeking to send to WIPP more than 3 million gallons of sludge waste in up to 20 tanks at the Hanford Site.

As waste continues to be vitrified at SRS, the option to send the canisters to WIPP could avoid the need to construct additional storage for tank waste canisters. “The [vitrification] facility has been working for 17 years, and we are about halfway through producing our canisters,” said Bert Crapse, of the DOE’s Sa-

vannah River Operations Office. “A lot of that could be disposed of at WIPP.” Contractor estimates put the up-front cost for such a new storage building at \$138 million, with a life-cycle cost of up to \$180 million. The DOE is also considering building an open-air dry storage facility for the canisters instead, similar to those used at nuclear power plants, which would cut costs somewhat but is still expected to run \$80 million to \$100 million, Crapse said.

Meanwhile, Hanford tank waste faces “very serious challenges,” Peterson said. “It has proven so difficult to move waste out of those tanks and get it vitrified into forms that can be stored. We now have a number of tanks that are leaking at the site, and this poses real challenges for how to manage that waste,” he said. “One of the technical options that has emerged is the option of taking at least some fraction of the tank waste, and removing it from the tanks and drying it and packaging it in containers that would be compatible with disposal in a salt repository.” Such a move would “reduce the burden on vitrification facilities at Hanford and the cost in the longer term.” And, he added, “If initial efforts go well, the necessary legal changes could be made to support having a larger fraction disposed of in this way.”

Vitrification was chosen as the option for tank waste because the characteristics of an ultimate repository were uncertain at the time, officials noted. But the properties of salt, which is generally elastic and self-sealing, make vitrification unnecessary. “It is important to note that if you have the option to place these materials into a salt repository like WIPP, then there would be no logic to putting in additional barriers in terms of the waste form,” Peterson said, adding, “If the technical path were put in place where a salt repository does become the disposal path for these materials, then you could save an enormous amount of money and time in terms of processing.” ■

*This report was prepared by the editorial staff of ExchangeMonitor Publications. For additional information, contact Mike Nartker, editor-in-chief, at [nartker@exchangemonitor.com](mailto:nartker@exchangemonitor.com).*

# THE ANNUAL RADWASTE SUMMIT

SEPTEMBER 2-5, 2014

JW MARRIOTT SUMMERLIN, NEVADA

**The Annual RadWaste Summit, now in its eighth year, is the premier event linking the radioactive waste management community with the decisionmakers.**

**Highlight Your Company, Project or Product**

**Partnership and Exhibiting  
Opportunities are Available!**

**For our 2014 RadWaste Summit Partnership & Exhibit Kit,  
contact our Forums office at 202-296-2814 x109  
or via email at [forums@exchangemonitor.com](mailto:forums@exchangemonitor.com)**

**For registration, partnership, and agenda information...**

**[WWW.RADWASTESUMMIT.COM](http://WWW.RADWASTESUMMIT.COM)**

***A report from the 25th Annual Weapons Complex Monitor Waste Management & Cleanup Decisionmakers' Forum, held October 21–24, 2013, in Jacksonville, Fla.***

## The DOE, State Regulators, and Small Businesses—and Budgets

The Department of Energy's efforts to continue to push forward with cleanup activities at its various sites while operating in a tough budgetary environment was one of the main topics of discussion at the 25th Annual *Weapons Complex Monitor Waste Management & Cleanup Decisionmakers' Forum*, held October 21–24, 2013, at the Omni Amelia Island Plantation in Jacksonville, Fla. More than 300 representatives from the DOE, the contracting industry, and state and local governments attended the event, which took place shortly after the federal government's 16-day shutdown ended. While the shutdown led to furloughs at the Savannah River Site (SRS), the Paducah Gaseous Diffusion Plant, and Los Alamos National Laboratory (LANL), much of the DOE's cleanup program was able to continue operating using carryover funding. "We really dodged a bullet. We did have some impacts at Savannah River, some small impacts at Paducah, and then subcontractors at Los Alamos," said Colin Jones, chief of staff for the DOE's Office of Environmental Management (EM). "If the shutdown had gone on for another few days or a week, we'd have been looking at potentially 8,000 to 10,000 furloughs at Oak Ridge, Rich-

land, and Idaho. Fortunately, [with] the timing of the deal that was done, we were able to prevent those shutdowns."

The government shutdown may have set back a key mission at LANL that aims to ship 3,706 m<sup>3</sup> of above-ground transuranic waste off-site for disposal by June 2014. LANL had been ahead of schedule on the shipments at the end of fiscal year 2013, having shipped 2,745 m<sup>3</sup> since the campaign started, compared to the goal of 2,600 m<sup>3</sup>. "That work was stopped for two weeks; it will be restarted this week," Jones said. "We did have some contingency in the schedule there, but we'll have to see whether that schedule contingency has been eaten up and whether we'll be able to meet the June 2014 deadline for removing all that waste out there."

In separate remarks at the meeting, Jack Surash, EM's deputy assistant secretary for Acquisition & Project Management, praised EM, the various DOE site offices, and contractors for their efforts in managing the impacts of the shutdown. "I really want to congratulate everybody on how well the entire team performed over the last couple of weeks during the tremendous uncertainty caused by the lapse of the fiscal year 2014 ap-

propriations," Surash told the gathered industry officials. "I saw a great integration in terms of budget, human capital, project and contract management, nuclear safety, programmatic, and those sorts of things. I saw this not only at headquarters, but at the site level. And this was led by the capable hands of [EM Senior Advisor] Dave Huizenga."

### EM'S RELATIONS WITH STATE REGULATORS

Another topic of discussion was EM's relationships with state regulators in the tough financial climate, with issues of increased pushback from state regulators in South Carolina and Washington on potential missed milestones for high-level waste cleanup and the current budget situation at the DOE, according to Jones. While EM enjoyed ample funding in recent years thanks largely to the Recovery Act, the DOE's cleanup program is now facing a more constrained budgetary environment that has led to a sharp proposed cut in funding next year for SRS's tank waste cleanup and concerns regarding the Hanford Waste Treatment and Immobilization Plant (WTP), Jones said. "For the first time

in a long time, we are having to make some really, really hard choices about what we can, can't do," he said. "I get the frustration of you having a facility that is operational and not being able to fully utilize that, but is that better than having no facility at all? These are the types of questions we have to ask ourselves as we try and manage the budget from a complex-wide perspective."

### The State of South Carolina

The state of South Carolina, however, is frustrated because it believes it is bearing the brunt of the budget cuts in the cleanup complex. SRS's tank waste cleanup allocation was cut \$183 million in the DOE's FY 2014 budget request, which would lead to delays in HLW work and numerous missed commitments to the state on tank closure. "We got the biggest reduction in terms of EM budget dollars," said Shelly Wilson, of the South Carolina Department of Health and Environmental Control (SCDHEC). "Can you make progress based on that budget? The answer is no, I don't believe they can meet all the commitments to risk reduction that they have for South Carolina. I'm aware that the entire nation is struggling with budget. But if you look at the decisions that DOE is making internally within EM, it is still obvious that South Carolina is getting slammed."

SRS has a fully operational liquid-waste system that led to the full closure of two tanks last year, with two more scheduled to be closed in the coming months, Wilson emphasized. "We thought that we had everything lined up in a crystal-clear path for all the dominoes to fall in place right after that, one after the other, in a manner very similar to the closure of the first two [tanks] and the recent two," Wilson said. "We are in a very unique position today from the state perspective. We are not arguing over technical or regulatory issues. The path forward is very clear on how to close the tanks. Most of the documents are already approved, so right now we are aligned, and we have been very cooperative in our approach. That is a very rare thing. All we need to make that happen is the appropriate budget."

The failure to request an adequate budget has changed the state's ap-

proach to conversations with the DOE, and in August, SCDHEC sent a letter to the DOE warning of hefty fines if milestones are not met. "We have always been cooperative and in a very partnering mode, and we are seeing that in this particular case with the 2014 budget that has not served us," Wilson said. "We are moving into a mode where we are spelling out our concerns and doing it in as loud a way as possible."

The DOE's decision on SRS liquid waste funding was based mainly on

the overall budget situation, according to Jones. "We, too, take it very seriously, our commitments to managing the liquid waste at the Savannah River Site. Between Savannah River, Hanford, Idaho, [tank waste] is our biggest risk activity, and when you look at the annual budget every year, that's where the majority of our funding goes to," he said. "We've been living in a different financial setting now. In FY '13 we had to deal with sequestration," he added, and took a hit of about \$400 million. He also



## RAD WASTE PROBLEMS?



### EQ IS THE ANSWER

EQ's nationwide network of treatment and disposal facilities offers reliable, safe and cost-effective solutions for all your waste streams. From disposal of radioactive waste including NORM/TENORM to RCRA regulated material, EQ offers the widest range of hazardous waste disposal options and waste treatment capabilities to ensure we can provide you with the best option for your specific needs.

- NORM/TENORM
- Radioactive Waste
- Hazardous and Non-Hazardous Waste Treatment and Disposal
- Remediation Transportation
- Industrial Services

### EQ-THE ENVIRONMENTAL QUALITY COMPANY

NATIONWIDE SERVICES • [WWW.EQONLINE.COM](http://WWW.EQONLINE.COM) • 800-592-5489

noted that there are issues dealing with budget caps.

When the DOE comes to renegotiate milestones with South Carolina, the state—in addition to its requests for adequate funding—wants the DOE to propose mitigation strategies. “We’re expecting DOE to come with something in hand that’s a trade,” Wilson said. “In asking for an extension, can they give an alternative treatment or speed it up? As long as DOE is willing to bear some of the burden or risk and some of the commitment, then all of a sudden, our mind-set changes.” Such strategies could include increasing the site’s interim waste treatment capability, or preparing for the implementation of new waste treatment technologies, such as Next Generation Solvent or the Small Column Ion Exchange.

### The State of Washington

In the state of Washington, the DOE has warned state regulators that a set of WTP milestones contained in a 2010 consent decree is now at “serious risk” of being missed. To renegotiate any milestones with Washington, the DOE must request adequate funding in its budgets, said Jane Hedges, of the Washington State Department of Ecology. “For Washington, we have expressed to DOE many times, they have to ask for the money they need to do cleanup,” Hedges said. “If Congress doesn’t give them the money, then they have an argument under our [Tri-Party Agreement] and under our consent decree. But they have to ask, and that means that the administration has to ask as well.” She added, “There are some trust issues around that. The technical issues are easier for all of us. We can see a technical issue and we can talk about it.”

### WHAT FUTURE FOR SMALL BUSINESSES?

The current budgetary environment has also posed challenges for small businesses operating in the DOE marketplace, industry representatives noted. Small business prime contracting for EM peaked at about 12 percent during the infusion of funds provided by the Recovery Act and has since settled to about 7.9

percent last fiscal year. Lower funding levels, however, have also prompted prime contractors to change approaches in subcontracting. “We are seeing some of the effects of a downturn in funding. It makes doing additional work that is not already under contract very difficult, and it will motivate prime contractors to cut costs,” Surash said.

Small businesses across the DOE complex have expressed concern as a number of prime contractors have made significant changes to subcontracting strategies. Notably, Hanford cleanup contractor CH2M Hill Plateau Remediation Company decided in January 2013 to largely self-perform work that had previously been subcontracted, and Oak Ridge cleanup contractor URS-CH2M Oak Ridge last year moved to a staff augmentation-based approach from task-oriented subcontracting. “The ability to perceive the value of the small businesses is being diminished

business work. “In our case, we lost more than 20 percent of our workforce overnight going through a particular disadvantage. That was an inadvertent consequence not related to our performance, not related to anything other than the way the contract was set up and the needs of the prime.”

Surash said that EM is aiming to maintain its small business prime contracting at about 6 to 7 percent but that there is little that EM can do related to subcontracting. “Whether that prime contractor wants to in-source that work to become more efficient, there is nothing I can do about it,” Surash said. “So all I can do is hold our prime contractors accountable for meeting their subcontracting goals. Some of our prime contractors, as you’re aware, we require for X amount to be subcontracted; some we don’t.”

But Gallagher disagreed. “The role of EM overseeing the primes in their

**“We are a big believer at EM of the value of small businesses. They are not going to be doing all of our work, but we would like to sustain or grow it.”**

every day; it’s not a bright picture for us at this point,” said Phil Gallagher, of Babcock Services. He added, “The current state of the primes not renewing small business subcontracts, not encouraging small business subcontracts and self-performing work, and actually absorbing the skills and resources of small businesses into the companies to self-perform more work cripples companies.”

Several small businesses noted that they have lost a significant number of employees due to changes in subcontracting from the primes. “The reduced budgets had some inadvertent consequences, such as the internalization of work. Because there was less subcontracting being done, the type of subcontracting mix for certain primes has changed,” according to Matt Moeller, chief executive officer of Dade Moeller. He noted that one prime contractor his company worked with had a performance award fee that required it to contract a certain level of disadvantaged small

subcontracting roles isn’t being policed very well,” he said, and warned that eventually there could be unintended consequences for the DOE. “Even if EM’s numbers climb up into the 6 [or] 7 percent [range], that loss at the other side, which is significantly more to begin with, is just going to result in the decline of small business opportunities,” he said. “It will actually make it harder for Jack [Surash] because there will be less companies to bid and less skill sets and less resources to go after the work he needs to get contracting. It’s spiraling the wrong way at this point.” Moeller added that “the number one threat to small businesses” is losing intellectual capital “literally overnight” as a result of prime contractor decisions.

The lack of meaningful subcontract work in the complex may also keep business from developing the experience and project management skills needed to grow, said Steve Moore, president of Wastren Advantage Inc. “We didn’t just wake up one

day and become a DOE prime contractor," he added. "I would describe the small business environment right now as a mile wide and an inch deep. . . . Unless you are able to develop the infrastructure, the experience, and kind of cut your teeth in a variety of different subcontracted areas, it's going to create more challenges for the sustainability."

"At EM we care about small business," Surash emphasized, noting that he is also looking at subcontracting. "We are really interested in the whole deal here. [Small business contracting] is still not that high, quite frankly, compared to other agencies," he said. "If you took all of our prime and subcontract work done by small businesses and add it all together, I think you'd get maybe 20 percent." He noted that the federal government's goal for small business contracting stands at about 23 percent.

And, Surash added, despite the downturn in funding, EM is focused on growing its prime small businesses at each site in the complex. "We are after a sustainable small business program," he stated. "We essentially attempt to set aside every single contract. That's the way we are able to drive small business. . . . Going in, it is 'can we set this aside for small business, can we create opportunities for small business, can we do some one-offs, can we split a big contract and pull something out?' At the end of the day, we are a big believer at EM of the value of small businesses. They are not going to be doing all of our work, but we would like to sustain or grow it. We are looking for meaty work for them to do."

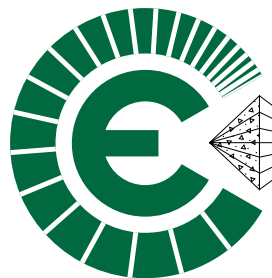
One way for small businesses to remain competitive is to participate in a mentor-protégé program, said Amar Raval, of TerranearPMC, which has such a partnership with EnergySolutions. "It's great to go down the path of putting this agreement in place, but it takes a big commitment from both sides to make it successful," he said. "We did it to be able to go after the larger and more complex projects. In some cases we were successful, and in others we weren't. That's a dynamic you're going to see. If you want to play in more competitive, complex procurements, there are not too many small businesses that can do it alone."

In the end, small businesses need to provide and not just be seen as a sta-

tistic, Moeller emphasized, stating that participation is key. "It can't be dictated. It has to be real. It means that small businesses have to add value. And, what we need in return for that is support to sustain small businesses," Moeller said, stating that sustainability is based on a few concerns. "The major one is intellectual capital. Don't take intellectual capital; let our employees be our employees. And number two, expect more of small businesses. Expect them to have work in other than the DOE marketplace. Ex-

pect them to have past performance that shows a competence and depth of resources that is not just minimally adequate but exceptional for whatever that piece of work may be." ■

*This report was prepared by the editorial staff of Exchange Monitor Publications. For additional information, contact Mike Nartker, editor-in-chief, at [nartker@exchangemonitor.com](mailto:nartker@exchangemonitor.com).*



**CUTTING EDGE**  
SERVICES CORP.

**"NUCLEAR"**

## CUTTING TOOLS & SERVICES

From superabrasives to shears, Cutting Edge has been deploying innovative cutting tools since 1997. Our CEO & founder, Tim Beckman, helped pioneer diamond wire sawing for removal of bioshield walls in 1983 (HB Robinson SGRP).

We provide design, fabrication & field services for wire saws, pole saws, wall saws, core drills & robotic devices.

- BROKK Robotic Concrete Demo
- SGRP Containment & Bio Openings
- Large Diameter & Deep Hole Drilling
- Water Powered Cutting Tools
- RV, SG & Tube Bundle Cutting

**513 / 388-0199**

**513 / 732-1248 (fax)**

[beckman@cuttingedgeservices.com](mailto:beckman@cuttingedgeservices.com)

[www.cuttingedgeservices.com](http://www.cuttingedgeservices.com)

*"The **CUTTING EDGE** of Technology"*

**Cincinnati - Seattle - Houston**

**ANS Best Oral  
Presentation  
Waste  
Management  
2013**

# Communicating Performance Assessment Results

*The primary goal of communicating the results of performance assessments prepared to support the closure of waste tanks at the Savannah River Site is to provide a clear understanding of the involved risks.*

By Mark Layton

The F-Area tank farms and the H-Area tank farm at the Savannah River Site (SRS) are owned by the U.S. Department of Energy and operated by Savannah River Remediation LLC, the liquid-waste operations contractor at SRS. These tank farms are active radioactive waste storage and treatment facilities consisting of 51 carbon steel waste tanks and ancillary equipment such as transfer lines, evaporators, and pump tanks.

Performance assessments (PA) for each tank farm have been prepared to support the eventual closure of the underground radioactive waste tanks and ancillary equipment. PAs provide the technical bases and results to be used in subsequent documents to demonstrate compliance with the pertinent requirements for final closure of the tank farms.

The tank farms are subject to a number of regulatory requirements. South Carolina regulates tank farm operations through an industrial wastewater permit and through a Federal Facility Agreement approved by the state, the DOE, and the Environmental Protection Agency (EPA). Closure documentation will include state-approved tank farm closure plans and tank-specific closure modules utilizing information from the PAs. For this reason, the state of South Carolina and the EPA must be

involved in the PA review process. The residual material remaining after tank cleaning is also subject to reclassification prior to closure via a waste determination pursuant to Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005.

PAs are performance-based, risk-informed analyses of the fate and transport of the F-Area and H-Area residual wastes following final closure of the tank farms. Since the PAs serve as the primary risk assessment tools in evaluating readiness for closure, it is vital that PA conclusions be communicated effectively.

In the course of developing the tank farm PAs, the following lessons learned have emerged regarding the communication of PA results:

- It is important to stress that the primary goal of the PA results is to provide risk understanding, recognizing the magnitude of risk and identifying the conceptual model decisions and critical assumptions that most affect the results.
- Conceptual models should be communicated that describe reality using simplified, mathematical approaches, along with their roles in arriving at the PA results.
- When presenting PA results, evaluations should typically focus on a single baseline (or base case) to provide a foundation for discussion.
- PA results should be supplemented by other studies (alternate configurations, uncertainty analyses, and sensitiv-



ity analyses) to provide a breadth of modeling for the base case. The suite of information offered by the various modeling cases and studies provides confidence that the overall risk is understood, along with the underlying parameters and conditions that contribute to risk.

Used to assess the long-term fate and transport of residual contamination in the environment, PAs provide the DOE with reasonable assurance that the operational closure of the SRS tank farms (waste tanks and ancillary equipment) will meet defined performance objectives for the protection of human health and the environment into the future.

PAs are intended to estimate consequences of facility closure over time, both chemically and radiologically, and are typically most focused on determining “peak dose” or “peak concentration” (i.e., the worst results over a one-year period) throughout an extended period of evaluation. PAs reflect the uncertainty that is inherent in conceptual modeling and also identify key parameters for which the models have the greatest sensitivity (i.e., the key parameters of greatest importance).

### PRESENTING PA RESULTS

When communicating PA results, it is important to stress that the primary goal of the PA is to provide risk understanding. PAs provide information regarding relative magnitudes of risks and need to clearly articulate the expected risks under the most probable and defensible conditions. PAs should build confidence that projected doses are reasonably likely to be within a given standard of comparison.

PAs quantify the general magnitudes of risks involved and identify the conceptual model decisions and critical assumptions that have the most impact on results but are not typically constructed to calculate precise dose results. PA results are not meant to be a precise prediction of actual doses to real people or an assessment of worst-case scenarios. What is most important for the PA results is to provide perspective on the significance of various features captured in the conceptual model and to demonstrate an understanding of the system.

In order to best communicate results, PAs require a breadth of modeling that recognizes that there is no single “right” approach to assessing the long-term fate and transport of residual contamination. Attacking the prob-

lem on multiple fronts is one way to address modeling uncertainty. PAs should concentrate on defining a most probable and defensible modeling case (i.e., the baseline modeling scenario, or base case), but should also supplement the base case with a full toolbox of additional models and studies. It isn’t helpful to pretend that the base case results are absolute and infallible—the uncertainty surrounding conceptual modeling and time-sensitive inputs requires that PA results be presented within their underlying context.

### THE ROLE OF THE BASE CASE

A PA utilizes conceptual models that are reasonable simplifications of the closure systems being evaluated. It is not important that the model capture all design features of the closure system, but it is important that it capture features that have an impact on results. The base case provides the foundation for understanding PA results. The consideration of results requires common ground for discussing risk (base case) and uncertainty. Ensuring that there is a single modeling case with well-understood design elements allows for the discussion of results from a common framework. It is also important to note that while the base case captures the best knowledge available, it will still allow for the introduction of new knowledge.

PA results are often used for comparison with regulatory standards or performance objectives. Establishing the base case as the most probable and defensible modeling case provides justification for its use as a “comparison” case. Initial modeling and research efforts should be geared toward maximizing understanding of the base case, thus providing confidence that the system performance is well understood. The base case captures system behavior in such a way that differences from expected behavior are understood and justified.

Once a base case is established, the most effective way to communicate PA results is to display underlying facets of the base case in multiple graphic and tabular formats. For example, running a base case model can produce a single peak radiological dose result over time (i.e., the peak all-pathways dose to a member of the public), as shown in Fig. 1, but that single dose curve does not convey the spatial complexity involved when determining peak doses. Figure 2 shows that the location of the peak dose changes over time with respect to the modeling sectors.

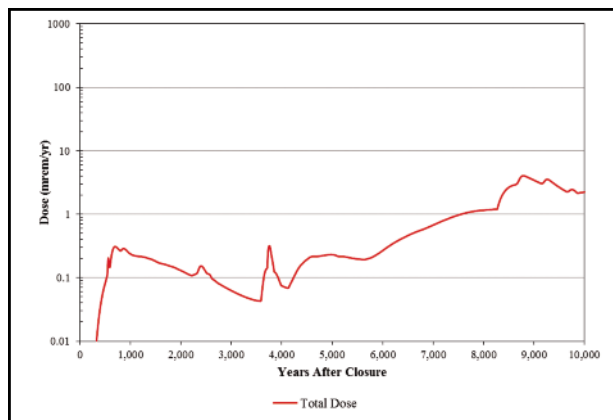


Fig. 1. Base case peak dose over time.

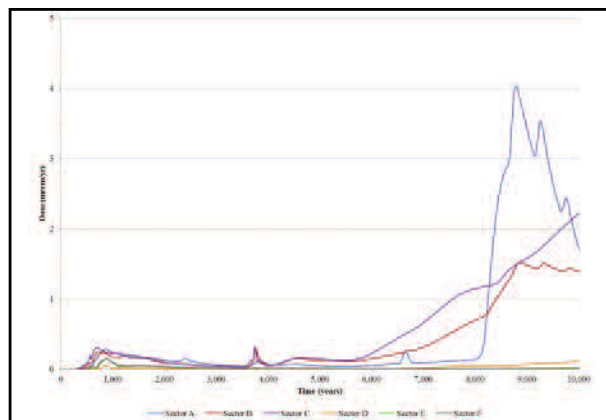


Fig. 2. Base case peak dose over time by sector.

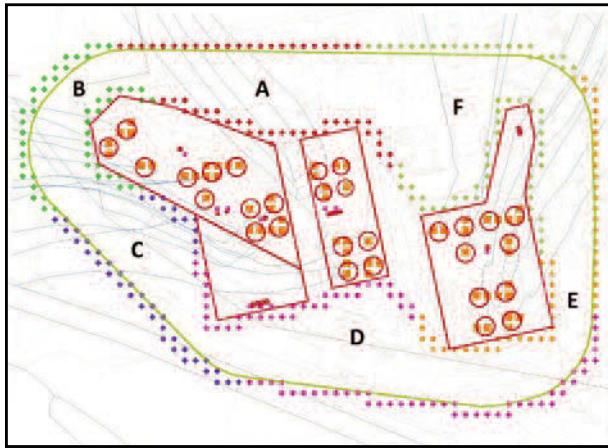


Fig. 3. Model evaluation sectors.

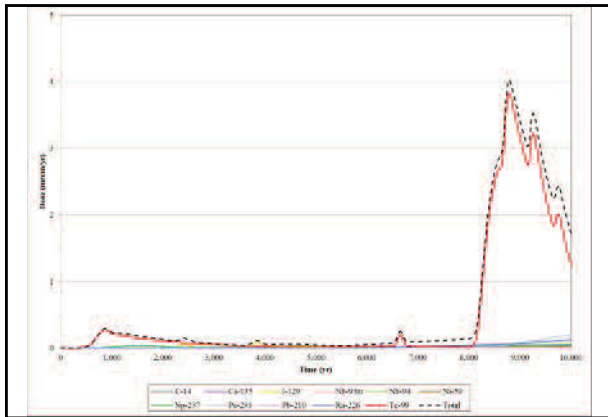


Fig. 4. Base case individual radionuclide contributors to Sector A peak dose.

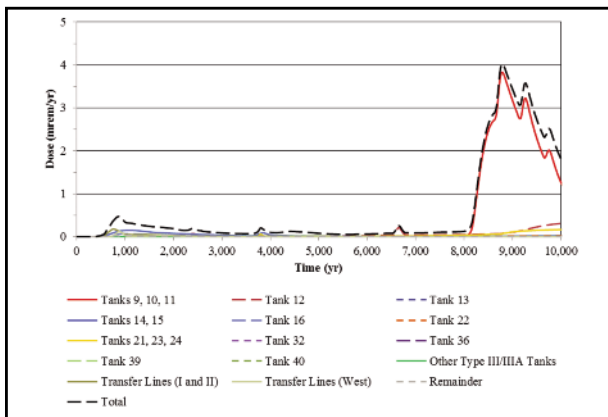


Fig. 5. Base case individual source contributors to Sector A peak dose.

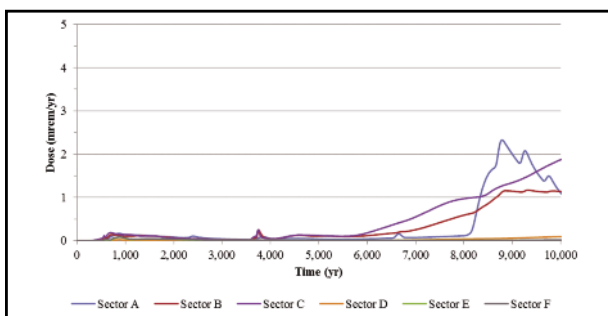


Fig. 6. Base case water ingestion contribution to peak doses.

The various sectors, shown in Fig. 3, allow variability in peak concentration for different areas of the H-Area tank farm to be more easily evaluated. Figure 4 shows that the radionuclides contributing to the peak dose also change over time, and Fig. 5 illustrates which inventory sources contribute to the peak dose over time. Finally, to help in understanding how the makeup of the dose scenario (e.g., water ingestion versus vegetable ingestion) affects the total dose, Fig. 6 shows how the water ingestion dose contribution to the peak dose changes over time.

It is important to convey and clearly explain the radiological and inventory complexity involved when determining peak doses, since many of the modeling inputs and barriers to release are dependent on timing, location, source term, radionuclide contributions, or dose pathways. These figures provide a better understanding of the model and where the system may be sensitive to different assumptions.

### ADDITIONAL MODELING TO SUPPORT THE BASE CASE

With a base case established as a foundation for assessment, additional modeling should be performed in support of the base case. These additional studies serve different purposes and can be useful in communicating different ideas. Alternate configurations can be modeled to show the impact of specific modeling choices. These alternate configurations would use the base case as a starting point but would demonstrate how changes to the base case influence results. For example, the base case could be modified to show what would happen if a closure cap were not put in place (Fig. 7). This analysis can then be used to facilitate discussion of the role of the closure cap and its impact on modeling results.

In addition to alternate configuration evaluation, sensitivity studies can also provide insights relative to the base case. Sensitivity studies should focus on areas of importance, initially informed by an understanding of the base case, with additional understanding building iteratively through the performance of multiple sensitivity studies. One area that needs to be emphasized as part of the sensitivity analyses is the performance of design elements that serve as barriers to release, such as waste tank steel liners and waste tank concrete basemats. Barrier analyses validate the base case model construction with regard to whether the base case captures those design features that can have a significant impact on results. For example, Fig. 8 shows a sensitivity analysis where the base case was modified to show the impact on peak dose if the cementitious materials that are used degrade at different rates (both faster and slower).

Sensitivity studies should also investigate the importance of critical modeling inputs and assumptions. For example, Fig. 9 shows a sensitivity analysis where the base case was modified to show the impact on peak dose if soil retardation properties are varied. The sensitivity analysis in Fig. 9 compares base case (normal) soil behavior to modeling where the soil is less effective by degrees (one-half and one-quarter) in retarding the movement of radionuclides through soil after release from the waste tanks.

Understanding of the PA results is further improved through uncertainty analyses. Uncertainty is inherent in

simplified numeric models that attempt to replicate engineered or natural systems. Supplementing the base case deterministic model with probabilistic models provides a vehicle to explicitly quantify parameter uncertainty in order to bound the range of possible dose outcomes.

The probabilistic model can be run multiple times to develop results to support the probabilistic analyses. The modeling runs use the Monte Carlo method to sample uncertain parameters. Each modeling run performs multiple realizations, where each realization represents a unique possible future outcome. The Monte Carlo method samples values from each of the uncertain parameters during each realization. Collectively, the multiple runs and realizations cover a probabilistic range for each parameter. The results of the independent realizations are assembled into probability distributions of possible outcomes, which provide insight into the base case model. Figure 10 is a statistical time history showing peak dose variability for a set of 1,000 base case realizations.

In addition to graphic statistical analysis, the uncertainty analysis can be used to investigate which probabilistic modeling realizations most affect the overall results. The results with the highest dose consequences can be reviewed to identify which combination of parameters, when they occur concurrently, produces dose results that are significantly higher than others. Parameters of interest are identified that have the greatest potential to influence the results. For example, a review of the peak realizations revealed that technetium-99 inventory variability was a modeling parameter that often showed up in the peak realizations. This investigation of realizations of interest provides another source of knowledge about the assumptions that most affect the conceptual model.

## BETTER UNDERSTANDING

As noted earlier, the primary goal of the PA results is to provide a better understanding of the risks associated with the fate and transport of contaminants following the final closure of SRS's F-Area and H-Area tank farms. To achieve this goal, the PA should provide results that concentrate on the relative magnitude of risk while identifying the conceptual model decisions/critical assumptions that most affect these results. Having a single baseline or comparison modeling case (i.e., base case) as a foundation for discussion makes achieving the desired understanding of risk easier. The PA base case results should be supplemented by other studies (alternate configuration, uncertainty analyses, and sensitivity analyses) that provide a width and breadth of modeling to supplement the base case. The suite of information offered by the range of modeling studies ties together to show which decisions/critical assumptions have the most impact on the results, providing confidence that the overall risk and the underlying contributors to risk are understood. ■

*Mark Layton is a principal engineer with Savannah River Remediation LLC. This article is based on a paper presented at Waste Management 2013, held February 24–28, 2013, in Phoenix, Ariz. Copyright WM Symposia Inc.*

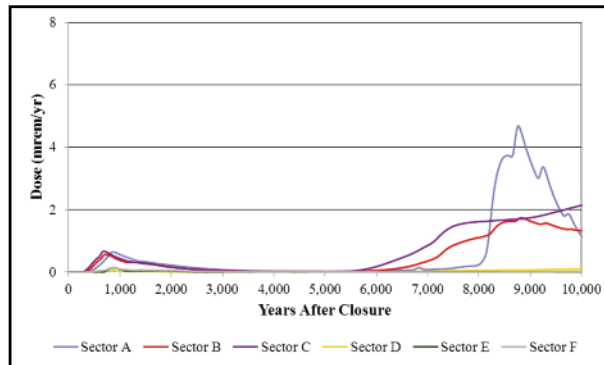


Fig. 7. No closure cap case peak dose over time by sector.

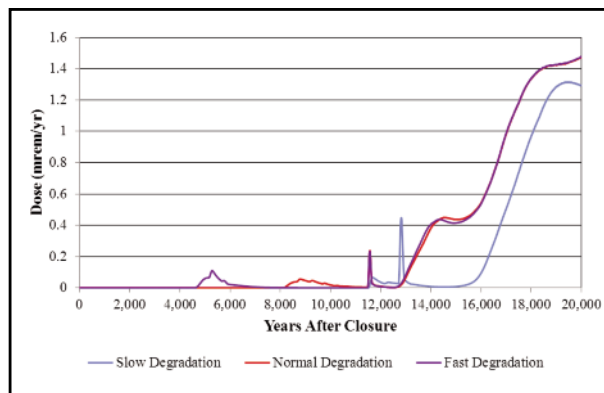


Fig. 8. Impact of cementitious material degradation timing on peak dose.

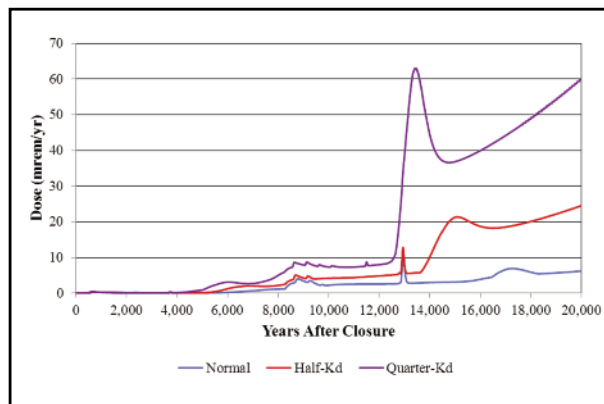


Fig. 9. Impact of soil Kd variability on peak dose.

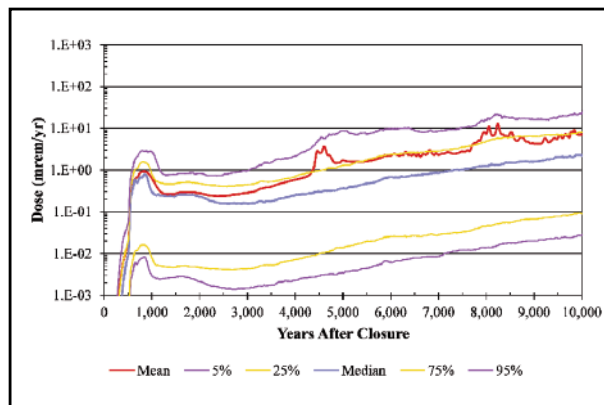


Fig. 10. Statistical time history of base case doses.

ASME Best Oral  
Presentation  
Waste  
Management  
2013

# Studies, Transport, and Treatment Concept for Boilers from the Berkeley Nuclear Power Plant

*In the first project of its kind in the United Kingdom, Studsvik was contracted to transport five decommissioned boilers from the Berkeley nuclear plant site to Studsvik's waste treatment facilities in Sweden for metal treatment and recycling.*

By Bo Wirendal, David Saul, Joe Robinson and Gavin Davidson

Among the first generation of nuclear reactors in the United Kingdom, the Berkeley nuclear power station had two natural uranium-fueled Magnox reactors (Fig. 1 illustrates the Magnox reactor principle). Both units at Berkeley came into service in 1962 and continued operation until Reactor 2 was shutdown in October 1988, followed by Reactor 1 in March 1989.

Each reactor had eight boilers (heat exchangers) located in housing structures external to the reactor building and connected by gas ducts aboveground (inlet duct) and belowground (outlet duct).

Berkeley was the first commercial nuclear power station in the United Kingdom to undergo decommissioning, and so far, this has included the removal of all fuel from the site in 1992, and the demolition of structures such as the turbine hall in 1995 and cooling ponds in 2001. The current stage of decommissioning is to prepare the site for long-term care and maintenance.

Each boiler comprises a 28.6-mm-thick, mild steel pressure vessel, 5.33 m in diameter and 21.34 m in length, with domed ends. Each vessel was held by a support skirt assembly. Inside the pressure vessel is a square section duct that runs the full length of the boiler pressure vessel and was

connected to the upper and lower gas ducts via inlet cone and outlet cone assemblies. This square section duct houses the boiler tube banks, which are positioned horizontally.

Between the square section duct and boiler pressure vessel is an interspace that enabled access to the vessel and the tube banks. This was achieved by means of hinged doors on the internal duct and access penetrations on the outside of the pressure vessel. Vertical access ladders and hinged trap doors enabled personnel to climb the length of the pressure vessel.

As part of the decommissioning program, all boilers were de-lagged and disconnected from the inlet and outlet gas ducts. The upper gas ducts were removed and size-reduced, and blanking plates were fitted to the gas duct apertures at the top and the bottom of the boiler pressure vessel. The water-side headers and recirculation penetrations were cut and blanked on the outside of the boiler pressure vessel.

In 1997, the boilers were lifted from their support skirts, transferred to a horizontal position, and placed around each reactor building (Fig. 2). The boilers were positioned in pairs, with each placed on two support saddles.

The total weight of each boiler is approximately 311 metric tons (t). This was recorded from the crane's weighing device used during the lowering of the boiler from its vertical position. The estimated makeup of the boiler weight is as follows:

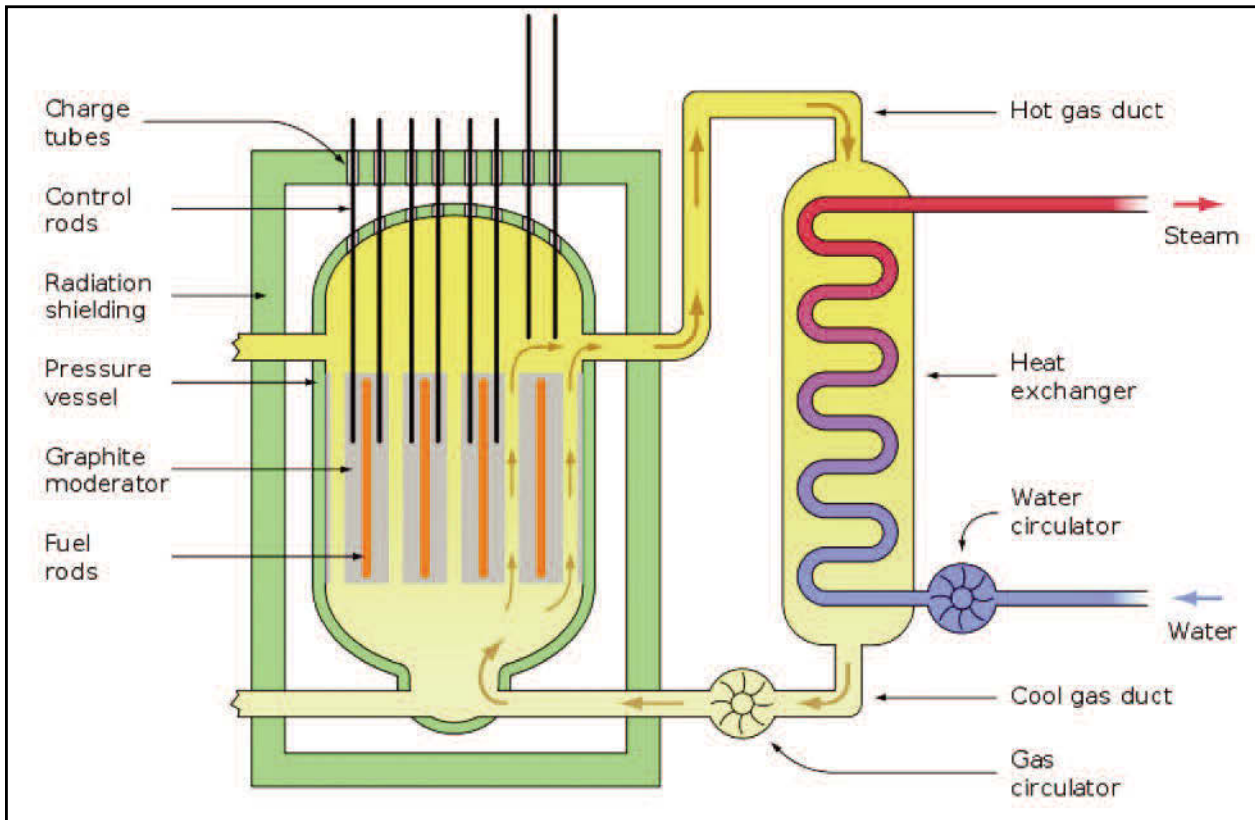


Fig. 1. Schematic of a Magnox reactor showing the reactor and boiler.



Fig. 2. Unit 1 at the Berkeley nuclear power station in safe storage condition, with the boilers shown stored horizontally next to the reactor building. (Photo: Magnox Ltd./www.magnoxsites.com)

Pressure vessel: 91 t.  
 Support beams and associated steelwork: 30 t.  
 Tube boxes: 33 t.  
 High-pressure superheater tubes: 16 t.  
 Low-pressure superheater tubes: 13 t.  
 Evaporator and economizer tubes: 100 t.  
 Total: 283 t.

The remainder of the 311 t comprises ladders, other pipework, and various other items.

Following the lowering operations, boiler No. 10 was size-reduced in a purpose-built temporary containment structure and the steel sections were decontaminated. All of the 15 remaining boilers remained in place, subject to ongoing maintenance and inspection.

Recirculating carbon dioxide gas was used to transfer heat from the reactors to the boilers via the upper gas ducts. The gas cascaded down through the boilers and was returned to the reactor via the lower gas ducts. As a result, the internal surfaces of the boilers, boiler tubes, steelwork, and vessel internals, were exposed to hot radioactive gas carrying particulate and are therefore contaminated. As tritium was present in the recirculating gas during operation, diffusion into the steelwork is known to have occurred.

The steelwork is not irradiated, and the radionuclide fingerprint identifies that the main radionuclides are tritium, carbon-14, and cobalt-60. Total activity for all 15 boilers was estimated to be 532 GBq (an average of 35.5 GBq per boiler).

The total weight of the boilers is estimated to be 4,670 t, which gives a total specific activity of 114 MBq/t, therefore classifying them as low-level radioactive waste under the U.K. system of radioactive waste classification.

Measurements taken within the pressure vessel during 1997 identified the following radiological information:

Dose rate: 50  $\mu$ Sv beta/gamma; 20  $\mu$ Sv gamma.

Contamination: 500 counts per second beta by RM6/BP4 probe.

No significant alpha contamination.

No evidence of contamination had been found within the water side of the boiler or in the steam pipework, and the internals of the boiler tubes were thought to be free of surface contamination.

## RADIOLOGICAL CHARACTERIZATION

To allow Magnox Ltd. to produce decommissioning strategies, a program of characterization work was carried out on the boilers and other Magnox boilers from the late 1980s onward. In 1987, gamma spectrometry measurements and swabs were taken primarily from boiler No. 7 at Berkeley, with additional measurements from four other boilers. The gamma spectrometry readings

*It was noted in one report that while the boiler shell represents approximately one-third of the total mass of the boiler, the internal surface of the shell accounts for only 3 percent of the total radioactive inventory, based on the assumption that all internal shell surfaces are contaminated to the same extent.*

from within the boilers identified Co-60 as the dominant gamma-emitting nuclide. Counting with the use of high-resolution gamma spectrometry and subsequent analysis of the swab samples was carried out to determine the low-energy gamma- and non-gamma-emitting nuclides as ra-

tios to the Co-60. A small number of radionuclides were inferred from the decay chains of those nuclides already identified through sampling and analysis. It was noted in the analysis report that the tritium inventory may be underestimated, as tritium is known to diffuse into the boiler steel itself, as well as being present as loose contamination. In light of this, in the mid-1990s, as part of the dismantling and decontamination of boiler No. 10, steel samples were taken, and actual levels of tritium within the steel were determined using liquid scintillation counting methods. Interestingly, it was noted in one report that while the boiler shell represents approximately one-third of the total mass of the boiler, the internal surface of the shell accounts for only 3 percent of the total radioactive inventory, based on the assumption that all internal shell surfaces are contaminated to the same extent. Through the collation of the sample and analysis information, the fingerprint and the expected inventory of a boiler were generated by Magnox.

Following the dismantling of boiler No. 10, Magnox carried out continuous health physics monitoring of the boilers. In support of the procurement for the supplier to remove, transport, and treat the boilers, it was necessary to produce a waste characterization form detailing the physical, chemical, and radiological inventory of the boilers. In conjunction with the Magnox Support Office, the Berkeley site collated all the available information, including retrieving archived information relating to disposals from the dismantled boiler. In the extensive characterization work carried out by Magnox, nearly 20 years was detailed in six reports held by the Berkeley site. This information was summarized and the radiological inventory was decay-corrected to bring it up to date.

## INTRODUCTION TO THE BERKELEY BOILERS PROJECT

The Berkeley boilers project was initiated by Magnox during 2011 and started as a Magnox graduate student project. The second-year graduates were asked to look at options for the removal, transport, and treatment of the boilers. As part of this project, the U.K. Low Level Waste Repository (LLWR) was engaged to provide advice on what options existed in the supply chain.

The graduate students initially suggested that the preferred option was to cut the boilers into three sections, each weighing approximately 100 t, for transport off-site for treatment. As a result of the engagement with the supply chain through LLWR, however, the option of transporting the boilers whole was identified. For many reasons, this was deemed to be more favorable, not the least because it minimized the risk associated with on-site working, and construction of bespoke (custom-made) cutting containments. In order to underpin the credibility of transporting the boilers whole, transport studies were commissioned through LLWR's Waste Services Contract.

## TRANSPORT AND TREATMENT OPTIONS STUDY

Studsvik was one of two companies selected to carry out a feasibility study, and Studsvik selected Abnormal Load Engineering (ALE), a specialist heavy transport company, to support them.

Studsvik and ALE evaluated a variety of options for lifting and transporting the boilers to Sweden. As part of this evaluation, stakeholders, including regulators, local authorities, and local port councils, were contacted to ensure that any selected option was credible.

In line with U.K. Highways Agency requirements, a key consideration was to minimize road transport, and this was possible by transporting the boilers to Sharpness, the nearest port. Sharpness, however, has access constraints due to a lock gate arrangement, which restricts the size of vessel that can be used.

One of the underlying principles adopted by Studsvik and ALE was to minimize lifting boiler operations. Therefore, a strategy utilizing roll-on/roll-off vessels was adopted. Such vessels capable of accessing Sharpness were limited to carrying two boilers, and in order to optimize transport to Sweden, the decision was made that pairs of

*A strategy utilizing roll-on/roll-off vessels was adopted. Such vessels capable of accessing Sharpness were limited to carrying two boilers, and in order to optimize transport to Sweden, the decision was made that pairs of boilers would be transported from Sharpness along the Severn Estuary to the larger port at Avonmouth, where they could be transferred to a larger seagoing vessel.*

boilers would be transported from Sharpness along the Severn Estuary to the larger port at Avonmouth, where they could be transferred to a larger seagoing vessel. This allowed for five boilers to be shipped to the Studsvik facility in one voyage. A roll-on/roll-off vessel previously used by Studsvik for similar European projects was selected, and a special-purpose barge previously used by ALE was selected for the inland waterway leg of the journey.

### BEST AVAILABLE TECHNIQUE

A Best Practicable Environmental Options (BPEO) study into the options for the boilers was first conducted in 2001. At that time there was no off-site treatment route that was deemed viable to allow the boilers to be transported from the site and treated. Previous on-site experience—in 1995, when one of the boilers was size-reduced

and was treated *in situ*—had limited success, and it was not seen as a viable, cost-effective option for the remaining 15 boilers. The outcome of this BPEO was that on-site storage until final site clearance was the preferred option.

When the graduate students started to investigate the possible options, it became clear that the 2001 BPEO was out of date and that there had been significant changes to the industry and supply chain capability, many having occurred fairly recently. The main changes were related to national policy: the U.K. government's policy for solid LLW (2007); the national LLW strategy (2010); and the strategic BPEO for metallic LLW (2006; revisited in 2011). In support of the changes, a number of routes had opened up through the LLWR's Waste Services Contract, which removes the requirement for individual sites to establish their own commercial routes by providing competitive frameworks for accessing services, such as metallic waste treatment and incineration services.

The team of graduate students produced an options paper, which demonstrated that there were a number of credible options available. Following engagement with LLWR and the suppliers on the Metallic Waste Treatment Framework, under the Waste Services Contract, it was identified that the boilers could be removed and transported off-site for treatment. In order to underpin this option, a transport study was conducted that detailed the transport route and any enabling works that would be required to make the option viable. The beauty of this solution was that the changes identified were minimal in scope and cost, and could be undertaken quickly.

Magnox used the transport studies as the basis of a reassessment of the original 2001 BPEO for the boilers. A panel of experts was convened to assess what the best available technique should be, utilizing Magnox's approved procedures. A screening process was carried out initially to identify alternative waste management options that could be applied. This allowed the waste management end-point to be moved—that is, LLW to “out of scope,” the equivalent of “free-release”—or a significant volume waste reduction. With the screening process and reasoned argument assessment, various options were considered, including size-reduction on-site, disposal of the whole boilers at a dedicated facility, or off-site treatment. It was concluded that the best available technique was recycling of the boilers, transported whole and treated off-site.

A competitive tendering exercise was carried out by Magnox via the LLWR Metals Treatment Framework and Studsvik was awarded an initial contract for the transport and treatment of five boilers.

### PROJECT DETAILS

Upon its selection, Studsvik began to work collaboratively with Magnox, LLWR, and ALE to develop the

project program and joint project risk register. The project officially commenced on November 4, 2011, and essentially comprised four stages: design and characterization, site enabling works, lifting and transportation, and treatment.

The contract to deliver five boilers to the Studsvik metal treatment facility in Sweden was let on a very tight timeline, and a series of key stakeholder deliverables needed to be met in order to obtain approval to ship. A project team was formed from all parties involved in the project: Magnox, LLWR, Studsvik, and ALE. The project benefited from having very clear goals and strong support from all parties to achieve these goals.

There were two key elements that helped the project meet the tight schedule. One was the use of an interactive documentation review process that required the key project documents to be issued for review. After this initial review, a face-to-face meeting was convened with all the reviewers present, and all comments were discussed, agreed to, or discarded, with the document ready for formal issue before the reviewers left the room. This significantly reduced the documentation approval cycle and limited the amount of rework needed, as changes were discussed and made interactively.

The other key element was a very strong communication process, where all parties were actively involved in the decision-making processes. This was achieved through the use of an active and dynamic communications process that included weekly progress meetings, weekly program management, the use of a contract management portal, and Microsoft "Live Meeting" software.

## DESIGN AND CHARACTERIZATION

A number of interrelated activities were carried out in parallel to achieve the project milestones.

Existing design information was reviewed, and this was further informed through nondestructive examination of boilers and saddles by visual, ultrasonic, and magnetic particle inspection.

Assessment of the boiler structure under all transport loadings was undertaken using finite element analysis in line with the requirements of applicable regulations [1, 2, 3].

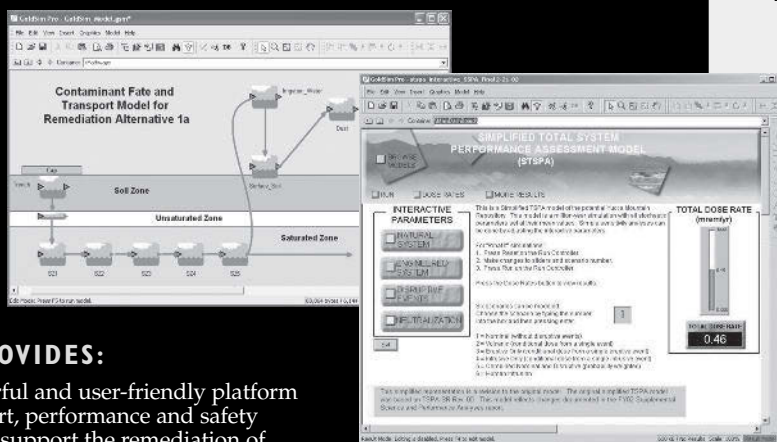
The assessment also considered the support saddle design and an optimum number of saddles was identified to ensure load security during all modes of on-site and off-site movement.

Radiological surveys were carried out to confirm dose rate and external contamination levels. Because of the specifics of the Berkeley boilers, any beta measurements recorded also contained a contribution from the emission of gamma radiation from inside the boilers. Therefore, a specific monitoring technique was established to determine the fixed beta contamination on the external surface of the boilers.

As such, a beta reading was taken, as normal, with the probe unshielded and at approximately 2 mm from the surface of the boiler. This reading represented the fixed beta contamination and the effect of the gamma radiation from the internal surfaces. The measurement was then repeated with the probe in the same location, but with a 1-mm-thick piece of steel shielding the probe. The shield removed all contributions from the surface beta contamination, but had little effect on the reading due to internal gamma radiation.

# ENVIRONMENTAL MODELING MADE EASIER

**IT'S EASY TO GET LOST** in the technical details related to the remediation, transport, storage and disposal of radioactive waste. That's why agencies and companies around the world rely on GoldSim software to give them the big picture view of their radioactive waste challenges.



### ONLY GOLDSIM PROVIDES:

- The world's most powerful and user-friendly platform for contaminant transport, performance and safety assessment modeling to support the remediation of existing radioactive waste sites and the design and licensing of disposal facilities
- The ability to update your model and view the results in minutes using a convenient PC-based platform
- A user-friendly framework that can integrate and simplify your existing models

Visit [www.goldsim.com/radwaste](http://www.goldsim.com/radwaste) to learn how GoldSim is being used to support radioactive waste management programs worldwide.



### Partial List of GoldSim Users:

- CH2M HILL PLATEAU REMEDIATION COMPANY/US
- ENERGYSOLUTIONS/US
- ENRESA/SPAIN
- JAPAN ATOMIC ENERGY AGENCY
- KOREA ATOMIC ENERGY RESEARCH INSTITUTE
- LOS ALAMOS NATIONAL LABORATORY/US
- NATIONAL NUCLEAR LABORATORY/ UNITED KINGDOM
- NUCLEAR DECOMMISSIONING AUTHORITY/ UNITED KINGDOM
- RADIOACTIVE WASTE REPOSITORY AUTHORITY/ CZECH REPUBLIC
- SANDIA NATIONAL LABORATORIES/US
- SAVANNAH RIVER NATIONAL LABORATORY/US
- US NUCLEAR REGULATORY COMMISSION
- WISMUT GMBH/GERMANY

SIMULATION for the REAL WORLD



The differences between these two readings were then, therefore, representative of the external fixed beta contamination. The results were recorded and calculated to infer the becquerels per cm<sup>2</sup> (Bq/cm<sup>2</sup>) and were compared against the transport limit of 0.4 Bq/cm<sup>2</sup> for alpha contamination and 4 Bq/cm<sup>2</sup> for beta/gamma contamination for external surfaces [1, 2]. The data collected confirmed that there was no external fixed contamination.

Also, during the radiological surveys, each boiler was swabbed to determine whether any loose contamination was detectable on the external surface of the boilers. A total of 345 swabs, each taken over a surface area of 300 cm<sup>2</sup>, were removed from each of the five boilers and were assessed to see if there was any loose contamination detectable. None of the swabs measured above a background level, and there was no evidence of loose contamination on the external surface of the boilers. This was as expected for the items stored externally for 14 years.

Beta/gamma surface dose rate measurements were collected in order to confirm worker and public doses and for use in confirming compliance with the transport regulations [1, 2]. The dose measurements collected were also used to undertake further confirmatory assessments of the radioactive content of the boilers. Computer modeling was undertaken to assess the potential radioactivity based on the dose rates measured at 1 m and in contact with the boilers. This modeling was performed using proprietary

Boiler Number	Highest Dose (μSv/h)	Average Dose (μSv/h)
9	1.5	0.9
11	2.2	1.3
12	3.1	2.0
13	1.9	1.3
14	1.7	1.0

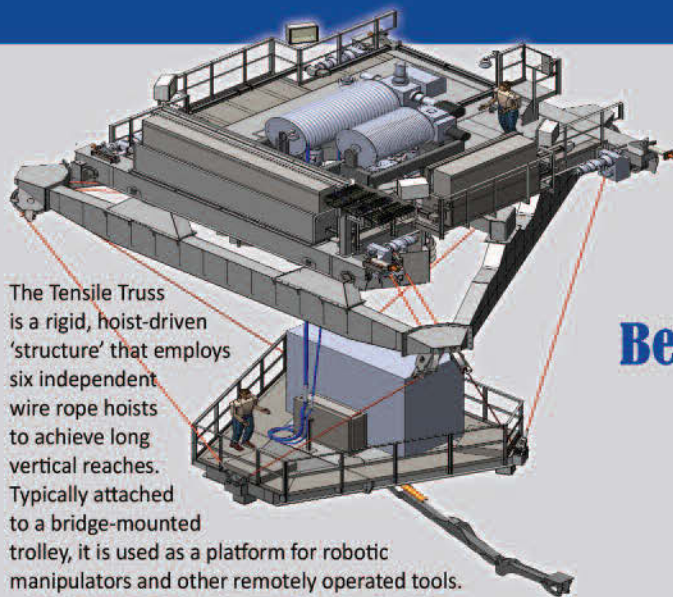
MicroShield software.

Dose rate measurements were taken at a distance of 1 m from the boiler using an Exploranium GR-135 sodium iodide detector. Table 1 summarizes the dose rates measured for each of the boilers.

Some small sections of the boilers recorded elevated contact dose rate measurements. These were very small collimated emissions that significantly reduced at a short distance. The dose rates measured ranged from 8 μSv/h to 31.5 μSv/h.

On completion of the dose rate surveys of the five boilers, a number of activity assessments were carried out using the MicroShield software to model the Co-60 emissions from the boilers. The models were developed to provide further confirmation to the accuracy of the Magnox radioactivity assessment.

These models were based on two different scenarios:



The Tensile Truss is a rigid, hoist-driven 'structure' that employs six independent wire rope hoists to achieve long vertical reaches. Typically attached to a bridge-mounted trolley, it is used as a platform for robotic manipulators and other remotely operated tools.



**Be Prepared for your  
Toughest Jobs**

www.par.com nuclear@par.com  
800.464.1320 or 651.484.7261



PaR is committed to complete customer satisfaction. Our proven dependable systems are backed by highly trained personnel 365, 24/7.

**Table 2**  
**Comparison of Total Activity Data Per Boiler (GBq)**

	Total Activity per Boiler (GBq)
Magnox Activity Assessment	35.5
Based on Internal Surface Contamination Models	45.9
Based on Internal Homogenous Volume Contamination Models	72.2

- Scenario One modeled the emissions associated with internal surface contamination.
- Scenario Two modeled the emissions associated with contamination spread homogeneously throughout the internal volume of the boilers.

Models were also developed to account for the activity associated with the “hot-spot” emissions, identified above.

Table 2 shows the total activities calculated from the MicroShield modeling. The results showed very good agreement between the modeling data and the Magnox data provided for the boilers.

An essential output from the work carried out was the preparation of a transport categorization report. This document collectively reported all engineering and radiological works and provided a safety case-type document for the categorization of the boilers as an SCO-I package (SCO = surface-contaminated object).

Throughout the work, regulators from the United Kingdom and Sweden were consulted and all necessary approvals were obtained. This included obtaining trans-

port shipment approval for transport between the United Kingdom and Sweden, and Highways Agency special approval for abnormal load transport by road in the United Kingdom. A number of other stakeholders were engaged to ensure that all local and international requirements were met.

As there were a number of discrete transport movements utilizing different organizations, individual radiological protection programs were produced together with an overarching command and control strategy to ensure clarity of roles and responsibilities for radiation protection during transport.

### SITE ENABLING WORKS

A number of on-site activities were carried out to prepare the boilers and support saddles for transport. This included the removal of miscellaneous steelwork and thermocouple attachments, plus modification to the existing support saddles to enable the load to be secured.



Civil works were undertaken to prepare the ground on-site and adjacent to the site in order to enable movement and temporary storage of the large loads. In some areas this included plate-bearing tests and subsequent modifications to ensure ground stability.

During this stage of the work, the Office for Nuclear Regulation Radioactive Materials Transport Team organized in-

**THE ROY G. POST FOUNDATION**

A NON-PROFIT ORGANIZATION

Dedicated to the Safe Management of Nuclear Materials

A NON-PROFIT ORGANIZATION

WM SYMPOSIA

MARCH 2 – 6, 2014

PHOENIX CONVENTION CENTER

---

STUDENT POSTER COMPETITION

MONDAY MARCH 3RD AT 1:30PM

The Roy G. Post Foundation is a non-profit organization that provides scholarships for students to develop careers in the safe management of nuclear materials and also participate in the annual WM Symposium, which is widely regarded as the premier international conference for the management of radioactive material and related topics.



Fig. 3. The boilers, traveling by flatbed truck through the town of Berkeley, from the plant to the port of Sharpness. (Photo: Magnox Ltd./www.magnoxsites.com)

dependent radiological surveys that confirmed Studsvik and Magnox survey data.

### LIFTING AND TRANSPORTATION

A number of potential techniques for lifting the boilers had been considered by ALE and Studsvik. An important consideration was loading of underground structures. The final movement of the boilers from site to the barge was carried out by a self-propelled trailer.

Four of the boilers were moved to temporary storage areas on the site and the fifth boiler was transferred directly to a road trailer for off-site transport to Sharpness. Three separate road transports were carried out over a seven-day period, the first involving one boiler, with each of the other transports involving two boilers (Fig. 3).

On arrival at Sharpness, the boilers were transferred to a special-purpose barge for shipment to the larger port at Avonmouth, where they were off-loaded and transferred to a dedicated storage area. Additional temporary security arrangements were imple-



Fig. 4. Five of the Berkeley boilers, transferred to a seagoing ship and ready for transport to Studsvik's facility in Sweden. (Photo: ALE)

mented by Studsvik and ALE for the in-transit storage period prior to loading to the seagoing vessel (Fig. 4). Careful coordination of transport activities was essential to maintaining the 14-day in-transit period specified by U.K. regulators.

All of the boilers were removed from the Berkeley site by March 22, 2012, nine days ahead of the project milestone. The boilers arrived at the Studsvik site in Sweden on April 6, 2012.

Prior radiological risk assessments had been produced for all stages of the transport, and these were monitored through the daily issuance of electronic personal dosimeters managed by Studsvik health physics personnel, who accompanied the boilers through each stage of their journey. The maximum individual dose recorded for any transport operation was 22  $\mu\text{Sv}$ , which was consistent with background radiation over the period. Collective dose for all transport-related activities was 292  $\mu\text{Sv}$ , which was significantly lower than the predicted 5,458  $\mu\text{Sv}$ .

### TREATMENT

On arrival at the Studsvik site in Sweden, all boilers were subject to radiological surveys. Four of the boilers were transferred to an internal storage facility and one was transferred directly to the treatment facility.

Treatment of the first boiler started in April 2012 and an initial controlled breakthrough of the boiler shell was carried out to identify radiological conditions and enable collection of any residual materials.

During the segmentation of the first boiler, it was important to learn where and how the different parts of the boiler were located and to segment it appropriately for the subsequent steps in the process of surface decontamination and, thereafter, melting. In order to achieve clearance of the material (ingots) after melting, it was necessary to decontaminate it before melting, a process that was carried out by blasting the material with steel shots.

During melting of the material, representative samples were taken from the molten metal. These samples were then sent to the Studsvik radiometry laboratory for measurement and evaluation. Based on the lab's results, a decision could be made as to whether the ingots could receive radiological clearance.

Based on that procedure, including both decontamination and melting, over 96 percent of the incoming weight of each boiler can be released from regulatory control after treatment. The remaining 3 to 4 per-

cent is secondary waste in the form of cutting residue, dust from the ventilation systems, blasting residue, and slag from the melting process.

Each boiler represents approximately 650  $\text{m}^3$  and 311 t upon arrival at Studsvik for waste treatment. Studsvik will return less than 12  $\text{m}^3$  of secondary waste to LLWR from each treated boiler for disposal. In terms of weight, the secondary waste is less than 20 t from each boiler treated.

Through optimization and high-density packing of the secondary waste, the number of 200-liter drums created was less than that estimated during the feasibility study stage. This means that the number of half-height ISO (HHISO) containers has been reduced from a predicted 3 to 1.5 of packaged secondary waste from each boiler.

All secondary waste will be returned from Sweden to the United Kingdom for disposal at LLWR. Studsvik will retain ownership of the radiologically cleared ingots in Sweden, which are supplied for remelting for the production of new steel products.

### RADIOLOGICAL ISSUES AND DOSE RATES DURING WASTE TREATMENT

The following dose rates were measured during the treatment of boiler No. 11:

Average of 3.0  $\mu\text{Sv/h}$  inside the boiler shell.

Average of 10  $\mu\text{Sv/h}$  within the tube banks.

Hot spots within the tube banks of up to 30  $\mu\text{Sv/h}$ .

The collective dose from the treatment of this boiler resulted in 7.57 person-mSv. Figure 5 shows the collective dose during the treatment period of boiler No. 11, which was the first boiler treated.

During the treatment of the boilers, there have been no issues relating to the working environment based on dose rates or contamination from the boilers. All work has been performed in accordance with standard facility procedures for the treatment of radioactive metal at Studsvik.

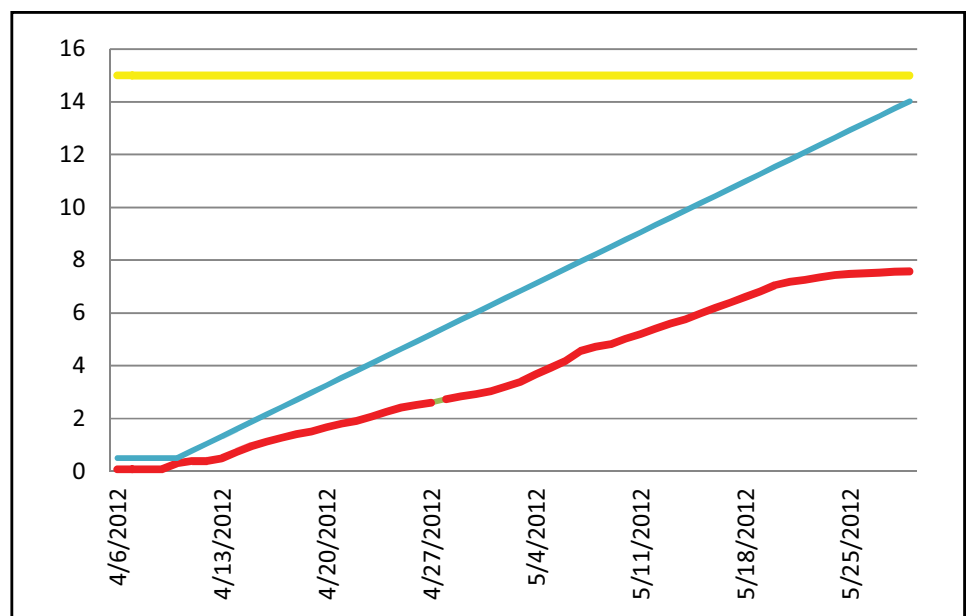


Fig. 5. Collective dose, in person millisieverts, for treatment of boiler No. 11. The yellow line is the goal for the collective dose, the blue line is the expected prognosis, and the red line is the actual dose.

## SUCCESSSES OF THE PROJECT

Based on the success of the Berkeley boilers project and the experience gained from the treatment of the boilers, the following conclusions can be drawn:

- The project demonstrated that large components from a Magnox gas circuit can be safely transported, size-reduced, and effectively decontaminated, enabling valuable metal to be recycled. To date, recycling of up to 96 percent of the steel has been achieved.
- All the secondary waste generated by the project to date is suitable for disposal at the U.K.'s LLW Repository.
- No secondary waste has been classified as intermediate-level waste, although initial characterization showed this to be a project risk, based on the carbon-14 content.
- The estimated volume of secondary waste was decreased even further, with only 1.5 HHISO container per boiler instead of the calculated 3.
- The volume saved is 638 m<sup>3</sup> per boiler.
- The project resulted in a lower-than-estimated dose to personnel.
- The project was the first of its kind in the United Kingdom and was successfully executed within a very short timescale. This was achieved through close teamwork among all parties—client, stakeholders, regulators, and contractors—as well as early and continuous engagement with all stakeholders.
- This project demonstrated that large items can be moved whole for treatment, which significantly reduces project timescales. Previously in the United Kingdom, the shipment of large radioactive items was seen as difficult

and unachievable. This project shows that large items can be safely moved whole, and delivery is quicker than if cutting work is conducted on-site. The project also demonstrates that having a focused team working in alignment with clear goals can deliver complex projects in tight timescales, safely and on budget.

## REFERENCES

1. IAEA Regulations for the Safe Transport of Radioactive Material 2009 TS-R-1 Edition, International Atomic Energy Agency.
2. Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material 2005 TS-G-1.1 Edition, International Atomic Energy Agency.
3. International Maritime Dangerous Goods Code, 2010 Edition, International Maritime Organization. ■


*Bo Wirendal is a product manager at Studsvik Nuclear AB, and David Saul, Joe Robinson, and Gavin Davidson are with Studsvik UK Ltd. This article is based on a paper presented at Waste Management 2013 Conference, held February 24–28, 2013, in Phoenix, Ariz. Copyright WM Symposia Inc.*


BIOASSAY ■ ENVIRONMENTAL ■ NUCLEAR ■ GROUNDWATER ■ DRINKING WATER

# KPA

## Simply better trace uranium analysis.

- Sensitive and precise.
- EPA approved ASTM method D5174-02.
- Robust method.
- Reliable, fast, and easy.
- Superior economy.



 **CHEMCEK™**  
INSTRUMENTS, INC.

CERTIFIED METHOD ASTM D5174-02.  
Approved for U.S. EPA Final Rule 40 CFR Drinking Water

TRACE URANIUM & LANTHANIDES  
**(509) 943-5000**  
**WWW.CHEMCEK.COM**

Innovate. Fabricate. Integrate.



# WHEN EVERY DETAIL MATTERS.

Nuclear experience makes an infinite difference. With that experience comes attention to detail. With attention to detail comes predictability, capability and excellence. At Oregon Iron Works, Inc., (O.I.W.) we build first-class hardware, on time, as promised, with more than 2,000,000 manhours of production logged under nuclear Quality programs. Vast capabilities, combined with our strict Quality Assurance program, means we consistently deliver the oversight and detailed documentation the world's most critical customers demand. When it must be right, it must be O.I.W.

- 320,000 SF Fabrication, Machining & Integration
- 150 Certified ASME Welders, 10 ga. to 12 inch
- Stainless, Inconel, Carbon, Nickel, Titanium, Hastelloy
- 160 Ton Shop Lift Capacity
- CNC Machining, 10 lbs to 100+ tons
- Mechanical Assembly, Integration, Controls
- EPRI Compliant Commercial Grade Dedication



**OREGON IRON WORKS, INC.**  
NUCLEAR PRODUCTS DIVISION

 N, NA, NS, NPT, U, U2

Clackamas, OR USA  
Vancouver, WA USA  
503.653.6300  
[www.oregoniron.com](http://www.oregoniron.com)  
[sales@oregoniron.com](mailto:sales@oregoniron.com)

ASME NQA-1 • 10 CFR PART 50, APP B

For the fastest information on the products, services and companies you have seen advertised in this issue, simply refer to the convenient contact information published on the following pages. You may also link to and e-mail advertisers directly from the ANS Web site at [www.ans.org/advertising](http://www.ans.org/advertising).

# Radwaste Solutions

January–March 2014

Advertiser	Page	Advertiser	Page
American Crane & Equipment Corporation	19	NUCON International, Inc.	23
American DND, Inc.	Cover 4	Oregon Iron Works, Inc.	84
Babcock Services, Inc.	59	ORTEC	13
Brokk Inc.	21	PacTec, Inc.	39
CANBERRA	49	PaR Systems, Inc.	79
Chemchek Instruments, Inc.	83	Petersen Inc.	Cover 2
CH2M HILL	15	Precision Custom Components LLC	55
Container Technologies Industries LLC	48	Reef Industries, Inc.	59
Cutting Edge Services Corp.	69	R.O.V. Technologies, Inc.	96
DAHER-TLI	11	RussTech Language Services, Inc.	93
Electric Power Research Institute	127	Siempelkamp Nuclear Services, Inc.	89
EnergySolutions LLC	1	SSM Industries, Inc.	25
EQ - The Environmental Quality Company	67	Thermo Scientific - CIDTEC	97
ExchangeMonitor - RadWaste Summit	65	Transnuclear, Inc.	5
F&J SPECIALTY PRODUCTS, INC.	17	Underwater Engineering Services, Inc.	92
Frham Safety Products, Inc.	63	UniTech Services Group	64
GEL Laboratories, LLC	56	Veolia ES Alaron, LLC dba Alaron Nuclear Services	24
GoldSim Technology Group LLC	78	Visionary Solutions, LLC	93
Holtec International	39	Waste Control Specialists LLC	6-7, 27
Major Tool & Machine, Inc.	62	Westinghouse Electric Company LLC	9
Marshallton Research Laboratories Inc.	53	WM Symposia, Inc.	80, Cover 3
Metal Solutions Design & Fabrication	91	Worthington Cylinders	47
NAC International	61		

**Radwaste Solutions** readers—send an E-MAIL or LINK to the web site of our advertisers listed above through the “Direct Answer/Index to Advertisers” link at: [www.ans.org/advertising/rs/da](http://www.ans.org/advertising/rs/da)

**Nuclear News**Regional Advertising  
Sales Representatives**United States and Canada****MID-ATLANTIC/  
MIDWEST****Barry Kingwill****Jim Kingwill**

Phone: 847-537-9196

Fax: 847-537-6519

barry@kingwillco.com

jim@kingwillco.com

**NORTHEAST  
AND CANADA****Lee Fernandez**

Phone: 617-722-8333

Fax: 617-722-8334

advertising@ans.org

**SOUTHEAST****Bill Powell**

Phone: 281-376-2368

Fax: 281-251-8555

citadel62@aol.com

**WEST****Warren DeGraff**

Phone: 415-721-0644

Fax: 415-721-0665

wdegraff@jjhs.net

**International and Other****SALES MANAGER****Jeff Mosses**

Phone: 708-579-8225

Fax: 708-352-6464

jmosses@ans.org

**Advertising Department**

Phone: 708-579-8226

800-NUC-NEWS

(682-6397)

Fax: 708-352-6464

advertising@ans.org

www.ans.org/advertising

**Radwaste Solutions Direct Answer****Advertiser Contact Information\*****American Crane & Equipment Corporation**

Beth Lerario

Tel: 610/385-6061, 877/877-6778 x224

Fax: 610/385-3191

sales@americancrane.com

www.americancrane.com

**American DND, Inc.**

Bill Schaab

Tel: 866/699-5515

Fax: 716/773-5515

adnd@americandnd.com

www.americandnd.com

**Babcock Services, Inc.**

Jimmy Harris

Tel: 865/574-2028

Fax: 865/574-8184

jharris@babcockservices.com

www.babcockservices.com

**Brokk Inc.**

Tony Marlow

Tel: 505/699-8923, 505/466-3614

tony@brokkinc.com

www.brokk.com/us

**CANBERRA**

Tel: 800/243-3955

Fax: 203/235-1347

customersupport@canberra.com

www.canberra.com

**Chemchek Instruments, Inc.**

Barbara Miller-Collins

Tel: 509/943-5000

Fax: 509/946-3368

sales@chemchek.com

www.chemchek.com

**CH2M HILL**

William Badger

Tel: 720/286-5632

Fax: 720/286-8017

william.badger@ch2m.com

www.ch2m.com

**Container Technologies Industries LLC**

Mike Fielden

Tel: 423/569-2800 x24

Fax: 423/569-2806

sales@containertechnologies.com

www.containertechnologies.com

**Cutting Edge Services Corp.**

Tim Beckman

Tel: 513/388-0199

Fax: 513/732-1248

beckman@cuttingedgeservices.com

www.cuttingedgeservices.com

**DAHER-TLI**

Lauren Haas

Tel: 301/421-4324

Fax: 301/421-4326

lhaas@tilusa.com

www.tliusa.com

**Electric Power Research Institute**

Tel: 800/313-3774

Fax: 650/855-2929

askepri@epri.com

www.epri.com

**EnergySolutions LLC**

Mark Walker

Tel: 801/231-9194

Fax: 801/321-0453

mwalker@energysolutions.com

www.energysolutions.com

**EQ – The Environmental Quality  
Company**

David Crumrine

Tel: 734/329-8032

Fax: 734/329-8140

dave.crumrine@eqonline.com

www.eqonline.com

**ExchangeMonitor - RadWaste Summit**

Martin Schneider

Tel: 202/296-2814

Fax: 202/296-2805

schneider@exchangemonitor.com

www.radwastesummit.com

**F&J SPECIALTY PRODUCTS, INC.**

Frank Gavila

Tel: 352/680-1177

Fax: 352/680-1454

fandj@fjspecialty.com

www.fjspecialty.com

**Frham Safety Products, Inc.**

Brian Anderson

Tel: 615/254-0841

Fax: 615/726-2514

banderson@frhamsafety.com

www.frhamsafety.com

**GEL Laboratories, LLC**

Bob Wills

Tel: 843/556-8171

Fax: 843/766-1178

robert.wills@gel.com

www.gel.com

**GoldSim Technology Group LLC**

Rick Kossik

Tel: 425/295-6985

Fax: 425/642-8073

support@goldsim.com

www.goldsim.com

\*The Publisher does not assume any liability for errors or omissions. This index is provided as an additional reader service.



**Holtec International**

Joy Russell  
Tel: 856/797-0900 x3655  
Fax: 856/797-0909  
j.russell@holtec.com  
www.holtecinternational.com

**Major Tool & Machine, Inc.**

Hans Lissman  
Tel: 317/917-2621  
Fax: 317/634-9420  
hlissman@majortool.com  
www.majortool.com

**Marshallton Research Laboratories Inc.**

Amy Leadford  
Tel: 336/983-2131  
Fax: 336/983-0096  
marshallton@windstream.net  
www.marshalltonlabs.com

**Metal Solutions Design & Fabrication**

David Berger  
Tel: 859/282-5000  
Fax: 859/282-5010  
davidb@msdf1.com  
www.msdf1.com

**NAC International**

Whitney West  
Tel: 678/328-1301  
Fax: 678/328-1501  
wwest@nacintl.com  
www.nactinl.com

**NUCON International, Inc.**

Curt Graves  
Tel: 614/846-5710  
Fax: 614/431-0858  
curt.graves@nucon-int.com  
www.nucon-int.com

**Oregon Iron Works, Inc.**

Bradley D. Dunkin  
Tel: 503/653-6300  
Fax: 503/794-2437  
bdunkin@oregoniron.com  
www.oregoniron.com

**ORTEC**

Susie Brockman  
Tel: 865/482-4411  
Fax: 865/483-0396  
ortec.info@ametec.com  
www.ortec-online.com

**PacTec, Inc.**

Jason Durham  
Tel: 800/272-2832  
jasondurham@pactecinc.com  
www.pactecinc.com

**PaR Systems, Inc.**

Brittney Keough  
Tel: 651/846-3003  
Fax: 651/483-2689  
bkeough@par.com  
www.par.com

**Petersen Inc.**

Rob Despain  
Tel: 801/732-2027  
Fax: 801/732-2098  
robd@peterseninc.com  
www.peterseninc.com

**Precision Custom Components LLC**

Jim Stouch  
Tel: 717/434-1802  
Fax: 717/843-5733  
jstouch@pcc-york.com  
www.pcc-york.com

**Reef Industries, Inc.**

Tom Scarborough  
Tel: 713/507-4251  
Fax: 713/507-4295  
tscarborough@reefindustries.com  
www.reefindustries.com

**R.O.V. Technologies, Inc.**

Jill Zachary/Jack Judge  
Tel: 802/254-9353  
Fax: 802/254-9354  
mail@rovtech.com  
www.rovtech.com

**RussTech Language Services, Inc.**

Michael Launer  
Tel: 850/562-9811  
Fax: 850/562-9815  
mklauner@russtechinc.com  
www.russtechinc.com

**Siempelkamp Nuclear Services, Inc.**

Steve Garner  
Tel: 803/796-2727  
Fax: 803/422-1322  
steve.garner@siempelkamp-sns.com  
www.siempelkamp-sns.com

**SSM Industries, Inc.**

Mark Saucier  
Tel: 412/777-5101  
Fax: 412/771-5382  
m.saucier@ssmi.biz  
www.ssmi.biz

**Thermo Scientific - CIDTEC**

Tony Chapman  
Tel: 315/451-9410  
Fax: 315/451-9421  
sales.cidtec@thermo.com  
www.thermoscientific.com/cidtec

**Transnuclear, Inc.**

Jean C. Tullier  
Tel: 410/910-6549  
Fax: 434/382-4952  
jean.tullier@areva.com  
www.transnuclear.com

**Underwater Engineering Services, Inc.**

Charles Vallance  
Tel: 772/429-9346  
Fax: 772/429-9990  
cvallance@uesi.com  
www.uesi.com

**UniTech Services Group**

Gregg Johnstone  
Tel: 413/543-6911 x16  
Fax: 413/543-2975  
gjohnstone@unitechus.com  
www.unitechus.com

**Veolia ES Alaron, LLC dba Alaron Nuclear Services**

Scott Eckler  
Tel: 513/759-4303  
scott.eckler@veoliaes.com  
www.veoliaes.com

**Visionary Solutions, LLC**

Adrienne Diffin  
Tel: 865/482-8670 x512  
Fax: 865/482-8678  
vscorp@vs-llc.com  
www.vs-llc.com

**Waste Control Specialists LLC**

Steve Ferguson  
Tel: 513/583-1744  
Fax: 513/583-8505  
sferguson@valhi.net  
wctexas.com

**Westinghouse Electric Company LLC**

Joseph Boucau  
Tel: +32 478 566529  
Fax: +32 67 28 8534  
boucauj@westinghouse.com  
www.westinghousenuclear.com

**WM Symposia, Inc.**

Mary E. Young  
Tel: 480/557-0263  
Fax: 520/829-3550  
mary@wmarizona.org  
www.wmsym.org

**Worthington Cylinders**

Brett Williams  
Tel: 800/338-8265  
Fax: 740/840-3456  
brett.williams@  
worthingtonindustries.com  
worthingtoncylinders.com

**Huntington Ingalls Industries** (HII) announced on January 2 that it has acquired **S.M. Stoller Corporation** for an undisclosed sum. A privately held company that performs work in 29 states from 18 offices nationwide, Stoller provides nuclear, environmental, and technical consulting and engineering services to the Department of Energy, Department of Defense, and the private sector. According to HII, Stoller will be a wholly owned subsidiary of HII and will operate under the company's Newport News Shipbuilding (NNS) division. NNS is the nation's sole designer, builder, and refueler of nuclear-powered aircraft carriers and one of only two shipyards capable of designing and building nuclear-powered submarines. Matt Mulherin, HII corporate vice president and NNS president, said that the strategic acquisition positions NNS for expanded growth within the DOE, environmental management, and commercial nuclear services markets.

In October, **NFT**, an engineering, automation, and precision metal fabrication company serving the nuclear, aerospace, and industrial markets, announced that it has acquired the TRUPACT maintenance business from **URS Corporation's** Engineered Products Division (EPD) in Carlsbad, N.M. NFT will be responsible for maintaining, testing, and certifying a fleet of approximately 100 specialized waste management containers for Nuclear Waste Partnership, the Department of Energy's managing contractor for the Waste Isolation Pilot Plant in Carlsbad. The containers—known as TRUPACTs, HALFPACTs, and RH72-Bs, based on size and capacity—are used to transport nuclear waste to WIPP.

As part of the acquisition, NFT

said that it will take over a 40,000-square-foot operating facility in Carlsbad, along with much of the existing equipment, significantly expanding the company's manufacturing capabilities.

Custom manufacturers **Precision Custom Components** (PCC) and **DC Fabricators** (DCF) jointly announced in November that they have formed **Precision Components Group** (PCG), a private holding company that now owns both companies in their entirety. The two companies will continue to operate independently, said PCG President and Chief Executive Officer Gary Butler, who will have operational and financial responsibilities for both companies. The corporate restructuring resulting from the formation of PCG, however, will enable the companies to leverage the operational and financial strengths of one another, Butler added.

Based in York, Pa., PCC is a manufacturer of custom-fabricated heavy pressure vessels, reactors, casks, and heavy-walled components for nuclear, commercial, and government applications. DCF, located in Florence, N.J., is involved in the design, technology, and manufacturing of steam condensers and heat exchangers for government and commercial heat transfer applications.

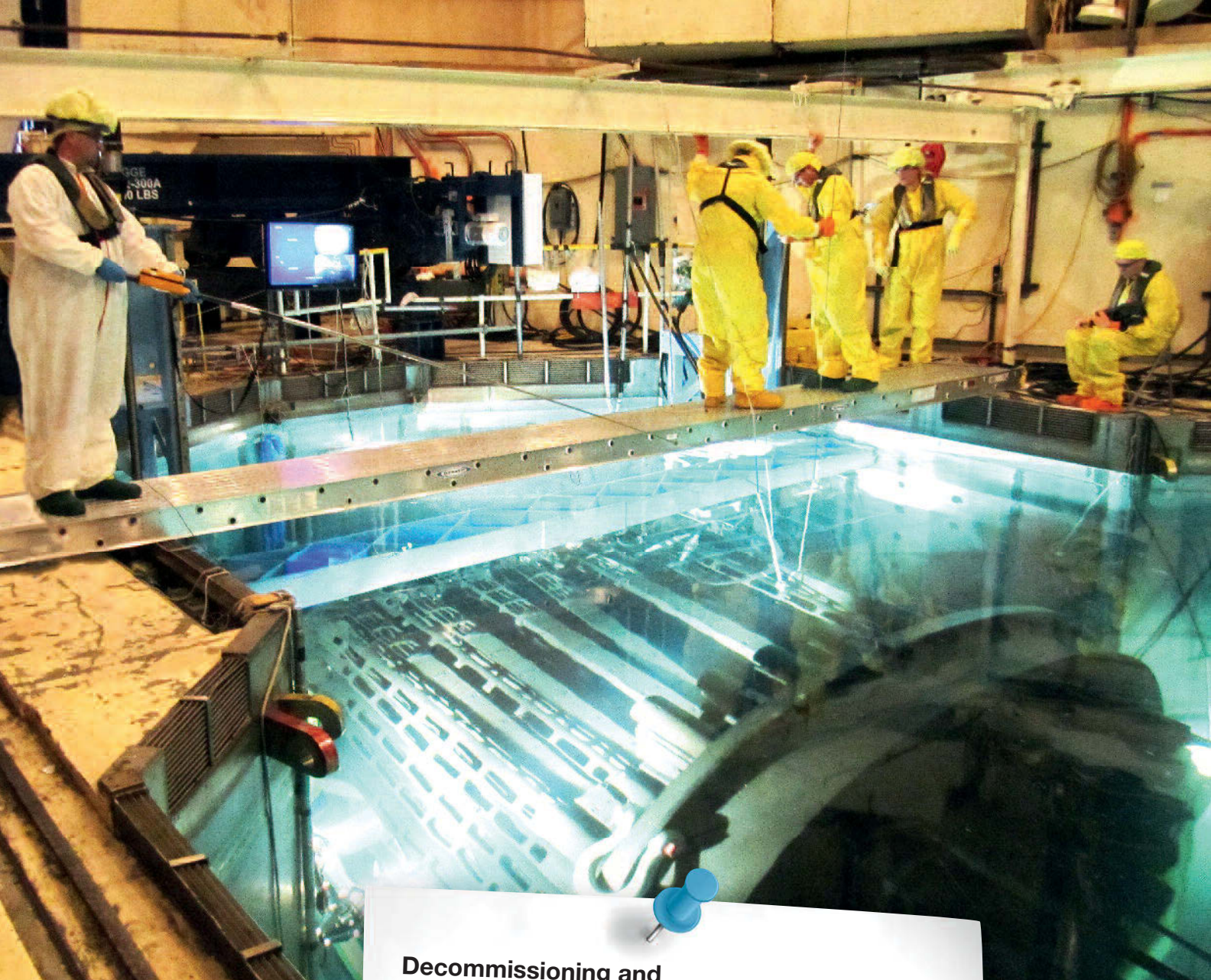
**PaR Systems**, an engineering and manufacturing company based in Minnesota, announced in December that it has acquired the major assets of Atlanta, Ga.-based **CAMotion** and **CAMotion Cranes**, which provide material handling equipment using Cartesian robotic technology for pick-and-place systems, palletizing and depalletizing machines, and advanced crane motion controls. Ac-

cording to PaR Systems, the acquisition will bring a suite of products and leading-edge technologies that will add to the existing material handling and crane technologies used by the company's hazardous environment, industrial, aerospace, and marine businesses.

### Business changes

**Perma-Fix Environmental Services** announced that its 1-for-5 reverse stock split became effective on October 15. Under the reverse split, the number of outstanding shares of the company's common stock decreased by a factor of five, while the respective exercise prices of the options increased by a factor of five. According to the company, the resulting combination of and reduction in the number of shares of Perma-Fix's outstanding common stock occurred automatically without any action on the part of the company's stockholders and without regard to the date that certificates of outstanding shares of (pre-reverse split) common stock were physically surrendered for certificates of new (post-reverse split) common stock. The authorized number of shares of the company's common stock does not change as a result of the reverse stock split, and the new common stock was given a new CUSIP number, 714157203, according to Perma-Fix.

Sweden-based **Studsvik** announced on November 18 that it is creating a new, customer-oriented organization. According to Studsvik, the change is intended to increase the company's commercial focus, understanding of customer needs, clarify responsibilities, and enable profitable growth in selected service and prod-



**Decommissioning and  
waste management services:**

project planning | cost estimating | project execution  
specialty segmentation tooling | hot cell | technology  
waste handling facilities | containers



**Siempelkamp**

Nuclear Services



[www.siempelkamp-sns.com](http://www.siempelkamp-sns.com)

**Products and Services for Nuclear Power Plants**

Compliance with the highest requirements in safety and quality is our business. We supply services, equipment and life-time support within the nuclear power industry. Our extensive know-how and experience over many years forms the basis for our successful delivery.

Steve Garner | T: 803.796.2727 | C: 803.422.1322 | [steve.garner@siempelkamp-sns.com](mailto:steve.garner@siempelkamp-sns.com)

uct offerings. The new organization has been in place since January 1, and is divided into three business areas: Waste Treatment, which will focus on the management and treatment of radioactive waste, with main markets in Europe and the United States; Consultancy Services, which will provide qualified consulting services in areas such as radiological protection, waste, engineering, and decommissioning at nuclear facilities worldwide; and Operating Efficiency, which will focus on issues of fuel and reactor operations, with a global market.

In the new organization, Studsvik Group's management consists of Mats Fridolfsson, president of Waste Treatment; Stefan Berbner, president of Consultancy Services; Michael Mononen, chief executive officer and acting president of Operating Efficiency; Pål Jarness, chief financial officer; and Sam Usher, senior vice president of Business Development.

**Holtec International** announced that as of January 1, its Corporate Center, located in Marlton, N.J., has a new address. The original street name, Lincoln Drive West, has been changed to Holtec Drive in honor of the company. According to Holtec, Evesham Township, of which Marlton is a part, extended the recognition to Holtec for its long-term commitment to investing in the welfare of the local community and for its technology contributions to the energy industry. The company's new mailing address is Holtec International, One Holtec Dr., Marlton, NJ 08053-3421.

### Used nuclear fuel

Areva TN announced in November that it has been awarded a \$12-

million contract by the Nebraska Public Power District's Cooper nuclear power plant to supply dry shielded canisters for the storage of used nuclear fuel. Areva TN said that its North Carolina-based subsidiary, Columbia Hi Tech, will manufacture the NUHOMS 61BTH canisters, which are scheduled to be delivered before the end of 2015. In addition, the company is currently constructing the Cooper plant's horizontal storage module that will store the NUHOMS canisters at the plant's independent spent fuel storage installation.

Earlier, in October, Areva TN said that it was awarded a multimillion-dollar contract to supply 46 NUHOMS dry cask storage systems to an unnamed U.S. nuclear utility for the management of its used nuclear fuel.

**Holtec International** announced in October that it has been awarded a contract by Svensk Kärnbränslehantering AB (SKB) to replace the company's existing fleet of transport casks with Holtec's HI-STAR 80 casks for the shipment of used nuclear fuel and core components from Sweden's Oskarshamn, Forsmark, and Ringhals nuclear power plants to SKB's central interim storage facility (CLAB). According to Holtec, the contract entails the design of the transport packages, licensing in the United States and Sweden, and fabrication at Holtec's facility in Pittsburgh, Pa., as well as training, testing, support services, and maintenance of the license for the next 30 years.

In addition to the casks, Holtec will design more than 30 pieces of ancillary equipment for the project and will fabricate and supply over 100 pieces of ancillary equipment, in-

cluding lifting devices designed to Swedish nuclear safety standards and replacement components for the CLAB facility to accommodate the HI-STAR 80 cask. The casks will transport 12 pressurized water reactor (Ringhals) or 32 boiling water reactor (Oskarshamn and Forsmark) high-burnup fuel assemblies (above 45 gigawatt-days per metric ton uranium).

### Utilities

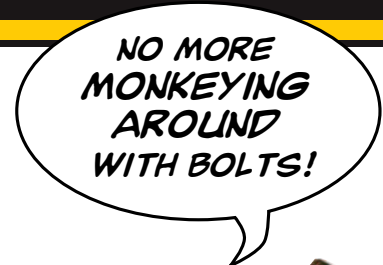
**Areva** announced in November that it has been awarded a contract to provide STP Nuclear Operating Company with four of its Vega through-air radar spent fuel pool level instrumentation systems. STPNOC operates two boiling water reactors at the South Texas Project site near Palacios, Texas. According to Areva, the Vega system meets the Nuclear Regulatory Commission's new requirements for spent fuel pool level monitoring, as outlined in the agency's task force recommendations on post-Fukushima safety upgrades at U.S. nuclear power plants.

The **Babcock & Wilcox Company** announced in November that its subsidiary, **Babcock & Wilcox Nuclear Energy**, has been selected to provide inspection and repair services for an unnamed U.S. nuclear power plant that contains two B&W replacement recirculating steam generators. According to the company, B&W is providing recirculating steam generator primary and secondary inspection and repair services, which includes inspection of the steam generator tubing, inspection of the secondary side of the steam generator tubing, sludge lancing, enhanced sludge removal and

# METAL SOLUTIONS

DESIGN AND FABRICATION

**NQA-1 Quality Program**  
**IP-1, IP-2, IP-3, 7A**  
**Reusable 7A TYPE A Fissile Containers**  
**Customer Driven Design**



## **DUO SHIELD CLOSURE SYSTEM**

- Close container without tools
- Provides double seal against leakage
- Quickly open and close multiple times.
- Easily sample contents
- Reduced transportation cost

Metal Solutions Design and Fabrication, LLC  
215 Main Street, Dayton, KY 41074  
Phone: 859-282-5000 • [www.msdf1.com](http://www.msdf1.com)

**LASER CUTTING - WATER JET CUTTING - AWS CERTIFIED WELDING - POWDER COATING**

Contracts, business news, etc. ▼

analysis, and tube plugging and stabilizing. Work under the contract began in October and is scheduled to run through October 2021.

## Spain

Westinghouse Electric Company received two separate contracts last fall from Spain's ENRESA (Empresa Nacional de Residuos Radiactivos) for nuclear waste management services. In September, Westinghouse announced that it received a contract to segment the reactor vessel head (RVH) and reactor vessel (RV) at the José Cabrera nuclear power station

(also known as Zorita) in Almonacid de Zorita, 43 miles east of Madrid, Spain. According to Westinghouse, the contract covers the dismantling and segmentation of the RVH and RV, including the up-front engineering studies. It also includes the design of the RVH/RV detachment, manipulation, and lifting to the spent fuel pool, where mechanical cutting of the components will take place. Westinghouse will be the lead contractor for the project, and MONLAIN and VSL will be the main subcontractors. The project began in June 2013 and is expected to take approximately two years to complete.

In addition, Westinghouse an-

nounced in October that it has received a multimillion-dollar contract from ENRESA to provide the main engineering services for the centralized high-level radioactive waste and spent fuel interim storage facility (Almacén Temporal Centralizado, or ATC) in Spain. According to Westinghouse, the company will be working with TRSA S.A. and GHESA S.A., the major partners in Empresarios Agrupados A.I.E, an international provider of engineering and consulting services based in Madrid. The consortium will be responsible for the main engineering of the project, including revising the generic design and developing the detailed en-



## Specialized Services for the Nuclear Industry

UESI Nuclear Services provides specialized services uniquely suited to the nuclear industry. Work can be performed under our 10CFR Appendix B Program to UESI or site procedures.

- Manned Diving & Remote Intervention
- Diving Services for RV, Fuel Pool, Suppression Pool
- Underwater Coating Inspection & Application
- ASME Section XI Code Inspections (IWE & IWF)
- ANSI & NACE Nuclear Coating Inspectors
- Condition Surveys and Asset Management
- Wet & Dry AWS or ASME Code Welding
- Nuclear Coating Experts
- Buried Pipe Coating Assessment
- QA Oversight & QC Inspection
- Project Planning & Management
- Heavy Marine Construction
- Intake & Discharge Diving Services
- Deactivation & Decommissioning



Partnerships for the New Nuclear Industry  
Call (772) 337-3116 or visit our website at [www.uesi.com](http://www.uesi.com)

gineering of the facility's main buildings: HLW storage, container reception and services, and auxiliary systems. The engineering scope includes civil, mechanical, electrical, and instrumentation and control, process analysis, and the integration of other modules in the project. The project started in April 2013 and is expected to take approximately five years to complete.

### United Kingdom

The United Kingdom's Nuclear Decommissioning Authority (NDA) announced in October that it is ex-

tending its contract with **Nuclear Management Partners**, a consortium of URS, AMEC, and Areva, for a second five-year period. The first five-year period of the 17-year contract for managing the cleanup of the Sellafield nuclear site in the United Kingdom comes to an end in March 2014. As the parent body organization for Sellafield Ltd., Nuclear Management Partners manages and operates the Sellafield site on behalf of the NDA, a government authority. The scope of the work includes reprocessing and waste storage facilities and the former nuclear power stations Calder Hall and Windscale, as well as the engineering design center

at Risley. The value of the contract was not disclosed, but according to the NDA, the planned site expenditure for 2013–2014 is £1.76 million (about \$2.8 billion).

"Sellafield is by far the most complex and challenging site in our portfolio, and we are determined to drive improved performance at the site," said John Clarke, chief executive officer of the NDA. "We have reviewed progress under the contract to date and concluded that the right decision is to extend the contract to give [Nuclear Management Partners] further time to bring about the improvements in capability and performance at the site that we and they are looking for."



A LEADING SERVICE PROVIDER FOR  
MATERIAL AND WASTE MANAGEMENT PROJECTS  
SINCE 2000

- ◆ Alternative and Renewable Fuels
- ◆ Design & Fabrication of Unique Components
- ◆ Transportation of Sensitive, High Value, and Radioactive Shipments
- ◆ Nuclear Non-Proliferation Projects
- ◆ Training & Program Management

[WWW.VS-LLC.COM](http://WWW.VS-LLC.COM)



**WE KNOW NUCLEAR!**  
RusTech Language Services specializes in providing *translation* and *interpreting* support for the nuclear sector.

- Radioactive Waste Treatment
- Packaging & Transportation (PAT)
- Source Collection & Threat Reduction
- Radiation Protection & Nuclear Safety

Let us be *your*  
International Language Connection



[www.russtechinc.com](http://www.russtechinc.com) • 850.562.9811 • [russtech@russtechinc.com](mailto:russtech@russtechinc.com)

Proudly serving the Department of Energy since 1995  
Please visit us in Booth 326 at WM2014

## Canada

The **Babcock & Wilcox Company** has entered into a teaming agreement with **Cavendish Nuclear** and **Battelle** in pursuit of the Government Owned Contractor Operated contract for managing Atomic Energy of Canada's Nuclear Laboratories. According to Babcock & Wilcox, at a November reception held in Petawawa, Ontario, Ken Camplin, vice president of Babcock & Wilcox Technical Services Group, was joined by Andrew Wettren, business development director for Cavendish Nuclear, and Ron Townsend, executive vice president of Global Laboratory Operations for Battelle, to announce the new partnership and address municipal and community leaders, along with members of the local media.

## Environmental Management

The Department of Energy's Office of Environmental Management announced in November that it has awarded a competitive small business set-aside contract worth up to \$7.9 million to **Ma-Chis Lower Creek Indian Tribe Enterprises** of Kinston, Ala., to provide DOE Transportation Tracking and Communications (TRANSCOM) technical support services. The DOE TRANSCOM system monitors and tracks active shipments of defense-related used nuclear fuel and unclassified radioactive/nonradioactive, hazardous, and transuranic waste to and from DOE facilities. According to the DOE, Ma-Chis will perform all TRANSCOM monitoring and

tracking functions and will manage the TRANSCOM Communication Center located in Carlsbad, N.M. The contract has a one-year performance period and four one-year extension options.

## Los Alamos National Laboratory

The Department of Energy announced in November that it has awarded a task order worth more than \$2.2 million to **Waste Control Specialists** of Andrews, Texas, to support the Los Alamos National Laboratory's legacy waste project. According to the DOE, the work will include the receipt and disposal of 355 yd<sup>3</sup> of Class C mixed low-level waste generated from cleanup and remediation activities at the lab. The fixed-price task order is based on pre-established rates and has a one-year performance period.

## Portsmouth

On December 30, the Department of Energy announced it has awarded task orders to **Pike Natural Gas** of Hillsboro, Ohio, and **Sage Energy Trading** of Jenks, Okla., for natural gas services at the department's Portsmouth Gaseous Diffusion Plant in Piketon, Ohio. The contract for Pike Natural Gas is a firm, fixed unit rate task order that is not to exceed \$5.25 million and has a 10-year performance period. Also a firm, fixed unit rate task order, the Sage Energy Trading contract is not to exceed \$2.5 million and has a one-year performance period. The contracts were

awarded through the DOE's Office of Environmental Management.

## Hanford

The Department of Energy announced on December 16 that it is extending by three years **Mission Support Alliance's** (MSA) contract for infrastructure and site services at the department's Hanford Site near Richland, Wash. According to the DOE, MSA was awarded in 2009 a cost-plus-award-fee contract valued at approximately \$3 billion for up to 10 years, with a five-year base period. The DOE said that it is exercising the first of two options for extension, which will take the contract through May 2017 for approximately \$736 million. MSA is a limited liability company formed by Lockheed Martin Integrated Technology, Jacobs Engineering Group, and WSI, along with a team of preselected subcontractors.

## Air monitors

**US Nuclear Corporation** announced in December that its **Overhoff Technology Corporation** division has received a series of new purchase orders worth \$860,000 from the Department of Energy's Los Alamos National Laboratory, Atomtec in China, and Radiation Measurement Systems in Canada. According to US Nuclear Corp., the orders are for new and enhanced air monitors and process monitors, including the company's Model 357 Wire Grid HTO, Model Triathalon, and Model TGMS, a multidetector system designed to support the development of molten salt reactors in China. ■



**Fumio Sudo**, Tokyo Electric Power Company board member and former president of steelmaker JFE Holding Inc., has been selected as the next Tepco chairman. Sudo will replace **Kazuhiko Shimokobe**, who retires from the position at the end of March.

**Donald Cool**, a senior advisor in the Nuclear Regulatory Commission's Office of Federal and State Materials and Environmental Management Programs, has been elected to the Main Commission of the International Commission on Radiological Protection (ICRP). In addition, Cool has been appointed chairman of ICRP Committee Four, the standing committee on the application of radiological protection recommendations. An active participant in the ICRP for 29 years and a member of the standing committee since 1993, Cool joined the NRC in 1982 as a health physicist in the Office of Nuclear Materials Safety and Safeguards' Fuel Cycle Safety Branch.

South Korea's Ministry of Trade, Industry, and Energy has named **Lee Jong-in** chief executive officer of the Korea Radioactive Waste Agency. Lee was formerly chief of the Korea Institute of Nuclear Safety's Radiation Safety Evaluation Department.

**Steve Edwards** has been named chairman, president, and chief executive officer of Black & Veatch, succeeding **Len Rodman**, who has retired from the firm after 42 years, 15 of those as CEO. Before being named the company's chief operating officer in April 2013, Edwards was an executive vice president serving as executive director of global engineering, procurement, and construction for Black & Veatch's energy business.

**Paula M. Marino** has been named senior vice president of engineering and construction services for Southern Company operations. Previously

vice president of engineering at the company's Southern Nuclear subsidiary, Marino has held various positions in distribution, transmission, fossil-hydro generation, and nuclear generation since joining Southern Company in 1993.

Southern Nuclear has named **Dennis Madison** vice president of fleet operations. Madison, who joined Southern Company in 1982, has been site vice president at the Hatch nuclear power plant since 2007. Replacing Madison at Hatch is **David Vineyard**, who had been plant manager at the site since 2012. **Tony Spring** has been selected to succeed Vineyard as plant manager at Hatch.

Also at Southern Nuclear, **Cheryl Gayheart** has been named site vice president at the Farley nuclear power plant, near Dothan, Ala. Prior to joining Southern Nuclear in 2012 as Farley plant manager, Gayheart was fleet operations corporate functional area manager at Exelon corporate. She began her career in 1985 as a staff engineer and supervisor at Exelon's Braidwood nuclear plant in Illinois. Gayheart's successor as plant manager at Farley is **JJ Hutto**, who previously was the facility's engineering director. He began his career at Farley in 1998 as an engineer in the maintenance department.

Babcock & Wilcox Conversion Services LLC has named **Gary L. Scott** to the new position of deputy manager of the DUF<sub>6</sub> Project's conversion plant in Piketon, Ohio. Most recently, Scott was acting plant deputy manager and director of waste management and transportation. He has also served as deputy manager of the Department of Energy's Carlsbad Field Office and was the facility manager of the Radioactive Waste Management Complex at the Idaho National Laboratory.

**Chris Theobald** has joined Babcock & Wilcox Technical Services

Group as vice president, United Kingdom. Theobald was previously managing director of the nuclear and defense technical services unit at Serco, an international service company. Prior to his work with Serco, Theobald served in a number of operations and business director roles for leading defense and technology companies, including BAE Systems.

**Bill Reis** has been appointed vice president of public and governmental affairs for Babcock & Wilcox Technical Services Y-12. Reis has worked at the Oak Ridge, Tenn., nuclear security site for 30 years in a variety of positions, and most recently was vice president for environment, safety, and health.

The Institute of Nuclear Power Operations' board of directors recently announced a number of organizational changes. **William Webster** and **Dianne Davenport** have been named executive vice presidents of U.S. industry and INPO corporate, respectively, while **David Garchow** has been appointed vice president of INPO International and regional director of the World Association of Nuclear Operators' Atlanta Center, replacing **David Farr**, who began an industry reverse loan assignment in January. Other appointments include **Clair Goddard**, senior vice president of industry self-awareness and continuous improvement; **David Igyarto**, senior vice president of workforce training, education, and proficiency; **James Lynch**, vice president of plant performance recovery; **Steve Nichols**, vice president of plant technical support; **Lisa Brattin**, vice president of talent and culture; and **Kris Straw**, chief financial officer and vice president of corporate structure.

Entergy has announced a number of organizational changes. **Mike Balduzzi**, senior vice president of technical services, retires on February 1 after more than 30 years in the com-

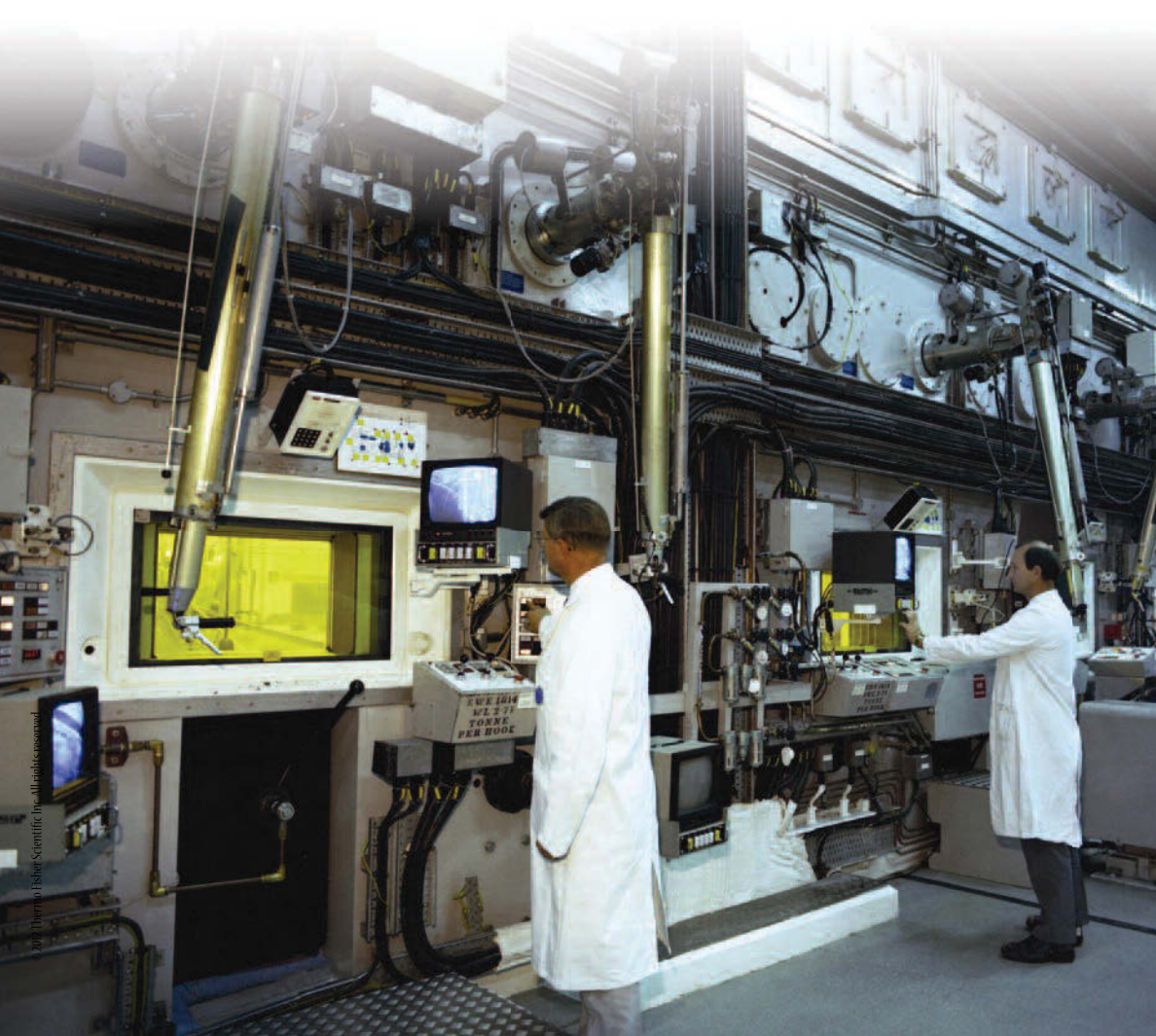


# got radiation?

Imaging in radiation environments just got easier with our MegaRAD line of radiation hardened cameras. With superior capabilities for operating in radiation environments, they provide excellent image quality well beyond dose limitations of conventional cameras. MegaRAD cameras provide excellent signal-to-noise and sensitivity with wide spectral response, making the MegaRAD series of cameras well suited for radiation hardened imaging applications

## see what you've been missing

• Learn more at [thermoscientific.com/cidtec](http://thermoscientific.com/cidtec)



MegaRAD3 cameras produce color or monochrome video up to  $3 \times 10^6$  rads total dose



MegaRAD1 cameras produce monochrome video up to  $1 \times 10^6$  rads total dose



Intensified cameras for high speed gated events and low light imaging

## People in the news ▼

tor, and **Cheryl Cabbil**, Nuclear and High Hazard Operations associate director. A 30-year veteran of LANL, Hockaday was the deputy associate director for the Weapons Physics Directorate prior to her new appointment and served as LANL's program director in support of the Department of Energy and National Nuclear Security Administration's Science and Inertial Confinement Fusion and High Yield campaigns. Cabbil, who joined LANL in December 2013, was previously with UCOR, the DOE cleanup contractor for the Oak Ridge Reservation, where she was vice president for environment, safety, health, and quality assurance. Before that, Cabbil was senior vice president for

United Research Services Safety Management Solutions and deputy laboratory director of research operations and assurance at Savannah River National Laboratory.

Cameco's board of directors has appointed **Catherine A. Gignac** as a member. A resident of Mississauga, Ontario, Gignac has over 30 years of experience in the Canadian mining industry as a geologist, mining equity research analyst, and consultant. She has held positions with several firms, including Merrill Lynch Canada, Wellington West Capital Markets Inc., UBS Investment Bank, RBC Capital Markets, Dundee Capital Markets Inc., and Loewen Ondaatje

McCutcheon Limited.

The board of directors at CB&I has approved two executive management appointments: **Patrick K. Mullen**, as executive vice president and operating group president of engineering, construction, and maintenance, and **James Sabin**, as executive vice president, global systems. Mullen joined CB&I in 2007 through the company's acquisition of Lummus Global and most recently served as CB&I's executive vice president for corporate development. Sabin joined CB&I in 2013 through the company's acquisition of Shaw and was previously CB&I's senior vice president for global systems. ■



Join the Decommissioning and Environmental Sciences Division



## ANS DESD

Working on projects in the nuclear decommissioning industry? Involved in the remediation of radiologically impacted sites? The **ANS Decommissioning and Environmental Sciences Division** wants you!

### Membership benefits include:

- Opportunities to network with leaders working current and potential new projects in the nuclear community with expertise in decommissioning, license termination, and the characterization and remediation of contaminated sites.
- Work with industry and regulatory experts in sustainable development and environmental stewardship.
- A semi-annual DESD newsletter on the status of the industry available only to members.
- Special pricing on publications related to the decommissioning and environmental sciences industry.
- Recognition and awards from peers for exceptional performance and lifetime achievement.

Why wouldn't you want to be a member of the DESD community?

Visit our website at [DESD.ANS.org](http://DESD.ANS.org)

## DUES & SUBSCRIPTION RATES

ANS membership and publication subscriptions are calendar year basis, expiring December 31. Payment must be made in full. Membership dues are prorated quarterly for the first year, with a credit applied to the following year. **Apply online at [ans.org/join](http://ans.org/join)**

Membership Dues - Option 1	Dues	Amount
Professional – age 36 & over	\$ 170	
Young Member – age 35 & younger	\$ 125	
Early Career – graduated after 2008	\$ 85	
Active US Military Personnel	\$ 85	
Entrance Fee	\$ 18	\$ 18
Extra Divisions \$10.00 ea. (2 included free)		

Residents of least developed/developing countries apply online at [www.ans.org](http://www.ans.org) or call 1-800-323-3044. Outside the U.S., Mexico and Canada, dues include *Nuclear News* online only.

### Membership Dues - Option 2

Contribute at the higher levels below and current year membership dues are included

Patron	\$ 500
Benefactor	\$ 250
Lifetime - see <a href="http://ans.org">ans.org</a> or call 1-800-323-3044	
Elective Publications	Price
<i>Radwaste Solutions Magazine</i> (4 issues)	\$ 45
<i>Nuclear Technology Journal</i> (12 issues)	\$ 160
<i>Nuclear Science &amp; Engineering Journal</i> (9 issues)	\$ 145
<i>Fusion Science &amp; Technology Journal</i> (8 issues)	\$ 165
<i>Nuclear Standards News</i> (Online Only)	\$ 60
<i>Transactions</i> (2x per year)	\$ 155
<i>ANS Proceedings</i> (CD-ROM) (3 per year)	\$ 155

Outside the U.S., Mexico and Canada, publications are online only. Subscribe to print version at [ans.org](http://ans.org)

Voluntary Contributions	Donation
Public Education/Center for Nuclear Science & Technology Info	\$ 25
Nuclear Engineering Education for the Disadvantaged (NEED)	\$ 25
Academic Scholarships	\$ 25
<b>Total</b>	

**Mail U.S. funds with application to:**  
 American Nuclear Society • 97781 Eagle Way • Chicago, IL 60678-9770  
 Fax credit card applications directly to 708-579-8295

**Wire transfers to:**  
 Account No. 824941 • JP Morgan Chase Bank  
 10 S. Dearborn St. 36th Floor • Chicago, IL 60603-2300  
 Swift Code: CHASUS33 Routing #: 021000021  
**WIRE TRANSFERS MUST INCLUDE MEMBER'S LAST NAME**

American Express  MasterCard  Visa  Diners Club  
 Card # \_\_\_\_\_ Exp. date \_\_\_\_\_  
 Signature \_\_\_\_\_

Note: ANS dues are tax deductible as allowed by law. Consult your tax advisor. Membership dues subscription allocations: *Nuclear News* - 49%.

## BENEFITS OF MEMBERSHIP

The American Nuclear Society is committed to lead in the development, dissemination, and application of nuclear science and technology to benefit humanity. Its 11,000 members are nuclear science and technology professionals who together represent a strong, unified voice in support of the advancement of nuclear science. ANS is the credible source for professional development and knowledge exchange. As a member of the American Nuclear Society, you'll receive:

- *Nuclear News*, providing you every month with the latest worldwide developments in the nuclear field, plus exclusive interviews with the movers and shakers shaping the profession.
- *ANS News*, reporting bi-monthly on the activities of the society, including public outreach efforts, position statements and honors and awards, plus providing news about members.
- *Nuclear Headlines*, links to nuclear-related news coverage updated every 15 minutes from 25,000 global sources.
- *Notes and Deadlines*, a monthly e-mail bulletin on topics of timely interest.
- Access to the Career Center in the members-only section of the ANS Website, where open positions are posted and you can post your resume.
- FREE membership in two ANS divisions, providing you with information and networking opportunities in your areas of specialty.
- Volunteer opportunities to express your viewpoints and enhance your career.
- Representation with regulators and legislators on behalf of the nuclear community.
- Substantial savings over the non-member registration fee at ANS meetings.
- Discounts on ANS journals, books, standards, and other publications.

**Join today! Apply online at [ans.org/join](http://ans.org/join)**

American Nuclear Society  
 555 N. Kensington Avenue  
 La Grange Park, IL 60526  
[ans.org](http://ans.org)

E-Mail: [members@ans.org](mailto:members@ans.org)  
 Tel: 800-323-3044  
 708-352-6611  
 Fax: 708-579-8295



**Embracing the past.  
 Looking to the future.**

**Join the most recognized society  
 for advancing and promoting  
 nuclear science and technology**

**2014 MEMBERSHIP APPLICATION**

**American Nuclear Society**  
**800-323-3044**  
**[ans.org](http://ans.org)**

**PERSONAL INFORMATION**

PLEASE PRINT

Dr.  Mr.  Mrs.  Miss  Ms.  Prof.  Other \_\_\_\_\_  
 First \_\_\_\_\_ M.I. \_\_\_\_\_  
 Last \_\_\_\_\_

Birth Date \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_  Male  Female  
MO DAY YR

Please provide **both** Home & Organization addresses to ensure delivery.

Please indicate postal mailing preference:  HOME  WORK

Please indicate e-mailing preference:  HOME  WORK

**Home address** \_\_\_\_\_

City \_\_\_\_\_

State/Province \_\_\_\_\_ Zip/Postal Code \_\_\_\_\_

Country \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

Cell Phone \_\_\_\_\_

E-Mail \_\_\_\_\_

**Primary employer** \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

State/Province \_\_\_\_\_ Zip/Postal Code \_\_\_\_\_

Country \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

E-Mail \_\_\_\_\_

Title \_\_\_\_\_

**Previous employer** \_\_\_\_\_

Title \_\_\_\_\_

**EDUCATION**

College/University \_\_\_\_\_

Major \_\_\_\_\_ Degree Received \_\_\_\_\_

Grad Year \_\_\_\_\_

**POSITION**

Please indicate one position which most nearly matches your own.

- |  |  |
|--|--|
| <input type="radio"/> President (11)               | <input type="radio"/> Health Physicist (41)              |
| <input type="radio"/> Vice President (12)          | <input type="radio"/> Chemist (42)                       |
| <input type="radio"/> Director (13)                | <input type="radio"/> Technician (43)                    |
| <input type="radio"/> Owner (14)                   | <input type="radio"/> Analyst (44)                       |
| <input type="radio"/> other official (19)          | <input type="radio"/> Consultant (45)                    |
| <input type="radio"/> Superintendent (21)          | <input type="radio"/> Scientist (46)                     |
| <input type="radio"/> Supervisor (22)              | <input type="radio"/> other specialist (49)              |
| <input type="radio"/> Manager (23)                 | <input type="radio"/> Professor (51)                     |
| <input type="radio"/> Chief Engineer (24)          | <input type="radio"/> Instructor (52)                    |
| <input type="radio"/> Department Head (25)         | <input type="radio"/> Trainer (53)                       |
| <input type="radio"/> other managerial title (29)  | <input type="radio"/> other educational title (59)       |
| <input type="radio"/> Nuclear Engineer (31)        | <input type="radio"/> Reactor Operator or Senior         |
| <input type="radio"/> Electrical Engineer (32)     | <input type="radio"/> Reactor Operator (71)              |
| <input type="radio"/> Mechanical Engineer (33)     | <input type="radio"/> Reactor Operations Supervisor (72) |
| <input type="radio"/> Chemical Engineer (34)       | <input type="radio"/> other (69)                         |
| <input type="radio"/> other engineering title (39) |  |

**INDUSTRY**

Please indicate one industry which most nearly matches your own.

- |   |  |
|---|--|
| <input type="radio"/> Manufacturer (11)               | <input type="radio"/> Construction Company (42)    |
| <input type="radio"/> Supplier (12)                   | <input type="radio"/> Educational Institution (41) |
| <input type="radio"/> Private Research Lab (21)       | <input type="radio"/> Medical Institution (61)     |
| <input type="radio"/> Test Lab (22)                   | <input type="radio"/> Consulting Company (71)      |
| <input type="radio"/> National Lab (31)               | <input type="radio"/> Service Company (72)         |
| <input type="radio"/> Government Agency (32)          | <input type="radio"/> Utility (81)                 |
| <input type="radio"/> Active Military (33)            | <input type="radio"/> other (69)                   |
| <input type="radio"/> Architect/Engineer Company (41) |  |

**PREFERENCES**

Member grade previously held in ANS:  Professional  Student

- Include my name on ANS mailings only
- DO NOT include my name in the Membership Directory
- I pay  My company pays/reimburses my membership dues
- I am a licensed Professional Engineer (P.E.)
- Local Section Member
- Contact me to identify the ANS/ANSI Standards status updates I would like to receive
- ANS News newsletter:  Mail only  Electronic only
- Referred by ANS Member (Opt'l) \_\_\_\_\_

**PROFESSIONAL DIVISIONS**

Dues include **free membership** in **TWO technical divisions**

Please rank your selections. (Ex: 1 Human Factors, 2 Reactor Physics, etc.); additional divisions are \$10.00 each.

Note: Professionals under age 36, Young Members Group (YMG) is an automatic addition to the two divisions. Others may join YMG for \$10.00. YMG may not be substituted for the two divisions included with membership.

- |  |  |
|--|--|
| — Accelerator Applications                             | — Materials Science & Technology                                   |
| — Aerospace Nuclear Science & Technology               | — Mathematics & Computation <sup>1</sup>                           |
| — Biology & Medicine <sup>1</sup>                      | — Nuclear Criticality Safety                                       |
| — Decommissioning & Environmental Science <sup>2</sup> | — Nuclear Installations Safety                                     |
| — Education, Training & Workforce Development          | — Nuclear Non-Proliferation Technical Group                        |
| — Fuel Cycle & Waste Management                        | — Operations & Power Radiation Protection & Shielding <sup>1</sup> |
| — Fusion Energy  | — Reactor Physics  |
| — Human Factors, Instr. & Controls                     | — Robotics & Remote Systems  |
| — Isotopes & Radiation                                 | — Thermal Hydraulics   |
|  | — Young Members Group (YMG)  |

<sup>1</sup> Includes Computational Medical Physics working group  
<sup>2</sup> Includes Nuclear Production of Hydrogen working group

**TO THE BOARD OF DIRECTORS**

I hereby apply for admission to the American Nuclear Society. I certify that the record of my training and professional experience is correct, and agree that if accepted, I will be governed by the Society's Code of Ethics (ans.org/about/coe), Bylaws, and Rules (ans.org/about/br) as long as I remain a member.

Signature \_\_\_\_\_ Date \_\_\_\_\_

FOR OFFICE USE ONLY	
Amount Received _____	ID# _____
Dues _____	NN _____
Entrance Fee _____	Extra Divisions _____
NT _____	NS&E _____
TRANS. _____	PROC. _____
FS&T _____	RWS _____
NSM _____	Schol _____
PI _____	NEED _____
Sub Total _____	Balance _____

## The Fuel Cycle and Waste Management Division

is one of the largest and most active divisions in the ANS. We deal with all aspects of the nuclear fuel cycle—mining, enrichment, fuel fabrication, fuel design, reprocessing, storage, geologic repositories, waste processing, waste form testing, advanced fuel cycle evaluations, fissile material management, and national fuel cycle policies.



# ANS FCWMD

## 2014 Awards Nomination Request

### Fuel Cycle and Waste Management Significant Contribution Award

This award was established in 2014 by the Fuel Cycle and Waste Management Division to recognize individuals or teams for a successful accomplishment that significantly advanced the scientific, engineering, societal, or regulatory aspects of the nuclear fuel cycle and/or the nuclear waste management.

Awards may be given to an individual or collectively to a team for success on a single project, activity, contribution, or sustained initiative related to the nuclear fuel cycle and/or nuclear waste management.

### Fuel Cycle and Waste Management Lifetime Achievement Award

This award was established in 2014 by the Fuel Cycle and Waste Management Division to recognize individuals who have made major lifetime contributions that significantly advanced the scientific, engineering, societal, or regulatory aspects of the nuclear fuel cycle and/or the nuclear waste management mission.

Nominees need to be living longstanding ANS members at the time of nomination with a minimum of 25 years working in the field.

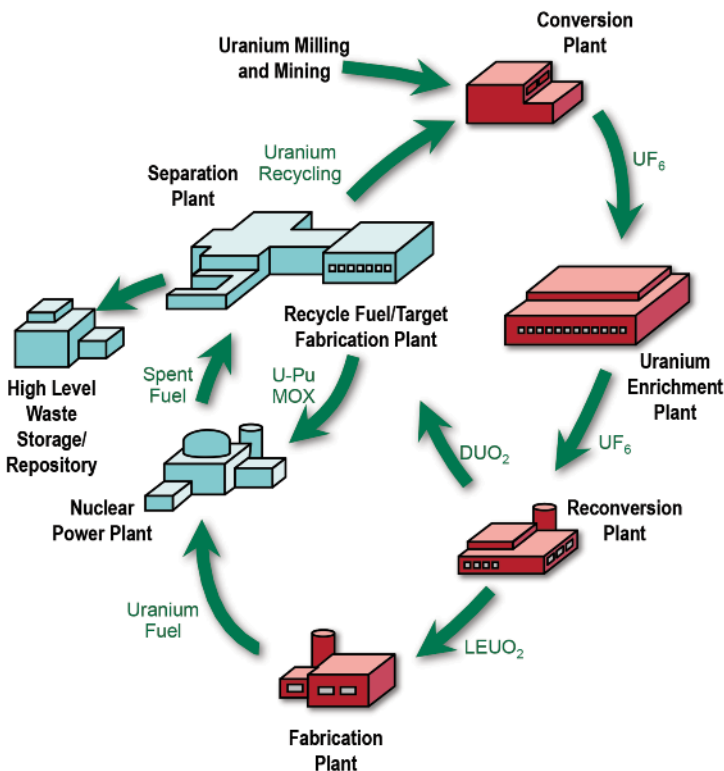
### Distinguished Service on behalf of the Fuel Cycle and Waste Management Division

This award was established in 2014 by the Fuel Cycle and Waste Management Division to recognize the outstanding participation in the leadership of the Division or in public outreach activities representing the division.

We would like to recognize outstanding contributions by our members to advancement of the common goals in relation to all aspects of the nuclear fuel cycle and we are actively seeking nominations for our three recently created prestigious awards.

Please send nominations to the FCWM chair at [delculgd@ornl.gov](mailto:delculgd@ornl.gov) not later than April 1st. The awards will be presented at the ANS National Meeting in Reno, Nevada in June.

For more information and details visit our web page [fcwmd.ans.org](http://fcwmd.ans.org) or contact the chair.



# Index to Articles in *Radwaste Solutions* (1994–2013)

## Biological and Medicine

The Decay-in-Storage Room at the Einstein College of Medicine. By George Hamawy and Carl Passler. Mar. 1995: 14-17.

Interim Storage Is Not Long-Term Disposal. By John R. Vincenti. Oct. 1994: 71-79.

Low-Dose Radiation Risk: A Biological Reality Check. By R. E. J. Mitchel. Mar./Apr. 2002: 30-35.

Radioisotopes, Medicine, and Low-Level Waste Disposal. By Rosalyn S. Yalow. Jan. 1994: 48-49.

A University Forum on LLW (Harvard, Texas A&M, Case Western Reserve). Sept. 1995: 32-46.

Waste Management by a One-Man Band: Managing a University and Medical LLRW Program. By P. Andrew Karam. Mar./Apr. 2000: 38-42.

## Blue Ribbon Commission on America's Nuclear Future

The Blue Ribbon Commission Has Its Say. Sept.-Oct. 2011: 4.

Draft Report from the Blue Ribbon Commission on America's Nuclear Future—Executive Summary. Sept.-Oct. 2011: 46-55.

Life After Death? Yucca Mountain and the Blue Ribbon Commission. By Nancy J. Zacha. May-June 2011: 59-62.

The Long Wait Is Over. Mar./Apr. 2010: 4.

What We've Heard: A Staff Summary of Major Themes in Testimony and Comments Received to Date by the Blue Ribbon Commission on America's Nuclear Future. May-June 2011: 51-58.

## Book Reviews

Nuclear Waste Stalemate: Political and Scientific Controversies. By Robert Vandenbosch and Susan E. Vandenbosch. Reviewed by Ruth Weiner. March/April 2008: 71-72.

Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting, Eds. Riley E. Dunlap, Michael E. Kraft, and Eugene A. Rosa. Reviewed by Domenic Forcella. Apr. 1994: 77-78, 86.

Uncertainty Underground: Yucca Mountain and the Nation's High-Level Waste, by Allison

M. Macfarlane and Rodney C. Ewing. Reviewed by Steve Turner. Mar./Apr. 2007: 44-45.

Waste Is a Terrible Thing to Mind: Risk, Radiation, and Distrust of Government, by John Weingart. Reviewed by Nancy J. Zacha. May/June 2001: 4.

Whose Backyard, Whose Risk: Fear and Fairness in Toxic and Nuclear Waste Siting, by Michael B. Gerrard. Reviewed by Domenic J. Forcella. July 1995: 39-42.

## Brokering

The Brokering of Radioactive Waste and the Politics of Disposal. By Peter Pastorelle. Jan. 1994: 13-19.

## Buildings and Other Shelters

And the Walls Came Tumbling Down . . . Rocky Flats Building 779 Closure Project. By Mark Zachary, Kelly Trice, and Tom Dieter. Sept./Oct. 2000: 56-64.

Closing the Most Dangerous Building in America. By Greg Meyer and Doug Hamrick. Sept./Oct. 1999: 43-48.

D&D . . . and Now Demolition. By Janenne Irene Harrington. Sept./Oct. 2001: 24-25.

Gimme Shelter! An "Out-of-the-Box" Structure Helps a Hanford Cleanup Project. By Tod Burrington. Sept./Oct. 2007: 47-50.

Utilizing Tensioned-Fabric Structures for Waste Processing and Storage Facilities. By Tom Ruprecht. July 1994: 33-38.

## Chemistry

The Importance of Radiological Data Validation. By Kendra K. Grega and LeRoy F. Wenrick. Mar. 1995: 28-32.

## Communications

Analogies and Dialogs: Integrating Natural Analog Studies into a National Confidence-Building Program. By I. McKinley and T. Tsuboya. Nov./Dec. 2001: 24-27.

Bored Board? Membership and Motivation in Site-Specific Advisory Boards. By Richard G. Telfer. Jan./Feb. 2000: 30-34.

Changing Public Participation at Fernald: Not an Easy (or Popular) Task. By Jeff Wagner. Mar./Apr. 2007: 54-58.

Community Relations—The NASA Way. By Burt Peretsky. July/Aug. 2002: 34-39.

The Dynamics of Public Opposition: Lessons from LLW Management. By Ellen Meadd. Nov./Dec. 2003: 30-35.

The Faces of Decommissioning and Site Cleanup: How "People" Issues Affect Work Progress. By Lara Harrison. Jan./Feb. 2001: 7-12.

Giving the Public Its Say: Learning Lessons from the DOE's Public Participation Program. By James L. Creighton. July/Aug. 1999: 38-44.

Good Things Can Happen When the Public Gets Involved: Gaining Public Acceptance of Nuclear Waste Management Activities. By Richard G. Telfer. July/Aug. 2000: 45-50.

Lending an Ear and a Voice: NASA's Plum Brook Station Community Workgroup. By Michael Morgan. July/Aug. 2007: 47-52.

Stakeholders Can Help: Improving D&D Policy Decisions at Rocky Flats. By Jack Hoopes. July/Aug. 1999: 45-48.

Taking Pride in Our Work—And Getting the Word Out. By Rhonda Carpenter and Nancy J. Zacha. Jan./Feb. 2000: 55-59.

Tell Them What They Want To Know: Designing a Community Outreach Program. By Darrell M. Lankford. Jan./Feb. 1999: 50-53.

## Compacts

Crossroads or Dead End: LLW Disposal in the United States. By E. Michael Blake. May/June 1999: 9-16.

The Design and Licensing Status of the Central Interstate Compact Facility: An Above-Grade LLRW Disposal Facility. By John E. Gunning, Michael A. Sabbe, Richard F. Schulman, and John H. DeOld. July 1997: 27-32.

Interim Storage Is Not Long-Term Disposal. By John R. Vincenti. Oct. 1994: 71-79.

Update on LLW Compacts and State Agencies. Sept. 1995: 24-31.

## Computer Technology

Evolving Requirements for Waste Management Software. By David W. James. Nov./Dec. 2003: 20-23.



Let's Model It: Using Computer Simulation to Improve Waste Processing Safety. By Jerry Fireman. Nov./Dec. 2000: 31-33.

Nuclear Waste Takes a TRIP: Electronic Signature Technology to Revolutionize Document Tracking. By Ben Groeneveld. Sept. 1998: 20-21.

Radioactive and Hazardous Materials Transportation Risk Assessment Using a Geographic Information System. By John E. Moore, Gary M. Sandquist, and David M. Slaughter. Jan. 1994: 75-76, 78.

### Conference Reports

Advanced Fuel Cycles, Cleanup Progress, and Other Issues: A Report from the 2006 ANS Summer Meeting. By Nancy J. Zacha. Sept./Oct. 2006: 62-64.

After Yucca Mountain: What's Next? By Nancy J. Zacha. Jan.-Apr. 2011: 96-98.

All Dressed Up with No Place To Go: The Disposition of Spent Nuclear Fuel. By Nancy J. Zacha. Jan./Feb. 1999: 41-42.

Analyzing the Blue Ribbon Commission Report. By Nancy J. Zacha. May-June 2012: 55-58.

ARRA, the BRC, and Radium Girls in the Spotlight at ANS Meeting. By Nancy J. Zacha. Jan.-Apr. 2012: 102-106.

Back to the Future: 9th International High-Level Radioactive Waste Management Conference. By Nancy J. Zacha. July/Aug. 2001: 48-52.

Catching Up on Decommissioning Projects—And Other Issues. By Nancy J. Zacha. Mar./Apr. 2005: 64-67.

The Changing Paradigm for LLW Management. By Nancy J. Zacha. Jan.-Apr. 2011: 91-95.

Clearing the Way for the Next Generation. By Nancy J. Zacha. Jan.-Apr. 2011: 82-90.

Closing Out a Tucson Tradition. By Nancy J. Zacha. May/June 2007: 37-41.

Consent-Based Siting . . . and Other BRC Issues. By Nancy J. Zacha. May-June 2013: 44-46.

Covering All the Bases at the Low-Level Summit. By Nancy J. Zacha. Nov./Dec. 2007: 13-20.

Current Topics in DD&R. By Nancy J. Zacha. Sept./Oct. 2005: 46-47.

D&D, Advanced Fuel Cycles Discussed in Reno. By Nancy J. Zacha. Mar./Apr. 2009: 74-78.

D&D Around the World. By Nancy J. Zacha. Nov./Dec. 2005: 14-17.

The D&D Challenge: Reducing Risks While Producing Results. By Nancy J. Zacha. Jan./Feb. 2005: 44-48.

D&D Dollars: D&D Expenditures Versus Cost Estimates. By Nancy J. Zacha. Sept./Oct. 2002: 50-52.

D&D, Fuel Cycle Issues Addressed at ANS Meeting. By Nancy J. Zacha. Sept./Oct. 2007: 57-60.

D&D in the Next Generation: A Report from the ANS 2001 Winter Meeting in Reno. By Nancy J. Zacha. Mar./Apr. 2002: 54-56.

D&D, Spent Fuel Transport Discussed at ANS Sessions. By Nancy J. Zacha. Sept./Oct. 2008: 52-54.

DD&R: The Transition to Closure: A Report from the 2005 ANS Topical Meeting on Decommissioning, Decontamination and Reutilization. By Nancy J. Zacha. Jan./Feb. 2006: 39-43.

Decommissioning at Savannah River—With a Focus on F Canyon Deactivation. By Nancy J. Zacha. Mar./Apr. 2005: 62-63.

Decommissioning Hot Topics. By Nancy J. Zacha. Sept./Oct. 2001: 47-48.

Decommissioning Successes: Progress Continues at the Nation's Commercial and Government Decommissioning Sites. By Nancy J. Zacha. Sept./Oct. 2002: 53-54.

Deep Borehole Disposal of Nuclear Waste. By Patrick V. Brady and Michael J. Driscoll. Sept./Oct. 2010: 58-60.

Dispositioning High-Level Waste in a Post-Yucca Mountain World. By Nancy J. Zacha. Sept./Oct. 2010: 61-63.

DOE Cleanup Programs Pushing toward Closure—And Other Radwaste Updates. By Nancy J. Zacha. May/June 2005: 51-54.

Dry Cask Storage, Stimulus Dollars, Multiple Agency Regulation . . . and TMI Redux. By Nancy J. Zacha. Mar./Apr. 2010: 76-82.

DU, Part 61, and a Host of Other Issues. By Nancy J. Zacha. Nov./Dec. 2009: 16-22.

East Meets West. By Michael D. Cavanaugh. July/Aug. 2001: 50.

"Easter Bunny Numbers" and Other Solid Materials Release Issues. By Nancy J. Zacha. Sept./Oct. 2004: 53-56.

Education and Opportunity for the Next Generation: A Report from Waste Management 2006. By Nancy J. Zacha. July/Aug. 2006: 44-49.

Engaging and Exchanging in Connecticut: 2001 ANS Executive Conference on Nuclear Facility Decommissioning and Used Fuel Management. By Nancy J. Zacha. Nov./Dec. 2001: 40-45.

Entering a New Era for Radioactive Waste Management. By Nancy J. Zacha. Jan.-Apr. 2012: 91-100.

Exploring the World of DD&R: Big Issues, Hot Topics, Cost Considerations, and More. By Nancy J. Zacha. July/Aug. 2000: 51-54.

Eyes on the Numbers: A Report on Spectrum '98. By Nancy J. Zacha. Nov./Dec. 1998: 47-52.

Farewell Yucca, Hello Stimulus Money, and Other Waste Management Issues. By Nancy J. Zacha. July/Aug. 2009: 51-56.

Focusing on LLW Issues at Waste Management '07. By Nancy J. Zacha. May/June 2007: 17-19.

Focusing on Science and Technology at the Spectrum Conference. By Nancy J. Zacha. Nov./Dec. 2002: 53-57.

Global Achievements and Challenges in nuclear Waste Management. By Nancy J. Zacha. May-June 2011: 63-69.

Global Progress Toward Safe Disposal: A Report from the 2006 ANS HLW Conference. By Nancy J. Zacha. July/Aug. 2006: 50-55.

Going to the Mountain. By Hugh Curley. July/Aug. 2001: 52.

Good Stewardship of the Past to Build the Future. By Nancy J. Zacha. Sept.-Oct. 2012: 53-57.

The Good, the Bad, and the Money; Or, What's Right and Wrong with Privatization. By Nancy J. Zacha. Jan./Feb. 1999: 38-40.

Groundwater Contamination . . . and Other Issues. By Nancy J. Zacha. Mar./Apr. 2008: 66-70.

High-Level Waste Management: At Home and Around the World. By Nancy J. Zacha. Jan./Feb. 2009: 37-44.

HLW Disposal Programs Around the World: What They're Doing and What They've Learned. By Nancy J. Zacha. July-Aug. 2011: 68-76.

Hot Topics and Regulatory Issues. By Nancy J. Zacha. Sept./Oct. 2004: 50-52.

Improving the Future by Dealing with the Past. By Nancy J. Zacha. May/June 2010: 46-49.

Improving the Future in Waste Management. By Nancy J. Zacha. May-June 2012: 66-71.

The Inspector Calls: Inspection Planning, Feedback, and Results on Decommissioning. By Nancy J. Zacha. Jan./Feb. 2001: 44-45.

Integrating Storage, Transportation, and Disposal. By Nancy J. Zacha. July-Aug. 2013: 60-66.

International Collaboration and Continuous Improvement. By Nancy J. Zacha. May-June 2013: 48-53.

The Last 5 Percent Seems to Take Forever . . . And Other DD&R Lessons Learned. By Nancy J. Zacha. Jan./Feb. 2008: 38-43.

Life After Death? Yucca Mountain and the Blue Ribbon Commission. By Nancy J. Zacha. May-June 2011: 59-62.

"Live by Satellite" and Other Events at Waste Management '04. By Nancy J. Zacha. May/June 2004: 48-52.

Low-Level Radioactive Waste: Depleted Uranium, Waste Imports, and Other Issues. By Nancy J. Zacha. May/June 2010: 28-31.

Low-Level Waste at Waste Management 2013. By Nancy J. Zacha. May-June 2013: 23-25.

Low-Level Waste Disposal: Is There a Solution Out There? By Nancy J. Zacha. May/June 2005: 29-31.

Low-Level Waste Issues in the Spotlight at WM11. By Nancy J. Zacha. May-June 2011: 15-18.

Low-Level Waste Storage Options, Concerns. By Nancy J. Zacha. May/June 2008: 22-24.

Managing Radwaste Around the World. By Nancy J. Zacha. Jan.-Apr. 2013: 64-69.

Marssim's Impact on Decommissioning. By Nancy J. Zacha. Jan./Feb. 1999: 43.

A New Entity to Manage Nuclear Fuel. By Nancy J. Zacha, Jan.-Apr. 2013: 70-75.

A New Life for Recycling—And Other Decommissioning and Waste Management Updates: A Report from the 2005 ANS Winter Meeting. By Nancy J. Zacha. Mar./Apr. 2006: 58-65.

Oak Ridge Day at Waste Management 2012. By Nancy J. Zacha. May-June 2012: 23-28.

Oh, Give Me A Home . . . : Spent-Fuel Dry Cask Storage Update. By Nancy J. Zacha. Jan./Feb. 2001: 48-50.

Optimism for 1997: The Cal Rad Forum's Fall Conference. By Nicki Hobson. Jan. 1995: 43-46.

- Please Release Me . . . : Materials and Site Free-Release Issues. By Nancy J. Zacha. Jan./Feb. 2001: 46-47.
- Private Offsite Spent Fuel Storage: A Report from the ANS Executive Conference. By Nancy J. Zacha. May/June 2006: 49-54.
- A Range of Colorful Challenges: A Meeting Report from Spectrum 2000. By Nancy J. Zacha. Nov./Dec. 2000: 46-51.
- Record Attendance for Waste Management's First Show in Phoenix. By Nancy J. Zacha. May/June 2008: 47-51.
- Rocky Starts, Lessons Learned, Midnight Runs, and Other Scenarios: DD&R Update. By Nancy J. Zacha. Nov./Dec. 1999: 57-60.
- Russia to the Rescue? International Spent-Fuel Storage Options Discussed at ANS Annual Meeting. By Nancy J. Zacha. July/Aug. 2002: 54-56.
- Same Issues, New Solutions at This Year's Radwaste Summit: A Report from the Second Annual Radwaste Summit. By Nancy J. Zacha. Nov./Dec. 2008: 16.
- Solving the Spent Fuel Dilemma. By Nancy J. Zacha. Sept.-Oct. 2012: 50-52.
- Spent Fuel, Nuclear Waste on the Regulatory Radar Screen. By Nancy J. Zacha. May/June 2007: 42-47.
- Spent-Fuel Storage: Rhetoric, But No Resolution. By Nancy J. Zacha. Sept./Oct. 2001: 54-56.
- Tackling Decommissioning/Spent-Fuel Issue in Traverse City. By Nancy J. Zacha. Sept./Oct. 1999: 54-59.
- Take My Spent Fuel . . . Please! By Nancy J. Zacha. July/Aug. 1999: 58-59.
- Taking Pride in Our Work—And Getting the Word Out. By Rhonda Carpenter and Nancy J. Zacha. Jan./Feb. 2000: 55-59.
- Team Completes Dismantlement and Layup of Two Brookhaven Reactors. By Fran Poda. Sept./Oct. 2010: 44-50.
- To Blend or Not to Blend: Blending U.S. Commercial Low-Level Waste to Allow Disposal. By Nancy J. Zacha. May/June 2010: 24-27.
- To DOC or Not To DOC: Managing Power Plant Decommissioning. By Nancy J. Zacha. July/Aug. 1999: 60-61.
- Toto, We're Not in Kansas Anymore. By Nancy J. Zacha. July/Aug. 2000: 4.
- Very Long Term Dry Fuel Storage . . . and Other Issues. By Nancy J. Zacha. Sept.-Oct. 2011: 59-64.
- Ward Valley: Heading for the Finish Line and Picking Up Speed. By Nicki Hobson. Jan. 1996: 55-58.
- Waste in Its Proper Place. By Nancy J. Zacha. Mar./Apr. 2007: 73-75.
- Waste Management Goes Silver: A Report on the 25th Anniversary Waste Management Conference in Tucson. By Nancy J. Zacha. May/June 1999: 58-64.
- Waste Management 2001. By Nancy J. Zacha. May/June 2001: 54-58.
- Waste Management 2002: Step-by-Step, Top-to-Bottom, Rebecca, and Other Topics. By Nancy J. Zacha. May/June 2002: 52-57.
- What If We Lose Barnwell? By Nancy J. Zacha. July/Aug. 1999: 62-63.
- Whatever Happened to TMI-2, and Other Nuclear Waste Issues. By Nancy J. Zacha. Mar./Apr. 2007: 68-72.
- Where the Elite Meet. Sept./Oct. 2001: 4.
- Where the Utilities Go. Nov./Dec. 2000: 4.
- The World, WIPP, and Other Waste Issues: A Meeting Report from Waste Management 2000. By Nancy J. Zacha. May/June 2000: 64-70.
- Y-12's Mercury Problem. By Nancy J. Zacha. Jan.-Apr. 2013: 62-63.
- Yesterday, Today, and Tomorrow in Focus at Meeting Sessions. By Nancy J. Zacha. Sept./Oct. 2009: 51-57.
- Yucca Mountain: Healthy or on Its Deathbed? A Meeting Report from the 2008 Regulatory Information Conference. By James F. Mallay. May/June 2008: 44-46.
- Yucca Mountain Updates—And Other Spent Fuel Issues. By Nancy J. Zacha. May/June 2005: 49-50.
- Decommissioning/Decontamination**
- 309 Building Demolition at Hanford. May-June 2011: 48-50.
- The ABCs of Decommissioning Safety. By Bill Grubilowicz and Janenne Irene Harrington. Jan./Feb. 2002: 8-11.
- Accelerating high-Hazard Reduction at Sellafeld. By Ali McKibbin and Lucy Watson. July/August 2010: 16-25.
- And Now for Something Completely Different: An Innovative Path Toward Zion Decommissioning. By Nancy J. Zacha. May-June 2012: 29-33.
- And the Walls Came Tumbling Down . . . Rocky Flats Building 779 Closure Project. By Mark Zachary, Kelly Trice, and Tom Dieter. Sept./Oct. 2000: 56-64.
- Andros and Rosie and Other Friends to D&D Workers: Decommissioning Technologies that Improve Worker Safety. By Steven Bossart and Danielle Blair. Jan./Feb. 2002: 16-10.
- Bats, Owls, and Cocoons: Hanford's F Reactor Interim Storage Project Complete. Mar./Apr. 2004: 48-50.
- Beneficial Reuse of Decommissioned Former Nuclear Facilities. By Lawrence E. Boing. July 1998: 44-49.
- The Benefits of International Cooperation on Decommissioning: U.S. and U.K. contributions to the Decommissioning of Kazakhstan's BN-350 Reactor. By D. Wells, J. Michelbacher, and T. Hayward. Nov.-Dec. 2011: 15-19.
- Bidding Farewell to Saxton. Mar./Apr. 2006: 43-45.
- Biodecontamination of Concrete Surfaces: Occupational and Environmental Benefits. By LaMar J. Johnson, Robert D. Rogers, Melinda A. Hamilton, Lee O. Nelson, Jenny Benson, and Martin Green. Jan. 1998: 28-35.
- The Big Cleanout at Big Rock Point. By Tim Petrosky. Jan./Feb. 2000: 14-21.
- The Big Rock Vessel Goes to Barnwell. By Tim Petrosky. Jan./Feb. 2004: 15-19.
- Bit by Bit . . . Taking It Apart: The Incremental Dismantlement of the Rancho Seco Secondary System. By Dennis E. Gardiner and John M. Newey. July/Aug. 1999: 9-14.
- Building Dismantlement and Site Remediation at the Apollo Fuel Plant: When Is Technology the Answer? By Lewis Walton. Jan. 1995: 20-25.
- Bye-Bye Big Rock: Greenfield Celebration Highlights Plant's Successful Decommissioning. By Dan Gretzner. Nov./Dec. 2006: 12-16.
- The Case of the Transuranic-Loving Squirrels: The Decontamination of the XF-90A. By James Seals. Nov./Dec. 2004: 41-45.
- Catching Up on Decommissioning Projects—And Other Issues. By Nancy J. Zacha. Mar./Apr. 2005: 64-67.
- Catching Up with Clearance Criteria. By Nancy J. Zacha. Sept./Oct. 2001: 57-58.
- Changing the Fernald Skyline: The Demolition of the Site's Production-Era Water Tower. Nov./Dec. 2003: 36-41.
- Chapelcross Cooling Towers—Ten Seconds to Demolition. Sept./Oct. 20007: 28-29.
- Cleaning Up and Closing Down the Fernald Site. By Michele Gerber. July/Aug. 2006: 16-29.
- Closing the Book: The Decommissioning of the Barnwell Nuclear Fuel Plant. By Jim McNeil. May/June 2000: 55-63.
- Connecticut Yankee Decommissioning: Removing Restoring, and Reusing. By Michael D. Cavanaugh. Mar./Apr. 2001: 59-61.
- The "Cocooning" of C Reactor: A Hanford Success Story. By John Crigler. Sept./Oct. 1999: 29-31.
- Closing the Most Dangerous Building in America. By Greg Meyer and Doug Hamrick. Sept./Oct. 1999: 43-48.
- Current Topics in DD&R. By Nancy J. Zacha. Sept./Oct. 2005: 46-47.
- Cutting Edge Characterization Technologies for D&D. By Steven J. Bossart and Kenneth M. Kasper. Jan./Feb. 1999: 23-30.
- D&D . . . and Now Demolition. By Janenne Irene Harrington. Sept./Oct. 2001: 24-25.
- D&D Around the World. By Nancy J. Zacha. Nov./Dec. 2005: 14-17.
- D&D at the Nevada Test Site: Facility History, Regulatory Framework, and Lessons Learned. By Jerel G. Nelson and Michael R. Kruzic. May/June 2005: 33-40.
- The D&D Challenge: Reducing Risks While Producing Results. By Nancy J. Zacha. Jan./Feb. 2005: 44-48.
- D&D Dollars: D&D Expenditures Versus Cost Estimates. By Nancy J. Zacha. Sept./Oct. 2002: 50-52.
- D&D, Fuel Cycle Issues Addressed at ANS Meeting. By Nancy J. Zacha. Sept./Oct. 2007: 57-60.
- The D&D Focus Area: Bringing New Technologies to the D&D Toolbox. By William Lupichuk. Mar./Apr. 2001: 43-47.
- D&D in the Next Generation: A Report from the ANS 2001 Winter Meeting in Reno. By Nancy J. Zacha. Mar./Apr. 2002: 54-56.
- D&D, Spent Fuel Transport Discussed at ANS Sessions. By Nancy J. Zacha. Sept./Oct. 2008: 52-54.
- DD&R: The Transition to Closure: A Report from the 2005 ANS Topical Meeting on Decommissioning, Decontamination and Reutilization. By Nancy J. Zacha. Jan./Feb. 2006: 39-43.
- Deactivation and Decommissioning Knowledge Management: A Partnership Among the

- DOE, Contractors, and Academia. By Himanshu Upadhyay and Leonel Lagos. Sept.-Oct. 2012: 46-49.
- Decisions, Decisions, Decisions . . . Better D&D Decision-Making through Life Cycle Analysis. By Katherine L. Yuracko, Bruce E. Tonn, Michael I. Morris, and James Bogard. July/Aug. 1999: 31-37.
- Decommissioning Fort St. Vrain. By Vincent F. Likar and G. Thomas Howard. Sept. 1995: 54-60.
- Decommissioning Hot Topics. By Nancy J. Zacha. Sept./Oct. 2001: 47-48.
- Decommissioning of a Hot Laboratory and Cyclotron Complex to Green Field. By David Loughborough, Clive Hamblin, and John Asquith. Jan. 1995: 47-54.
- The Decommissioning of Zion: A Status Update. By Patrick Daly. Nov.-Dec. 2013: 18-27.
- Decommissioning One, Operating Two: At San Onofre, Breaking Up Is Hard To Do. By Ray Golden. July/Aug. 2000: 20-23.
- Decommissioning Planning at Whiteshell Laboratories. By Randall Ridgway. Nov./Dec. 2002: 31-28.
- Decommissioning Successes: Progress Continues at the Nation's Commercial and Government Decommissioning Sites. By Nancy J. Zacha. Sept./Oct. 2002: 53-54.
- Decommissioning the Building A59 Hot Cells at Winfrith. By Keith Miller, G. Tizzard, Steve Parkinson, Rowland Cornell, and Andrew Staples. Sept./Oct. 2004: 41-49.
- Decommissioning the Next Generation of Nuclear Plants. By John Newey. Mar./Apr. 2006: 26-28.
- Decommissioning "The Rock": A Photo Tour of the Big Rock Point Restoration Project. Sept./Oct. 1999: 60-62.
- Decommissioning the Quehanna Hot Cell Facility. By Kenneth M. Kasper and Lee G. Penney. May/June 2001: 44-48.
- Decommissioning the University of Illinois TRIGA Research Reactor. By Thomas Gilmore, Corey DeWitt, Dustin Miller, and Kevin Taylor. July-Aug. 2013: 24-27.
- Decommissioning the World's Largest Open-Air Nuclear Fuel Storage Pond. July-Aug. 2011: 32-36.
- Decommissioning: Thinking Through to the End—A Perspective on the End State of Decommissioning. By Russell A. Mellor. Sept./Oct. 2001: 26-28.
- Decommissioning Trojan: A Step-by-Step Tour of a Landmark Process. By Stephen Quennoz. May/June 1999: 17-21.
- A Decommissioning Wrapup: Commercial Reactor Decommissioning Status in 2006. By Edward C. Doubleday. Mar./Apr. 2007: 46-52.
- Decommissioning Yankee Rowe. By Kenneth J. Heider and Russell A. Mellor. July 1994: 26, 27-32.
- Decommissioning's "Father" Known Best: A Profile of Decommissioning Pioneer Bill Manion. By Janenne Irene Harrington. Jan./Feb. 2001: 41-43.
- Decontaminating 30 Million Square Feet. By Anne Smith. Nov./Dec. 2004: 28-33.
- The Decontamination and Decommissioning Debate. By Anthony J. Thompson and Michael L. Goo. Apr. 1994: 32-41.
- Decontamination and Decommissioning of Building 889 at Rocky Flats Environmental Technology Site. By Kent A. Dorr, Mark E. Hickman, Brian J. Henderson, and Richard J. Sexton. Sept. 1997: 37-40.
- Decontamination and Melting of Low-Level Waste. By D. W. Clements. Mar. 1997: 36-41.
- Decontamination of Radioactive Concrete: A Permanent Solution That's RCRA Friendly. By Michael Simmons. Jan. 1994: 25-29.
- Defueling the ORNL Molten Salt Reactor Experiment Facility. By Michael R. Jugan, Andrew P. Kelsey, Mahmoud H. Haghghi, and E. Paul Larson. Nov./Dec. 1999: 35-39.
- Delivering Cleanup at Sellafield. By Byron Smith. Mar./Apr. 2006: 30-35.
- Designing Decommissioning into New Reactor Designs. By Jas S. Devgun. Sept./Oct. 2007: 40-46.
- Determining Endpoints for the Decontamination and Decommissioning of Facilities. By Linda Albrecht, Dennis Morgan, Louise Buker, and Don Davis. May 1998: 30-34.
- DfD at Big Rock Point. By Jane Dunshee and Lisa Wheat. May/June 1999: 28-30.
- Diamonds Are a Cutter's Best Friend: Diamond Wire Cutting the Tokamak Fusion Test Reactor. By Keith Rule, Erik Perry, and Robert Parsells. May/June 2002: 40-45.
- Dismantling the Recirculation Pump Room at Big Rock Point. By Janenne Irene Harrington. Mar./Apr. 2001: 56-58.
- DOE, Fluor-B&W Portsmouth Clear Way for D&D in Piketon. By Julie Doering. Jan.-Apr. 2012: 58-63.
- DOE Pursuing Accelerated Cleanup at Fernald. By Terry Borgman. Jan. 1996: 42-44.
- Doin' the D&D: Dancing to the Regulatory Tune. By John D. Haseltine and Stephen J. Milioti. Jan./Feb. 1999: 44-49.
- Economic Development at DOE Cleanup Sites: Whose Job Is It, Anyway? By Katherine N. Probst and Amy S. Fitzgerald. July/Aug. 2000: 55-61.
- The End of an Era: Decommissioning Four German Fuel Cycle Facilities. By Helmut Rupp, Roland Baumann, Peter Faber, Manfred Ruhbaum, and Helmut Schmitt. May/June 2000: 28-40.
- Engineering and Technology in the Deconstruction of Nuclear Materials Production Facilities. By Richard S. Kingsley, W. Evans Reynolds, and David C. Heffner. Jan. 1996: 25-31.
- EPRI Comes to Dounreay: The Cooperative Assistance Program for Waste Management. By Michael Dunnett and Paul McClelland. Mar./Apr. 2004: 62-71.
- EPRI Decommissioning Technology Program. By Christopher J. Wood, Carol Hornibrook, and Robert C. Thomas. July/Aug. 1999: 24-30.
- EPRI's Decommissioning Technology Program. By Christopher J. Wood and Sean Bushart. July/Aug. 2006: 30-35.
- The EPRI DFD Process: Decontaminating Retired Components and Reactor Coolant Systems Following Plant Shutdown. By David Bradbury, George R. Elder, and Christopher J. Wood. Sept./Oct. 2001: 16-23.
- Exploring the World of DD&R: Big Issues, Hot Topics, Cost Considerations, and More. By Nancy J. Zacha. July/Aug. 2000: 51-54.
- The Faces of Decommissioning and Site Cleanup: How "People" Issues Affect Work Progress. By Lara Harrison. Jan./Feb. 2001: 7-12.
- A Farewell at Fernald. By Nancy J. Zacha. May/June 2007: 26-30.
- Fermi-1 Update: Impact of a Decommissioning Evaluation and the Decommissioning Rule. By Lynne S. Goodman. Nov. 1997: 45-48.
- The Final Chapter: Planning the Decommissioning of the Barnwell Nuclear Fuel Plant. By Jim McNeil. May/June 1999: 51-57.
- Finding (and Counting) the Needles in a Haystack: Estimating the Radioactivity in the XC1 Hot Cell at West Valley. By Jeffrey A. Choroser, Cynthia Dayton, and Herman R. Moore. Sept./Oct. 2004: 31-35.
- First Nuclear Fuel Movement in 50 Years Is a Decommissioning Milestone at Sellafield. Jan.-Apr. 2012: 54-56.
- Fostering Community Participation in Decommissioning. By Maureen Brown. Sept. 1998: 31-35.
- From the Bottom Up: Tank Removal at Trojan. By Brian D. Clark and Roger M. Lewis. Mar./Apr. 2000: 22-31.
- Fueling Up for the Long Haul: Training for Decommissioning. By Larry Boing. Jan./Feb. 2001: 25-27.
- Getting "Fired" Up: Size-Reduction with an Oxy Gasoline Torch. By K. A. Szlis, K. R. Schneider, S. W. Chase, J. A. Choroser, and H. R. Moore. Sept./Oct. 2001: 10-15.
- Getting the Lead Out: Recycling and Decontamination at the INEL. By Erik A. Simpson. July 1994: 49-51.
- Getting Pumped: Lessons Learned from the Decontamination and Removal of High-Level Waste Pumps at the West Valley Demonstration Project. By William F. Hamel Jr., Kimberly J. Mansfield, and Paul J. Valenti. Jan./Feb. 1999: 5-14.
- A Glitch Caught in Time Saves . . . : Lessons Learned during Reactor D&D at Argonne National Laboratory. By Charles R. Fellhauer. Jan./Feb. 2000: 22-29.
- Goodbye, Golden Goose: The Effects of Connecticut Yankee Decommissioning on the Surrounding Community. By Terry Concannon. Jan./Feb. 1999: 54-57.
- Hanford Scores Another Successful Open-Air Demolition: 232-Z Plutonium Incinerator Facility Demolished in July. By Michele Gerber. Jan./Feb. 2007: 31-39.
- Handling the Unexpected: Connecticut Yankee's Concrete Block Recovery Effort. By Richard Sexton. Jan./Feb. 1999: 58-59.
- Hands Off! New West Valley Facility Cuts Rad Components Down to Size. By Jim Hurst, Kathy Szlis, and Tom Vero. July/Aug. 2004: 29-33.
- Hanford's C Reactor Large-Scale Demonstration Project. By James D. Goodenough and Jeremiah J. McGuire. Mar. 1997: 31-35.
- Have Pipe Cleaning System, Will Travel: Innovative, Cooperative Effort at Big Rock Point. By Janenne Irene Harrington. Nov./Dec. 2000: 21-25.
- How to "Do" Windows: Refurbishment of Shield Windows at the West Valley Demonstration Project. By K. R. Schneider, M. J. Fiz-

- zano, J. L. Drake, and C. Kalkwarf. Jan./Feb. 2001: 37-40.
- Improved D&D through Innovative Technology Deployment. By Steven J. Bossart and Kenneth M. Kasper. Jan. 1998: 36-40.
- Improving Efficiency with 3-D Imaging: Technology Essential in Removing Plutonium Processing Equipment from Plutonium Finishing Plant Gloveboxes. By Stephen Crow, Richard Kyle, and Michael Minette. Sept./Oct. 2008: 26-31.
- Innovative Technologies for Asbestos Removal and Treatment. By Steven J. Bossart and Kenneth M. Kasper. Jan. 1998: 10-18.
- In-Process Characterization is a SNAP at Rocky Flats. By William R. Salazar. July/Aug. 2004: 15-23.
- Interview with Andrew C. Kadak. By David A. Schabes. Jan. 1996: 17-24.
- Introduction to the Theme Issue on DD&R: Back to the Future, New Technologies, and Innovative Engineering Practices. By Neil Norman and Dennis Bitz. Jan. 1996: 4.
- It Takes a Team: The Omega West Reactor D&D. By Stephen F. Mee, Keith R. Rendell, Martin J. Peifer, John A. Gallagos, and Joe B. Stringer. Mar./Apr. 2004: 52-60.
- It's Complicated: The Complexities of Decommissioning a Uranium Mill Site. By Matthew Meyer. Sept.-Oct. 2011: 43-45.
- Just Tooling Around . . . Conventional Equipment Makes Light Work of Decontamination Challenges. By Scott Chase, John Drake, Kathy Szlis, and Peter Vlad. Mar./Apr. 2004: 38-46.
- K-25 Challenges Met. By Fran Smith. July-Aug. 2013: 16-23.
- Keeping an Eye on the Bottom Line. By Michael S. Terrell. Sept./Oct. 2000: 30-32.
- La Crosse BWR Reactor Vessel Shipped to Barnwell. Sept./Oct. 2007: 30-32.
- Large Component Disposal: Do It Now or Do It Later? By Paul J. Larsen and Jay K. Vance. Jan./Feb. 2006: 20-25.
- The Last 5 Percent Seems to Take Forever . . . And Other DD&R Lessons Learned. By Nancy J. Zacha. Jan./Feb. 2008: 38-43.
- Leading the Way in Community Transfer: The Economic Development and Commercialization of Mound. By Dottie Atkins. Nov./Dec. 2000: 42-45.
- Lessons Learned from Large Decommissioning Projects—The Spanish Experience. By Juan Luis Santiago and Alejandro Rodriguez. May-June 2013: 26-29.
- Making MERLIN Disappear Without a Trace (Almost). By B. Stahn, R. Printz, K. Matela, and C. Zehbe. July/August 2010: 26-40.
- Making Safety Work: Safety-Enhancing Technologies and Practices at INEEL Decommissioning Projects. By Richard Meservey. Jan./Feb. 2002: 20-24.
- Making the Impossible Possible: Closing Rocky Flats—Ahead of Schedule and under Budget. By Ed Bodey. Sept./Oct. 2005: 39-45.
- Marssim's Impact on Decommissioning. By Nancy J. Zacha. Jan./Feb. 1999: 43.
- Michigan Historical Marker for Big Rock Point Site. By Tim Petrosky. Nov./Dec. 2007: 10-12.
- Milestone Reached at Sellafield Primary Separation Plant Decommissioning Project. Mar./Apr. 2010: 36-38.
- (Mission) Shifting Gears: How to Survive Change. By Justin Schulz. Mar. 1995: 33-40.
- Moving to Another Stage of Life: Shipping, Decontaminating, and Final Disposition of the Maine Yankee Large Components. Sept./Oct. 2000: 50-55.
- Navigating a Year of Decisions in Piketon. By Julie Doering. May-June 2012: 13-16.
- A New Approach for the Deployment of Innovative D&D Technologies. By Lawrence W. Vogel, Stuart L. Claggett, and John R. Duda. May 1998: 24-29.
- New Life for an Old Lab: Commercializing a DOE Laboratory. By Barry A. Stephenson. Mar./Apr. 2009: 30-37.
- A New Start for BNFL: Magnox Reactor Decommissioning Strategy. By Paul B. Woollam. July/Aug. 2001: 28-34.
- New Technologies in the SRS "Toolbox." By David Yannitell. July/Aug. 2000: 28-34.
- The Next Stage for EPRI'S DFD Process: Decontamination and Recycling of Radioactive Material from Retired Components. By Chris Wood, Sean Bushart, David Bradbury, and George Elder. Nov./Dec. 2004: 17-21.
- Nondestructive Assay for Waste and D&D Applications. By Bruce Gillespie. Mar./Apr. 2009: 38-42.
- Now Appearing at an Airport Near You: Adapting Aviation Ground Support Equipment for Removing Nuclear Waste at Rocky Flats. By Bill Badger. Jan./Feb. 2004: 42-45.
- Now There Are None: The Last Uranium Production Building at Fernald Has Been Toppled, the Culmination of a 10-Year Demolition Project. By Jeffrey Wagner. July/Aug. 2004: 24-28.
- NRC's D&D Regulations. By Anthony J. Thompson. Mar. 1998: 47-54.
- Pathfinder: The Long Road Toward Decommissioning. By C. E. Burtoff, J. W. Closs, J. M. Gushue, J. J. Holthaus, K. Lucken, and J. C. Seitz. March/April 2008: 18-27.
- Plan Ahead, Establish Support Lines, and Be Prepared for Surprises: Lessons Learned from the BNFP Decommissioning Project. By Jim McNeil. Jan./Feb. 2001: 30-36.
- Planning Ahead: Preparing for the Early Retirement and Decommissioning of Oyster Creek. By James E. Hildebrand. Nov./Dec. 1998: 31-36.
- Planning for Decommissioning: What, How, When, and Why? By W. W. Bixby and W. J. Manion. Sept./Oct. 1999: 66-68.
- Potential Radioactive Scrap Metal Quantities from Nuclear Power Plants Worldwide. By Leslie A. Nieves and Roger W. Tilbrook. Jan. 1996: 45-53.
- Radioactive Waste Is Getting Slimed! Microbial Janitors Tackle Nuclear Cleanup Problems. By Deborah Hill. Nov./Dec. 1999: 54-56.
- Radioactive Waste Not Wasted with New Green Chemistry Technology. By Thomas Smith and Judy Thomas. Sept./Oct. 2008: 32-35.
- The Rancho Seco Eleven: A Story of Spent Fuel Racks from Removal to Burial. By Robert A. Snyder. Jan./Feb. 2004: 26-32.
- Recycling and Waste Management Related to Decommissioning: German Experiences and Concepts. By Heinz Peter Berg, Peter Wilhelm Brennecke, and Rudolph Görtz. Mar. 1998: 41-46.
- Redistributing Fernald's Government Assets. By Deborah Dunn. Sept./Oct. 2007: 34-39.
- Remediating the Past and Preparing for the Future at Sandia National Laboratories. By Thomas L. Sanders. Jan. 1996: 32-41.
- Resuming Decommissioning Activities at Fermi-1: Problems Encountered and Lessons Learned. By Danny Swindle, Jon Couillard, and Lynne Goodman. July/Aug. 1999: 15-19.
- The Rocky Flats Challenge: Driving Worker Exposures As Low As Reasonably Achievable during Decommissioning. By Jennifer Thompson. July/Aug. 2001: 42-47.
- Saving D&D \$\$\$: New D&D Technologies at the INEEL. By Julia Tripp, Richard H. Meservey, and Ann-Marie Phillips. Nov./Dec. 2000: 36-41.
- Science, Technology, and Workforce Innovations: Keys to a Successful D&D of Hanford's Plutonium Finishing Plant. By Stacy Charboneau, Andrea Hopkins, Bruce Klos, Robert Heineman, and Brian Skeels. Mar./Apr. 2007: 60-66.
- Segmenting and Disposing of the Rancho Seco Reactor Vessel Internals. By Karl Johnson. Sept./Oct. 2006: 37-50.
- Segmenting the Rancho Seco Reactor Head—A Cost-Effective Option. By Michael Snyder. Nov./Dec. 2004: 22-27.
- Segmenting and Removing the CVTR Moderator Tank. By Michael G. Anderson. Sept./Oct. 2008: 18-25.
- Sheer Grit: ARRA Transforms Y-12. By Gail Powell. July-Aug. 2011: 22-31.
- Small Business Tackles BIG Challenge: Hanford Contracts with Small Businesses on D&D Projects. By Ken Powers and Mark Lesinski. Sept./Oct. 2004: 36-40.
- Softening Things Up at Big Rock Point: Controlled Blasts Assist Demolition. Mar./Apr. 2006: 46-49.
- SRS Demolished Massive K Cooling Tower. July/August 2010: 41-43.
- Status of Chernobyl Decommissioning Efforts. By Tom W. Wood, P. Ken Jackson, and Mark R. Morton. Jan. 1998: 19-27.
- Striking the Right CORD: Decontamination for Decommissioning at Connecticut Yankee. By Scott Watson, Richard N. McGrath, Horst-Otto Bertholdt, Edmund Friedrich, William J. Szymczak, and Ed Ruzauskas. Mar./Apr. 1999: 46-51.
- Tackling Tough Challenges at SRS: Deactivation and Materials Disposition at F Area. By Fran Poda. Sept./Oct. 2005: 23-29.
- Taking Down the Maine Yankee Containment Building. By Eric Howes. Jan./Feb. 2005: 40-43.
- Talk the Talk and Walk the Walk: Focusing on Safety during Fusion Reactor Decommissioning. By Keith Rule, Erik Perry, and Jerry Levine. Jan./Feb. 2002: 12-15.
- Tapping into Lessons Learned at West Valley: High-Risk Decon Experience Leads to Repeat Success. By Helene Houston, Ken Schneider, Kathy Szlis, and John Drake. Nov./Dec. 2004: 34-40.
- Ten Spectacular Seconds: Successful Cooling Tower Implosion at Trojan Reflects Careful Planning. July/Aug. 2006: 36-38.
- T(h)anks for the Technology. By Mike Berriochoa. July/Aug. 2005: 18-21.

Thinking “Inside” the Box at West Valley: Decontaminating a Cell Tower. By Jeff Choroser, Helene Houston, Ken Schneider, Kathy Szlis, and Ahman Al-Daouk. May/June 2004: 28-33.

Thinking Outside the (Glove) Box: The Evolution of Decommissioning at Rocky Flats. By Jeanna Blatt. July/Aug. 2002: 26-29.

To DOC or Not To DOC: Managing Power Plant Decommissioning. By Nancy J. Zacha. July/Aug. 1999: 60-61.

To Decommission or Not To Decommission? A Guide for Utilities. By Leo Lessard. Sept./Oct. 1999: 32-36.

To Toss or Not to Toss—That Is the Question. By J. Mark Price. Jan./Feb. 2006: 12-19.

Tunneling Out at 20.85 Meters: Cleanup Progress at Sellafield’s Pile Fuel Cladding Silo. By David Skilbeck. July/Aug. 2005: 10-16.

Unique Team Gets the Job Done—And Then Some: 247F Decommissioning and Demolition at the Savannah River Site. By Fran Podá. Jan./Feb. 2006: 31-35.

Up for Decades, Down in Seconds: Completing the Demolition of a Sphere Enclosure Building. Mar./Apr. 2009: 28-29.

The UPI D&D Program at Marcoule: Decontamination and Dismantling of Process Facilities. By Jean-Louis Garcia, Philippe Fontana, Didier Vernhet, and Didier Boya. Sept./Oct. 2007: 16-27.

A Video Look in the Pool: Spent-Fuel Characterization for Dresden-1 Decommissioning. By Coleman McDonough, Linwood Ray, John J. Villanueva, and Ed Ruzauskas. July/Aug. 1999: 20-23.

Vision 2010: Cleanup, Renewal of the Port Hope Uranium Conversion Facility. By Aldo D’Agostino. Mar./Apr. 2009: 20-26.

Where Are You Going—And How Are You Going to Get There? Creating a Virtual Organization for Nuclear Power Plant D&D. By Carroll Eichhorn. Jan./Feb. 2000: 52-54.

Work at the DOE’s Largest Closure Site Is 75 Percent Complete. By Todd Nelson. May-June 2011: 37-47.

Working Toward a New Beginning: Using Innovative Methods at ETTP to Clean Up the Manhattan Project Legacy. By Wayne McKinney. May-June 2012: 17-22.

The Workings of a Waste Processor: A Radwaste Magazine Interview with GTS Duratek’s Bob Prince. Nov./Dec. 1999: 40-42.

### Deep-Sea Burial

The International Arctic Seas Assessment Project. By Gordon S. Linsley and Kirsti-Liisa Sjöebloom. July 1994: 64-68.

### Detection

Experts Test Agencies’ Skills at Radiological Detection and Control. July-Aug. 2012: 46-50.

Improvements to Alpha Continuous Air Monitoring Systems at the WIPP. By H. Bates Estabrooks, Sheila G. Clayton, and Richard F. Farrell. Oct. 1994: 80-85.

Journey to the Center of the . . . Vadose Zone. By Mary Beckman. July/Aug. 1999: 55-57.

### Dewatering

Decide, Design, and Dewater de Waste: A Blueprint from FitzPatrick. By Dennis E. Robert. Apr. 1994: 21-22.

### Editor’s Note

At Long Last, the Yucca Mountain License Application. July/August 2008: 4.

The Blue Ribbon Commission Has Its Say. Sept.-Oct. 2011: 4.

A Buyers Guide, and Sharing Experience. Nov.-Dec. 2013: 4.

Buyers Guide—Take Two. Nov./Dec. 2006: 4.

Changing Times. July/Aug. 2005: 5.

Coming Attractions. Nov./Dec. 2007: 4.

The Courts Giveth . . . and the Courts Taketh Away. May/June 1999: 4.

Credit Where Credit Is Due. Nov./Dec. 2002: 4.

The Curse of the Hungry Proofreader. Jan./Feb. 2010: 4.

Decommissioning, Decontamination, and Reutilization. Sept./Oct. 2007: 4.

The Election’s Over, What Happens Next? Jan./Feb. 2005: 3.

Environmental Anniversaries. May/June 2009: 4.

Fear of Shipping. Mar./Apr. 2003: 4.

Fernald: From Weapons to Wetlands. July/Aug. 2006: 4.

Good Leadership, Bad Politics, and All That. Sept./Oct. 2000: 4.

Heavy Subject, Light Touch. May/June 2001: 4.

Heard in the Halls. Jan./Feb. 1999: 4.

Hurrah for ARRA. July/August 2010: 4.

I Remember LLW Disposal. May/June 2007: 4.

Isn’t It Ironic? May/June 2008: 4.

Issues and Outtakes. July/Aug. 1999: 4.

It’s About Time. May/June 2000: 4.

It’s All About Science—Or Is It? Mar./Apr. 2009: 4

It’s the Politics, Stupid! May/June 2003: 4.

Knocking About in Knoxville. Nov./Dec. 1999: 4.

Last Thoughts. July-Aug. 2013: 4.

The Long Wait Is Over. Mar./Apr. 2010: 4.

Looking Down the Road. Jan.-Apr. 2011: 4.

Looking on the Lighter Side. Nov./Dec. 2008: 4.

LLW Crisis? What LLW Crisis? May/June 2008: 4.

Making the World Safe for Gambling . . . and Other Issues. May/June 2002: 4.

My Goat—And How To Get It. July/Aug. 2003: 4.

The Journey of a Thousand Miles. Mar./Apr. 2004: 4.

New Hope for Disused Sealed Source Disposal. May-June 2013: 4.

The New Kid on the Block. Mar./Apr. 2001: 4.

New Nuclear Plants and Old Radioactive Waste. Mar./Apr. 2005: 4.

No Respect. May/June 2005: 4.

NOT Thinking About Yucca Mountain. July/Aug. 2002: 4.

A Note of Appreciation. May/June 2006: 4.

Nuclear Winter and Nuclear Summer. July/Aug. 2007: 4.

Odds and Ends. Nov./Dec. 2001: 4.

On Nuclear Waste, the DOE, and 1984 (the Novel, not the Year). July-August 2011: 4.

The “Passion” Excuse. Jan.-Apr. 2012: 4.

Politics: Global and Backyard. Sept./Oct. 2010: 4.

The Politics of Hope. July-Aug. 2012: 4.

Random Thoughts and Musings. March/Apr. 1999: 4.

The Right Time, the Right Place. Sept./Oct. 1999: 4.

Ring in the New Year. Jan./Feb. 2004: 3.

A River Runs Through It. Sept./Oct. 2006: 4.

Safety First. Jan./Feb. 2002: 4.

A Salute to 2006! Jan./Feb. 2006: 4.

Scare Tactics. Mar./Apr. 2002: 4.

Science vs. Society. May/June 2004: 4.

Sic Transit Gloria . . . and All That. Jan.-Apr. 2013: 4.

So Much Promise . . . So Little Progress. Mar./Apr. 2000: 4.

Solutions, Solutions, We’ve Got Solutions. Jan./Feb. 2000: 4.

Speaking Out. Jan./Feb. 2003: 4.

Still Hopeful, After All These Years. July/Aug. 2001: 4.

Stop All Waste Work Now! Nov./Dec. 1998: 4.

A Tale of Two Denvers. Sept./Oct. 2005: 4.

A Tale of Two States. Nov.-Dec. 2012: 4.

Thinking the Unthinkable. Mar./Apr. 2006A: 4

Too Many Choices? Mar./Apr. 2007: 4.

Toto, We’re Not in Kansas Anymore. July/Aug. 2000: 4.

Tragedy All Around Us. May-June 2011: 4.

Transformations. Nov.-Dec. 2013: 4.

The Value of Demolition. July/Aug. 2004: 3.

Visualizing Nuclear Waste. Sept.-Oct. 2012: 4>

Waiting for the Blue Ribbon Panel. Sept./Oct. 2009: 4

Walking the Plank. Sept./Oct. 2004: 4.

We Happy Few . . . Jan./Feb. 2001: 4.

Welcome to Our Buyers Guide. Nov./Dec. 2005: 4.

What If? July/Aug. 2009: 4.

What lies Ahead. Nov./Dec. 2010: 4.

What LLW Generators Really Want. May/June 2010: 4.

What’s New. Jan./Feb. 2007: 4.

What Voters Really Need To Know. Jan./Feb. 2008: 4.

Where the Elite Meet. Sept./Oct. 2001: 4.

Where the Utilities Go. Nov./Dec. 2000: 4.

Whither GNER, Yucca Mountain, and Other Nuclear Programs. Jan./Feb. 2009: 4.

Why High-Level Waste Could Be Good for Nevada. Sept./Oct. 2002: 4.

Yes, We Are Making Progress. Nov.-Dec. 2011: 4.  
Your Tax Dollars at Work. Nov./Dec. 2009: 4.  
The Yucca Mountain Court Cases. May-June 2012: 4.  
Yucca Mountain, Politicians, and the Non-Per-  
sistence of Memory. Sept./Oct. 2008: 4.

### Environmental Remediation

Accelerating SRS Tank Closure with Help from  
Partners, Technology. By Rick Kelley. Sept./  
Oct. 2009: 25-30.

Advanced Remedial Methods for Metals and  
Radionuclides in Vadose Zone Environments.  
By Dawn M. Wellman, Shas V. Mattigod, Susan  
Hubbard, Lirong Zhong, Martin Foote, Yuxin  
Wu, and Danielle Jansik. Jan.-Apr. 2012: 82-90.

Battling Groundwater Contamination at Han-  
ford. By Michele Gerber. Sept./Oct. 2006: 17-  
28.

Building on a Tradition of Environmental Con-  
cern: The Evolution of Environmental Reme-  
diation at the Savannah River Site. By W. Dean  
Hoffman and Bruce Cadotte. Sept./Oct. 2000:  
9-18.

The Burial Ground Complex at the Savannah  
River Site: Large-Scale Remediation. By J.  
Michael Griffith. Nov. 1997: 35-39.

Celebrating SRS's First Area Closure. By Fran  
Poda. July/Aug. 2007: 11-16.

Cleaning Up Trench 1 at Rocky Flats. Sept./  
Oct. 1999: 38-41.

Closing Waste Tanks at the Savannah River Site:  
It's Never As Easy As It Looks. By Madeline  
Blair. Sept.-Oct. 2012: 18-23.

Construction Progress at Hanford's Waste  
Treatment Plant. Sept./Oct. 2009: 32-35.

Cocooning Hanford's N Reactor—And Other  
River Corridor Closure Activities. By Mark  
McKenna. Sept.-Oct. 2012: 24-32.

Cost-Effective Radiological Risk Reduction: A  
Remediation Case Study. By Lawrence Moos,  
Kou-John Hong, and Andrew D. Gabel. Mar.  
1998: 62-67.

Creating a Desert Oasis: Hanford Gravel Pit  
Converted to Wetland. By Todd Nelson. Jan./  
Feb. 2001: 28-29.

Dedicated to Cleanup: Environmental Reme-  
diation at Hanford. By Todd A. Nelson. July/  
Aug. 2001: 17-23.

DOE Reclamation Work at the Moab Site. Sept.-  
Oct. 2012: 34-39.

Doin' What Comes Naturally: Natural Reme-  
diation at Savannah River Site. By Catherine M.  
Lewis and Robert Van Pelt. Sept./Oct. 2002:  
22-28.

Ecological Restoration with Native Grasses  
and Forbs: The Fernald Preserve and Weldon  
Spring Restoration Projects. By Jane Powell,  
Frank Johnston, John Homer, and Yvonne  
Deyo. July/August 2008: 12-18.

The End of Drum Mountain. Nov./Dec. 2000:  
34-35.

Enhanced "Interrogation" Techniques: Soil  
Contamination Imaging at Hanford. By Mike  
Berriochoa. Sept.-Oct. 2011: 21-25.

Environmental Remediation at the Maxey Flats  
Disposal Site. By Martin Brownstein and Greg  
Rice. Jan./Feb. 2005: 34-39.

Environmental Remediation of Hanford's Riv-  
er Corridor. By Todd Nelson. Sept./Oct. 2009:  
12-16.

Environmental Restoration: Fernald Ecologists  
and Engineers Integrate Restoration and Clean-  
up. By Eric Woods and John Homer. Sept./Oct.  
2002: 12-19.

Ethics, the Environment, and Radioactive  
Waste. By Claudio Pescatore. Jan./Feb. 2000:  
49-51.

From Superfund Site to Waterfront Develop-  
ment: The Glen Cove Waterfront Project. By  
JoAnne Castagna. May/June 2006: 39-41.

From Test Site to Wildlife Refuge: Tatum Salt  
Dome Test Site Transferred to State. Sept.-Oct.  
2011: 26-29.

Getting Remediation Done at ORNL. By Ma-  
linda Conger, Amy Harkey, Ken Schneider, and  
Dirk Van Hoese. Sept.-Oct. 2011: 15-20.

Groundwater Protection at Nuclear Plants. By  
Karen Kim, Brozia Clark, and Steven Swilley.  
July-Aug. 2011: 37-43.

Groundwater Re-injection at Fernald: Its Role  
in Accelerating the Aquifer Remedy. By Ken-  
neth A. Broberg and Robert Janke. Sept./Oct.  
2000: 19-23.

Groundwater Restoration at the La Rosita in-  
Situ Uranium Recovery Project. By Michelle  
Rehmann, Mark Pelizza, Katie Sweeney, and  
Rod Grebb. Sept.-Oct. 2011: 35-42.

Hanford Groundwater Contamination Areas  
Shrink as EM Exceeds Cleanup Goals. Sept.-  
Oct. 2013: 20-21.

Hanford's Tank C-106 Project: The First of  
Many. By Ed Aromi. Sept./Oct. 2004: 24-30.

How Should We Clean Up the Water? Ground-  
water Remediation Plans at the Paducah  
Gaseous Diffusion Plant. By Gary Bodenstein  
and Mark Gage. Sept./Oct. 2000: 24-29.

Improved Cost-Effectiveness of Remedial Ac-  
tion Plans at Historic Waste Sites in Canada  
Through the Use of Waste Segregation Ap-  
proaches. By Robert W. Pollock and Christo-  
pher H. Clement. Nov. 1997: 26-34.

In Situ Redox Manipulation: Fierce Energy of  
Groundwater VOCs and Heavy Metals. By  
Mary H. Ace. July/Aug. 2001: 24-27.

Innovative Approaches to Environmental  
Restoration at FUSRAP Opportunity Sites. By  
James D. Kopotic, Donald E. Dunning, Deb-  
bie S. Browning, George M. Stephens, Melissa  
A. Kucera, and Michael E. Redmon. Nov. 1997:  
16-24.

Innovative Mercury Treatment Benefits Stream,  
Fish. Jan.-Apr. 2013: 58-60

It's Complicated: The Complexities of Decom-  
missioning a Uranium Mill Site. By Matthew  
Meyer. Sept.-Oct. 2011: 43-45.

Legacy Management at the Rocky Flats Site. By  
Bob Darr, John Boylan, Rick DiSalvo, George  
Squibb, Jody Nelson, and Scott Surovchak.  
Sept./Oct. 2010: 12-19.

Low Tech Meeting High Tech: Remediating  
Two Basins Containing Radioactive Sludge at  
ORNL. By Angie Brill, Elizabeth Krispin,  
Lynn Whitehead, and John Julius. July/Aug.  
2001: 11-16.

Management of Contaminated Land at Doun-  
reay. By Mike Pearl, Frank Dennis, and Mark  
Liddiard. Mar./Apr. 2006: 36-42.

Monitored Natural Attenuation for an Aerobic  
TCE Plume. By Ryan A Wymore, Lance N. Pe-

terson, Lee O. Nelson, and Kent S. Sorenson Jr.  
Mar./Apr. 2006: 50-57.

Multiple Waste Retrievals at Hanford's C Tank  
Farm. Sept.-Oct. 2012: 40-45.

Offsite Contamination in Plum Brook—From  
Discovery and Characterization to Demon-  
stration of Regulatory Compliance, by Keith  
M. Peacock. Sept./Oct. 2010: 20-27.

On the Lookout for Subsurface Solutions: The  
DOE's Subsurface Contaminants Focus Area.  
By Virginia Kay. Nov./Dec. 2000: 26-30.

Permeable Reactive Barriers: Advancing Nat-  
ural In-Situ Remediation for Treatment of Ra-  
dionuclides in Groundwater. By Scott D.  
Warner. Sept.-Oct. 2011: 30-34.

A "Poplar" Solution to Groundwater Con-  
tamination: Phytoremediation at the  
Portsmouth Gaseous Diffusion Plant. By Amy  
C. Lewis, Del R. Baird, and Scott Burton.  
Sept./Oct. 2004: 15-19.

The "Poplar Solution: How's It Working? A  
Radwaste Solutions Followup. By Amy C.  
Lewis and Del R. Baird. Sept./Oct. 2005: 34-37.

Putting Plants to Work: The ANL-West Phy-  
toremediation First-Year Field Season Demon-  
stration. By Scott Lee. May/June 2000: 49-54.

Putting the Stimulus to Work. By Fran Poda.  
Sept./Oct. 2009: 18-24.

Rehabilitation of the Former British Nuclear  
Weapons Test Site at Maralinga in South Aus-  
tralia, Australia. By Robert (Rob) Rawson,  
Caroline Perkins, and Lorimer (Lori) Felling-  
ham. Nov. 1997: 10-15.

Reducing the Risk of Hanford's Legacy: Com-  
pleting Cleanup at the Last Big Liquid Waste  
Site near the Columbia River. Sept./Oct. 2006:  
29-31.

Remediation of Uranium-Impacted Sediments  
in a Watercourse. By E. Shephard, N. Walter,  
H. Downer, P. Collopy, and J. Conant. Sept.-  
Oct. 2012: 12-17.

Right in Your Own Back Yard: Onsite Dispo-  
sal of Radioactive Materials. By Barry Koh.  
Sept./Oct. 1999: 22-28.

Self-Assessments Help Nuclear Plants Enhance  
Groundwater Protection. Sept.-Oct. 2013: 17-  
19.

A Snapshot of Paducah Remediation and  
Cleanup. By Dennis Ferrigno, Joe Tarantino,  
and Reinhard Knerr. Sept./Oct. 2010: 36-43.

Stream Reconstruction: Designing for Natural  
Stream Stability. By Robert Spurling and Jason  
Darby. Sept./Oct. 1999: 15-21.

The Strontium Garden: Cleanup of One of  
Hanford F Area's Last Research Stations. By  
Todd Nelson. Sept./Oct. 2002: 20.

Targeting Chromium in Hanford's 100-D Area.  
By Scott W. Petersen, John G. Morse, K.  
Michael Thompson, and M. J. Tonkin. Jan.-  
Apr. 2011: 74-81.

Technical and Policy Challenges in Deep Va-  
dosed Zone Remediation of Metals and Ra-  
dionuclides. By Dawn M. Wellman, Michael J.  
Truex, Mark Freshley, P. Evan Dresel, and Kirk  
J. Cantrell. Jan.-Apr. 2013: 76-84.

Testing, Testing . . . Simple Technology Im-  
proves Groundwater Monitoring along the Co-  
lumbia River. By Judy Graybeal. May/June  
2006: 28-33.

Tests, Tests, and More Tests at Rig Rock Point:  
Soil and Water Testing Helps Ensure Public

Safety. By Tim Petrosky. Sept./Oct. 2004: 20-23.

Visitors Flock to the Remediated Fernald Preserve. By Gary Stegner and Stacey Elza. Sept./Oct. 2010: 28-35.

Watching the Grass Grow: Closing SRS's Highest Risk Waste Unit. By Fran Poda. July/Aug. 2007: 17-21.

Wetland Mitigation at the Fernald Preserve. By Jane Powell and John Homer. Sept.-Oct. 2013: 14-16.

Wetlands Restoration at Fernald: Reconstructing Natural History with Ecological Restoration Principles. By Craig Straub. Sept./Oct. 1999: 9-13.

Why and When To Use Turnkey Remediation. By Richard H. Wilkinson. Sept./Oct. 1999: 49-53.

Y-12's Mercury Problem. By Nancy J. Zacha. Jan.-Apr. 2013: 62-63.

## FUSRAP

The Ashland 2 Cleanup. By Bruce K. Howard, David J. Conboy, Michelle R. Rehmann, and Harold R. Roberts. Mar./Apr. 1999: 39-44.

Stimulus Dollars Help Communities Recover. By JoAnne Castagna. Jan.-Apr. 2011: 60-62.

## High-Level Waste Management

55-Inch Hole Safely Cut into the Dome of Hanford's Tank C-107. Jan.-Apr. 2011: 48-53.

Are Deep Geologic Repositories Really Necessary? By Christopher M. Timm and Cassandra Mueller. July-Aug. 2012: 61-66.

Artifact to Analogue: Archeology of Arid Environments points to Management Options for Yucca Mountain. By Neil Chapman, Amy Dansie, and Charles McCombie. Mar./Apr. 2007: 22-31.

Back to the Future: A Rationalized Rock Salt Repository. By Leif G. Eriksson and George E. Dials. Jan.-Apr. 2011: 24-34.

Back to the Future: 9th International High-Level Radioactive Waste Management Conference. By Nancy J. Zacha. July/Aug. 2001: 48-52.

Breaking Good: Study Examines Durability of Glass with Ties to Nuclear Waste Storage. By Eric Pierce, Wendy Shaw, Charity Plata, and Kristin Manke. Jan.-Apr. 2011: 42-46.

Breaking the High-Level Waste/Spent Fuel Logjam. A Perspective by Dade W. Moeller. May/June 2006: 18-20.

Can-in-Canister Demonstration at DWPF. By Nicholas H. Kuehn III, Jeffery R. Brault, David T. Herman, M. John Plodinec, Mary K. Andrews, Jeffery T. Coughlin, Poh-Sang Lam, and W. Gene Ramsey. May 1997: 20-22, 24, 26.

Closing High-Level-Waste Tanks at the Savannah River Site. By Thomas B. Caldwell, Paul D. d'Entremont, Christine A. Langton, Jeffery L. Newman, Eloy Saldivar, Jr., and Narasimhan Rajendran. Mar. 1998: 19-26.

Consent-Based Siting . . . and Other BRC Issues. By Nancy J. Zacha. May-June 2013: 44-46.

Consent-Based Siting: What Have We Learned? By Daniel Metlay. July-Aug. 2013: 28-36.

The Costs of Prolonging the Status Quo. By Kris Sanda. May 1997: 10-12.

Deep Borehole Disposal of Nuclear Waste. By Patrick V. Brady and Michael J. Driscoll. Sept./Oct. 2010: 58-60.

Deep Disposal of Irradiated Nuclear Fuel: An Alternate Viewpoint. By Björn Cronhjort. Mar./Apr. 2002: 19-22.

Design Options for the U.K.'s HLW Geological Disposal Facility. By Neil Chapman, Tamara Baldwin, Fiona Neall, John Mathieson, and Matthew White. Mar./Apr. 2009: 44-54.

Dispositioning High-Level Waste in a Post-Yucca Mountain World. By Nancy J. Zacha. Sept./Oct. 2010: 61-63.

The Engineered Barrier System for a Deep Geologic Repository in Canada. By Sean B. Russell and Gary R. Simmons. Jan./Feb. 2004: 7-14.

An Environmental Policy Imperative: Addressing Security Concerns at the Back End of the Nuclear Fuel Cycle. By Charles McCombie, Neil Chapman, and Tom Isaacs. July/Aug. 2009: 27-32.

Everything Old Is New Again. By Michael V. Berriochoa. Jan.-Apr. 2011: 36-40.

First Double-Shell Tank Leak Discovered at Hanford. By Rob Roxburgh and John Britton. Jan.-Apr. 2013: 40-42.

Further Development of Modified Monosodium Titanate, an Improved Sorbent for Pretreatment of High-Level Nuclear Waste at the Savannah River Site. By Kathryn M. L. Taylor-Pashow, Fernando F. Fondeur, Samuel D. Fink, and David T. Hobbs. Jan.-Apr. 2012: 64-81.

Getting Pumped: Lessons Learned from the Decontamination and Removal of High-Level Waste Pumps at the West Valley Demonstration Project. By William F. Hamel Jr., Kimberly J. Mansfield, and Paul J. Valenti. Jan./Feb. 1999: 5-14.

Global Progress Toward Safe Disposal: A Report from the 2006 ANS HLW Conference. By Nancy J. Zacha. July/Aug. 2006: 50-55.

High-Level Waste Management: At Home and Around the World. By Nancy J. Zacha. Jan./Feb. 2009: 37-44.

Historical Fuel Reprocessing and HLW Management in Idaho. By Dieter A. Knecht, M. Dan Staiger, Jerry D. Christian, C. Lee Bendixsen, G. W. (Bill) Hogg, and Julius R. Berreth. May 1997: 35-47.

HLW Disposal Programs Around the World: What They're Doing and What They've Learned. By Nancy J. Zacha. July-Aug. 2011: 68-76.

Integrating Storage, Transportation, and Disposal. By Nancy J. Zacha. July-Aug. 2013: 60-66.

International and Regional Repositories: The Key Questions. By Charles McCombie and Ralph Stoll. Mar./Apr. 2002: 12-18.

International Retrievability Scale for Waste in Geological Disposal. By Jean-Noël Dumont and Claudio Pescatore. July-Aug. 2012: 30-35.

Introducing Cigéo, the French Geological Repository Project. By T. Labalette, A. Harman, M. C. Dupuis, and G. Ouzounian. July-Aug. 2013: 46-51.

It's Time for Radioactive Waste Disposal in Salt. By Ray Funderburk. May-June 2013: 54-56.

Modern Alchemy: Solidifying High-Level Nuclear Waste. By Christopher C. Newton. July 1997: 42-49.

A Nuclear Renaissance Without Disposal? By Charles McCombie and Neil Chapman. July/Aug. 2009: 19-26.

Policy Issues Associated with Deep-Borehole HLW Disposal. By M. J. Driscoll and K. G. Jensen. July-Aug. 2012: 42-45.

Preliminary Performance Assessment for Deep Borehole HLW Disposal. By Peter N. Swift, Bill W. Arnold, Patrick V. Brady, Geoff Freeze, Teklu Hadgu, Joon H. Lee, and Yifeng Wang. July-Aug. 2011: 60-65.

A Question of Dry vs. Wet: The Case for Dry Rock Disposal of Nuclear Waste. By Björn Cronhjort and Nils-Axel Mörner. May/June 2004: 44-47.

Radiofrequency Technology Tracks Mixer Efficiency. By Brenda Pittsley. Jan./Feb. 2006: 36-38.

A Regional Approach to HLW, Spent Fuel, and TRU Waste Disposal in New Mexico. By Christopher M. Timm. Sept.-Oct. 2013: 29-34.

Repositories with Retrievable Spent Nuclear Fuel: Four Options, Four Geologies. By C. W. Forsberg and L. R. Dole. July-Aug. 2012: 36-41.

Reversibility and Retrievability in Radioactive Waste Disposal: Part I. Nov./Dec. 2002: 39-44.

Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (January 2013). May-June 2013: 34-43.

A Team of Seven—The Tanks Focus Area: Providing Technical Solutions for Cleaning Up the DOE's Radioactive Tank Wastes. By Wayne Cosby. Sept./Oct. 2000: 43-49.

Thinking Back to Front: A Comprehensive Approach to Dealing with the Everlasting nuclear Waste "Problem." By Mario Carelli, Fausto Franceschini, Ed Lahoda, and Bojan Petrovic. May-June 2011: 30-36.

Vitrification at the West Valley Demonstration Project. By William F. Hamel, Jr., Michael J. Sheridan, and Paul J. Valenti. Mar. 1998: 27-40.

What We've Heard: A Staff Summary of Major Themes in Testimony and Comments Received to Date by the Blue Ribbon Commission on America's Nuclear Future. May-June 2011: 51-58.

What Now for Permanent Disposal of Used Nuclear Fuel and HLW in the United States? By Andrew Sowder, John Kessler, Mick Apted, and Matt Kozak. Jan.-Apr. 2013: 26-39.

Wrapping Up the Leftovers: Management of Expended Materials Relating to the West Valley Demonstration Project High-Level Waste Vitrification Facility. By L. E. Krieger, R. DiBiase, W. F. Hamel, and P. J. Valenti. Mar./Apr. 2000: 12-20.

Yucca Mountain: Dumped and Wasted? By Nancy J. Zacha. July/Aug. 2009: 12-18.

## Human Factors

Human Factors in Waste Management. By Neville Moray. Oct. 1994: 58-63.

The Faces of Decommissioning and Site Cleanup: How "People" Issues Affect Work Progress. By Lara Harrison. Jan./Feb. 2001: 7-12.

(Mission) Shifting Gears: How to Survive Change. By Justin Schulz. Mar. 1995: 33-40.

Monitoring Human Activities near a Waste Repository: Valuable for Performance Confir-

mation. By Richard I. Beauheim. July/Aug. 2007: 39-46.

### Hydrology

3-D Imaging Gives Hanford Scientists a Better View of Waste Plumes. By Michael V. Berriocha. Mar./Apr. 2010: 14-22.

Creating a Desert Oasis: Hanford Gravel Pit Converted to Wetland. By Todd Nelson. Jan./Feb. 2001: 28-29.

Groundwater Re-injection at Fernald: Its Role in Accelerating the Aquifer Remedy. By Kenneth A. Broberg and Robert Janke. Sept./Oct. 2000: 19-23.

The Industry Ground Water Protection Initiative: A Watershed Moment. By Kathleen C. Yhip, George J. Oliver, and Ralph L. Andersen. Mar./Apr. 2010: 24-28.

In Situ Redox Manipulation: Fierce Energy of Groundwater VOCs and Heavy Metals. By Mary H. Ace. July/Aug. 2001: 24-27.

Journey to the Center of the . . . Vadose Zone. By Mary Beckman. July/Aug. 1999: 55-27.

Notes from the Vadose Zone. By Joseph R. Hearst, John R. Brodeur, and John G. Conaway. July 1994: 74-76, 78.

A Road Map to Cleanup Success: Hanford's Groundwater/Vadose Zone Integration Project. By Steven P. Sautter and Geoffrey L. Harvey. May/June 2001: 31-35.

Six Science Secrets of the Subsurface. By Kristin Manke and Julie Wiley. Mar./Apr. 2010: 30-35.

### Indigenous Peoples

An Indian Tribal View of the Back End of the Nuclear Fuel Cycle: Historical and Cultural Lessons. By Mervyn L. Tano, J. Herman Reuben, Donna Powaukee, and A. David Lester. Mar. 1996: 44-47.

### International

Accelerating High-Hazard Reduction at Sellafield. By Ali McKibbin and Lucy Watson. July/August 2010: 16-25.

The Added-Value Approach in Siting Nuclear Waste Facilities. By Matti Kojo and Phil Richardson. Jan.-Apr. 2012: 38-50.

Analogs and Dialogs: Integrating Natural Analog Studies into a National Confidence-Building Program. By I. McKinley and T. Tsuboya. Nov./Dec. 2001: 24-27.

The Benefits of International Cooperation on Decommissioning: U.S. and U.K. Contributions to the Decommissioning of Kazakhstan's BN-350 Reactor. By D. Wells, J. Michelbacher, and T. Hayward. Nov.-Dec. 2011: 15-19.

Boon or Bane? A Repository's Effects on the Local Community. By Timo Seppälä. Jan./Feb. 2010: 34-37.

Chapelcross Cooling Towers—Ten Seconds to Demolition. Sept./Oct. 20007: 28-29.

A Cold War Legacy: The Current Status and Challenges of Radioactive Waste Management in the Russian Navy. By John D. Gerken. May/June 1999: 31-38.

D&D Around the World. By Nancy J. Zacha. Nov./Dec. 2005: 14-17.

Dealing with the U.K.'s Nuclear Legacy. By James Atkin. May/June 2006: 34-38.

Decommissioning Planning at Whiteshell Laboratories. By Randall Ridgway. Nov./Dec. 2002: 31-28.

Decommissioning the Building A59 Hot Cells at Winfrith. By Keith Miller, G. Tizzard, Steve Parkinson, Rowland Cornell, and Andrew Staples. Sept./Oct. 2004: 41-49.

Decommissioning the KNK Compact Sodium-Cooled Nuclear Reactor. By Werner Kathol and Volker Ruedinger. Nov./Dec. 1998: 17-24.

Decommissioning the World's Largest Open-Air Nuclear Fuel Storage Pond. July-Aug. 2011: 32-36.

Delivering Cleanup at Sellafield. By Byron Smith. Mar./Apr. 2006: 30-35.

Design Options for the U.K.'s HLW Geological Disposal Facility. By Neil Chapman, Tamera Baldwin, Fiona Neall, John Mathieson, and Matthew White. Mar./Apr. 2009: 44-54.

Disposal of Disused Radioactive Sources. By R. Dayal and J. M. Potier. July/Aug. 2004: 39-47.

Down, ROVer, Down. July-Aug. 2012: 51-53.

The End of an Era: Decommissioning Four German Fuel Cycle Facilities. By Helmut Rupp, Roland Baumann, Peter Faber, Manfred Ruhbaum, and Helmut Schmitt. May/June 2000: 28-40.

Endless Search, Endless Failure, Endless Conflict: The Siting of a Radioactive Waste Disposal Facility in South Korea. By Yearn Hong Choi. May/June 2002: 20-24.

The Engineered Barrier System for a Deep Geological Repository in Canada. By Sean B. Russell and Gary R. Simmons. Jan./Feb. 2004: 7-14.

Engineering for Transportation and Disposal of Low-Level Radioactive Wastes in Japan. By Yutaka Suzuki, Yoshihiro Akagawa, and Hiroo Ohno. Oct. 1994: 64-70.

EPRI Comes to Dounreay: The Cooperative Assistance Program for Waste Management. By Michael Dunnett and Paul McClelland. Mar./Apr. 2004: 62-71.

Extension Before Construction: Posiva's Spent Fuel Disposal Program. By Jussi Palmu and Timo Äikäs. May/June 2010: 36-41.

The First Integrated SNF Transshipment/Interim Storage Facility in Northwest Russia. By R. S. Dyer, E. Baner, R. L. Snipes, and S. Hoibraten. July/Aug. 2005: 47-51.

First Nuclear Fuel Movement in 50 Years Is a Decommissioning Milestone at Sellafield. Jan.-Apr. 2012: 54-56.

Handling Legacy Waste Streams at Trawsfynydd. By Simon Parsons. July/Aug. 2007: 22-29.

The IAEA Radioactive Waste Management Programme. By Donald E. Saire. July 1994: 57-63.

Impact Analyses and Tests of a Metal Cask in the Event of an Aircraft Engine Crash. By Sanghoon Lee, Woo-Seok Choi, Ki-Young Kim, Je-Eon Jeon, and Ki-Seog Seo. Jan.-Apr. 2013: 86-92.

In-Situ Nuclear Measurements for Decommissioning: Recent Trends and Needs. By C. Le Goaller and C. Mahé. May/June 2008: 39-43.

In-Tank Pipe Cropping a Great Success at Sellafield. By Steve McGowan. July/Aug. 2007: 30-33.

Interim Storage of Low-Level and Intermediate-Level Waste in Finland. May 1998: 18-20.

International and Regional Repositories: The Key Questions. By Charles McCombie and Ralph Stoll. Mar./Apr. 2002: 12-18.

The International Arctic Seas Assessment Project. By Gordon S. Linsley and Kirsti-Liisa Sjoebloom. July 1994: 64-68.

International Collaboration and Continuous Improvement. By Nancy J. Zacha. May-June 2013: 48-53.

International Retrievability Scale for Waste in Geological Disposal. By Jean-Noël Dumont and Claudio Pescatore. July-Aug. 2012: 30-35.

International Storage of Commercial Spent Fuel and High-Level Waste. By Alex. R. Burkart. Sept./Oct. 2002: 29-33.

Introducing Cigéo, the French Geological Repository Project. By T. Labalette, A. Harman, M. C. Dupuis, and G. Ouzounian. July-Aug. 2013: 46-51.

The Journey of the MCL Trader: Ship Modification for Spent Fuel Transport. By Michael Tyacke, Igot Bolshinsky, Włodzimierz Tomczak, Sergey Nalotov, and Oleg Pichugin. July-Aug. 2011: 46-58.

Lessons Learned from Large Decommissioning Projects—The Spanish Experience. By Juan Luis Santiago and Alejandro Rodriguez. May-June 2013: 26-29.

LLRW Volume Reduction in Russia: Processing of Solid and Liquid Waste from Submarine Dismantlement. By J. H. Saloio, J. A. Jones, C. A. Aas, S. J. Simon, R. A. Penzin, and V. P. Tarasov. Jan./Feb. 2001: 13-19.

Low- and Intermediate-Level Waste Management in Spain. By Pablo Zuloaga. May/June 2000: 20-26.

Low-Level Radioactive Waste Management in Korea. By In Soon Chang. July 1997: 33-37.

Making MERLIN Disappear Without a Trace (Almost). By B. Stahn, R. Printz, K. Matela, and C. Zehbe. July/August 2010: 26-40.

Management of Contaminated Land at Dounreay. By Mike Pearl, Frank Dennis, and Mark Liddiard. Mar./Apr. 2006: 36-42.

Managing Radwaste Around the World. By Nancy J. Zacha. Jan.-Apr. 2013: 64-69.

Managing the UKAEA Graphite Liabilities. By Michelle Wise. Nov./Dec. 2002: 29-38.

Microwave In-Drum Drying: A New Volume-Reduction Process for Radioactive and Toxic Liquid Waste. By Christian Giessmann. Jan./Feb. 2007: 21-24.

Milestone Reached at Sellafield Primary Separation Plant Decommissioning Project. Mar./Apr. 2010: 36-38.

The Monolith Project: An Alternative to the Chernobyl Shelter Implementation Plan. By Alexander Melnikov, Edward E. Purvis III, and Vladimir Tokarevsky. July/Aug. 2004: 34-38.

A New Day for Radioactive Waste Management Activities in Korea. By Myung-Jae Song and Chang-Lak Kim. Sept./Oct. 2001: 36-39.

A New Start for BNFL: Magnox Reactor Decommissioning Strategy. By Paul B. Woollam. July/Aug. 2001: 28-34.

New Waste Management Solutions at Hungary's Paks Nuclear Power Plant. By P. Ormai and J. Schunk. Jan./Feb. 2004: 33-41.

Nuclear Waste Management in Sweden. By Jan Carlsson. Nov./Dec. 1998: 25-30.



- The Nuclear Waste Program in the United Kingdom: An Interview with Ian Handyside. Nov./Dec. 1998: 14-15.
- Planning Ahead: Tailings Management for High-Grade Uranium Ores with High Arsenic and Nickel Content. By Arnaud de Bourayne, Robert Pollock, and John Rowson. May/June 2000: 42-48.
- The Plutonium Issue: Materials Science Aspects of Going MOX and Alternative Solutions. By Hansjoachim Matzke and Jacques van Geel. Mar. 1996: 71-76.
- Post Operational Cleanout Success at BNFL Sellafield in the United Kingdom. By E. J. Williamson, D. H. Norton, A. F. Hurley, and N. P. Houghton. July 1997: 38-41.
- A Question of Dry vs. Wet: The Case for Dry Rock Disposal of Nuclear Waste. By Björn Cronhjort and Nils-Axel Mörner. May/June 2004: 44-47.
- Radioactive Waste Is Getting Slimed! Microbial Janitors Tackle Nuclear Cleanup Problems. By Deborah Hill. Nov./Dec. 1999: 54-56.
- Rehabilitation of the Former British Nuclear Weapons Test Site at Maralinga in South Australia, Australia. By Robert (Rob) Rawson, Caroline Perkins, and Lorimer (Lori) Fellingham. Nov. 1997: 10-15.
- A Repository on the Doorstep: Finland's Low and Intermediate-Level Waste Repository at the Loviisa Nuclear Power Station. By Simon Rippon. July/Aug. 2000: 26-27.
- Returning HEU Fuel From the Czech Republic to Russia. By Michael Tyacke and Igor Bolshinsky. Sept./Oct. 2009: 39-50.
- Russia to the Rescue? International Spent-Fuel Storage Options Discussed at the ANS Annual Meeting. By Nancy J. Zacha. July/Aug. 2002: 54-56.
- Shipping Spent Nuclear Fuel from the Czech Republic's NRI to the Russian Federation for Reprocessing. By Josef Podlaha. Mar./Apr. 2010: 48-62.
- Sludge Retrieval Receives a Lift at Sellafield. Jan.-Apr. 2013: 44-48.
- Soil Washing: Its Potential Application to the Treatment of Radioactively Contaminated Soils, Rubble, and Rocks from UKAEA Sites. By Mike Pearl. Jan./Feb. 2004: 46-52.
- Spent Fuel Disposal Success vs. Failure: A Comparison of the Swedish and U.S. Repository Programs. By Leif G. Eriksson. Jan./Feb. 2010: 22-30.
- Stabilizing the Shelter at Chernobyl. By Marye Hefty. Nov./Dec. 2001: 32-34.
- Taking It Step by Step: Finland's Decision-in-Principle on Final Disposal of Spent Nuclear Fuel. By Junahi Vira. Sept./Oct. 2001: 30-35.
- The Tokai-1 Decommissioning Project. By Tadamichi Satoh. March/April 2008: 28-35.
- Tunneling Out at 20.85 Meters: Cleanup Progress at Sellafield's Pile Fuel Cladding Silo. By David Skilbeck. July/Aug. 2005: 10-16.
- The UP1 D&D Program at Marcoule: Decontamination and Dismantling of Process Facilities. By Jean-Louis Garcia, Philippe Fontana, Didier Vernhet, and Didier Boya. Sept./Oct. 2007: 16-27.
- Uranium Mine Cleanup in Australia. Nov./Dec. 1998: 6-13.
- Using Mixed Bed Ion Exchange Resins in the MARS Nuclear Power Plant. By Enrico Celli, Gilberto Rinaldi, Maurizio Cumo, and Antonio Naviglio. July/August 2008: 45-49.
- Vision 2010: Cleanup, Renewal of the Port Hope Uranium Conversion Facility. By Aldo D'Agostino. Mar./Apr. 2009: 20-26.
- "When Is the Blowdown Date?" The Public Information Campaign for the Chapelcross Cooling Tower Demolition. By Dan Gould. Jan./Feb. 2008: 32-36.
- The Zaporozhye ISFSI. By David G. Marcelli and Tommy B. Smith. Jan./Feb. 2002: 28-32.
- Legal Issues**
- Appeals Court: DOE Must Take Spent Fuel or Pay the Consequences. By Michael A. Bauser. Sept. 1996: 15-18.
- Awaiting a New Permit at WIPP. By Susan Scott. Sept./Oct. 2006: 56-61.
- Courts Say Take or Pay: Litigation Related to the U.S. Department of Energy's Failure to Accept Spent Nuclear Fuel. By Michael A. Bauser. July/Aug. 2000: 15-19.
- The Decontamination and Decommissioning Debate. By Anthony J. Thompson and Michael L. Goo. Apr. 1994: 32-41.
- Finding Harmony: Developing Cleanup Criteria to Address Multiagency Requirements. By John Peters, Jeffrey W. Lefely, and Nelson Walter. July/Aug. 2005: 36-46.
- Getting It Right: New Hampshire's State-of-the-Art Nuclear Decommissioning Law. By Bruce J. Musico and Harold T. Judd. Nov./Dec. 2001: 21-23.
- Remote Sight to Monitor Mound Site: Applying Machine Visions for Long-Term Stewardship. By David Reichhardt and Andrea T. Hart. Jan./Feb. 2005: 29-33.
- State of New York, et al., Petitioners., v. Nuclear Regulatory Commission and United States of America, Respondents. July-Aug. 2012: 54-60.
- Trusts for Long-Term Stewardship at Decommissioned Nuclear Facilities. By Anthony J. Thompson and Christopher S. Pugsley. July/Aug. 2002: 45-49.
- Low-Level Waste Management**
- Advanced Approaches to Reduce Waste, Slash Costs. July-Aug. 2012: 17-19.
- "And the Train Pulls Out from . . ." Fernald's Waste Pits Cleanup. By Julie Loerch and Dave Lojek. Mar./Apr. 2000: 32-37.
- Assured Storage Facilities: A New Perspective on LLW Management. By William F. Newberry, Thomas A. Kerr, and David H. Leroy. Sept. 1995: 13-22.
- Assured Storage Integrated Management Systems: The Most Frequently Asked Questions. By William E. Newberry, Thomas A. Kerr, and David H. Leroy. Sept. 1996: 20-25.
- Careful Operations at Envirocare of Utah. May/June 2001: 11-14.
- Controlled Recycle: An Alternative to the Burial of Low-Level Radioactive Waste. By J. Mark Price. Sept./Oct. 2008: 44-48.
- Covering All the Bases at the Low-Level Summit. By Nancy J. Zacha. Nov./Dec. 2007: 13-20.
- Crossroads or Dead End: LLW Disposal in the United States. By E. Michael Blake. May/June 1999: 9-16.
- The DC Plasma-Arc Furnace: A High-Temperature Solution to Waste Treatment. By Ronald W. Goles, William F. Bonner, and Whitney D. St. Michel. Jan./Feb. 2000: 40-43.
- The Decay-in-Storage Room at the Einstein College of Medicine. By George Hamawin and Carl Passler. Mar. 1995: 14-17.
- The Design and Licensing Status of the Central Interstate Compact Facility: An Above-Grade LLRW Disposal Facility. By John E. Gunning, Michael A. Sabbe, Richard F. Schulman, and John H. DeOld. July 1997: 27-32.
- Disposal of Low-Level Radioactive Waste: American Nuclear Society Position Statement, November 2004. May/June 2005: 32.
- Disposal of Low-Level Radioactive Waste: American Nuclear Society Position Statement, February 2009. Sept./Oct. 2009: 38.
- Disposition of the West Valley Demonstration Project Vitrification Melter. By Jim McNeil, David Kurasch, Daniel Sullivan, and Thomas Crandall. July-Aug. 2012: 20-29.
- DU, Part 61, and a Host of Other Issues. By Nancy J. Zacha. Nov./Dec. 2009: 16-22.
- The Dynamics of Public Opposition: Lessons from LLW Management. By Ellen Meadd. Nov./Dec. 2003: 30-35.
- Entering a New Era for Radioactive Waste Management. By Nancy J. Zacha. Jan.-Apr. 2012: 91-100.
- Environmental Remediation at the Maxey Flats Disposal Site. By Martin Brownstein and Greg Rice. Jan./Feb. 2005: 34-39.
- Environmentalism and Low-Level Waste—The Aftermath. By Peter J. Pastorelle. May 1995: 41-51.
- EPRI Takes on Low-Level Waste Disposal Issues. By Phung Tran and David James. May/June 2008: 14-21.
- EPRI's Low-Level Waste Management R&D Program. By Carol Hornbrook. July 1997: 14-16, 18, 20.
- Focusing on LLW Issues at Waste Management '07. By Nancy J. Zacha. May/June 2007: 17-19.
- Here's a TIP: The Advanced Resin Cleaning System Is Success for Grand Gulf. By Philip Theibert. Nov./Dec. 1998: 43-46.
- Heroes for Zeros—Developing a High-Performance Team. By Christopher A. Lewis. Sept. 1998: 36-39.
- The IAEA's Current Activities in Low- and Intermediate-Level Radioactive Waste. By Ramesh Dayal. May/June 2002: 10-18.
- In Pursuit of Risk-Informing Low-Level Waste Disposal Regulations. By David James, Thomas Kalinowski, and Phung Tran. May/June 2010: 13-19.
- Insights and Perspective on the Blending Issue. By Michael H. Mobley. May/June 2010: 32-33.
- Interim Storage Is Not Long-Term Disposal. By John R. Vincenti. Oct. 1994: 71-79.
- Interim Storage of Low-Level and Intermediate-Level Waste in Finland. May 1998: 18-20.
- July 1, 2008—Just Another Day in the Life of Low-Level Radwaste Generators. By Jack Harrison and David Cronshaw. May/June 2008: 9-13.
- Less Means Less: Duke's Liquid Radwaste Solution. By Tom Shiel. Nov./Dec. 1998: 37-42.
- Let the Private Sector Help. By Charles Judd. May/June 2000: 14-15.

- Licensing a NORM/TENORM Disposal Site: The Deer Trail Landfill. By W. E. Kennedy Jr., Phillip G. Retallick, John H. Kehoe, Michael M. Webgb., David B. Nielsen, James R. Spaanstra, and Lynn M. Kornfeld. May/June 2006: 42-48.
- LLRW Volume Reduction in Russia: Processing of Solid and Liquid Waste from Submarine Dismantlement. By J. H. Saloio, J. A. Jones, C. A. Aas, S. J. Simon, R. A. Penzin, and V. P. Tarasov. Jan./Feb. 2001: 13-19.
- Looking to the STARS to Reduce Class B/C Waste: EPRI's Waste Logic-Solid Waste Manager Can Help. By Clint Miller. Nov./Dec. 2003: 24-28.
- Low- and Intermediate-Level Waste Management in Spain. By Pablo Zuloaga. May/June 2000: 20-26.
- Low-Level Radioactive Waste: Depleted Uranium, Waste Imports, and Other Issues. By Nancy J. Zacha. May/June 2010: 28-31.
- Low-Level Radioactive Waste Disposal: Are We Having a Crisis Yet? By Nancy J. Zacha. May/June 2007: 10-16.
- Low-Level Radioactive Waste Management in Korea. By In Soon Chang. July 1997: 33-37.
- Low-Level Radioactive Waste Management in the United States: What Have We Wrought? By Lawrence R. Jacobi Jr. July-Aug. 2012: 14-16.
- Low-Level Radwaste Storage Facility at Hope Creek and Salem. By Larry C. Oyen, Kristen K. Lee, Richard Bravo, and Bruce Bovankovich. Jan. 1994: 71-74.
- Low-Level Waste at Waste Management 2013. By Nancy J. Zacha. May-June 2013: 23-25.
- Low-Level Waste Disposal: Is There a Solution Out There? By Nancy J. Zacha. May/June 2005: 29-31.
- Low-Level Waste Issues in the Spotlight at WM11. By Nancy J. Zacha. May-June 2011: 15-18.
- Low-Level Waste Storage Options, Concerns. By Nancy J. Zacha. May/June 2008: 22-24.
- Managing Radwaste Around the World. By Nancy J. Zacha. Jan.-Apr. 2013: 64-69.
- Moving the Goal Posts: Another Delay in the Ward Valley Land Sale. By Alan D. Pasternak. May 1996: 44-47.
- The National Low-Level Radioactive Waste Act: Success or Failure? By Richard F. Paton. July 1997: 21-26.
- New Material Traps Radioactive Ions Using "Venus Flytrap" Method. May/June 2010: 34.
- A New Role for the Nevada Test Site. By Richard G. Telfer. Mar./Apr. 2002: 48-53.
- NNSS Waste Disposal Proves Vital Resource for DOE Complex. By Angela Ramsey. Jan.-Apr. 2013: 50-57.
- On-Site Low-Level Waste Storage at D.C. Cook. By Walter T. MacRae. Apr. 1994: 66-70.
- Onsite Storage: Reducing the Burden. By Lisa Edwards. May/June 2010: 20-23.
- On-Site Waste Minimization Programs at McGuire Nuclear Station. By Graham T. Johnson. May 1998: 21-23.
- Pennsylvania's Community Partnering Plan. By John Burk. Sept. 1996: 43-46.
- Performance Assessment for Low-Level Radioactive Waste Disposal. By James R. Cook, Robert H. Hsu, Elmer L. Wilhite, and Andrew D. Yu. Sept. 1996: 32-38.
- The Politics of Low-Level Radioactive Waste Disposal. By Alan Pasternak. May/June 2001: 16-20.
- Post-Barnwell Disposal of Class B and C Resins and Filters. By Charles Jensen and Clint C. Miller. Jan./Feb. 2008: 14-18.
- Post Operational Cleanup Success at BNFL Sellafield in the United Kingdom. By E. J. Williamson, D. H. Norton, A. F. Hurley, and N. P. Houghton. July 1997: 38-41.
- Public Confidence Needed for Successful Low-Level Waste Management. By Gregory B. Jaczko. July/Aug. 2009: 36-37.
- Radioactive Waste Disposal in the United States. By Aubrey V. Godwin. July-Aug. 2011: 66-67.
- A Radwaste Magazine Interview: Managing LLW at the Palo Verde Nuclear Power Plant. July 1997: 10-13.
- A Repository on the Doorstep: Finland's Low- and Intermediate-Level Waste Repository at the Loviisa Nuclear Power Station. By Simon Rippon. July/Aug. 2000: 26-27.
- Reverse-Osmosis Applications for PWR Liquid Radwaste Processing. By Pete Gunderson, Tom Jamieson, Billy Cox, and Charles Jensen. Jan./Feb. 2008: 10-13.
- The Right Thing to Do. By Kathryn V. Haynes. May/June 2000: 16-17.
- Safe Disposal of Low-Level Radioactive Waste: Statutory Process Versus Ad Hoc Committees. By Donna Earley. May/June 2000: 18-19.
- Same Issues, New Solutions at This Year's Radwaste Summit: A Report from the Second Annual Radwaste Summit. By Nancy J. Zacha. Nov./Dec. 2008: 16.
- SMAC on the Track or on the Road: New Intermodal Containers for LLW. By Scott Dempsey. May/June 2005: 27-28.
- Southeast Compact Commission Policy Statement: Management of Low-Level Radioactive Waste. Mar./Apr. 2006: 66-67.
- The State of Affairs in the Wasteland. By Jack K. Lemley. May/June 1999: 65-66.
- Successful Closure of the Beatty, Nevada Low-Level Radioactive Waste Disposal Facility—An Industry First. By Mark S. Cade and James A. Shaffner. May 1998: 10-12.
- A Team Effort: Reducing the Volume of Low-Level Radioactive Waste. By Kerry Zimmermann. Sept. 1996: 39-41.
- There Is No Commercial Low-Level Waste Disposal Crisis in the United States—Yet! By Nancy J. Zacha. May/June 2004: 14-17.
- Time Can Change Everything: Low-Level Radioactive Waste Amid Changing Realities. By John Weisart. May/June 2001: 22-24.
- To Blend or Not to Blend: Blending U.S. Commercial Low-Level Waste to Allow Disposal. By Nancy J. Zacha. May/June 2010: 24-27.
- Two Novel Approaches: Lowering Waste Management Life-Cycle Costs through Onsite Volume Reduction of Class B and C Wastes. By John Raymont and Gaetan Bonhomme. Nov./Dec. 2010: 14-22.
- Unwanted and Orphan Sources: Disposition Efforts and Challenges. By R. E. McBurney, C. R. Meyer, and D. B. Gilley. May-June 2011: 12-14.
- Waste Control Specialists—Where They Are and Where They're Going. By Daniel D. Burns. May-June 2013: 18-22.
- Waste Management by a One-Man Band: Managing a University and Medical LLRW Program. By P. Andrew Karam. Mar./Apr. 2000: 38-42.
- Waste Volume Modeling for a New LLRW Disposal Facility in Illinois. By Thomas W. Ortiger, Michael E. Klebe, and Paul Corpstein. May 1998: 13-17.
- WCS Begins Construction of LLW Disposal Facilities in Texas. By Rickey Dailey. May-June 2011: 19-22.
- We're from the Government, and We're Here to Help Ourselves: Low-Level Waste, the Act, Cabbages, and Kings. By Peter J. Pastorelle. Nov./Dec. 1998: 53-54.
- Why We Need Better Management of Low-Activity Radioactive Waste. By John R. Wiley. May/June 2005: 20-26.

### Mine/Mill Tailings

A Case of Customized Design: DOE UMTRA Project Disposal Cell Summary. By John C. Lommler, Ping K. Chen, Edward Artiglia, Frank B. Guros, Barbara Bridgeman, and Steven Cox. May/June 1999: 39-50.

Planning Ahead: Tailings Management for High-Grade Uranium Ores with High Arsenic and Nickel Content. By Arnaud de Bourayne, Robert Pollock, and John Rowson. May/June 2000: 42-38.

Transporting the Moab Uranium Mill Tailings to White Mesa Mill by Slurry Pipeline. By Ron F. Hochstein, Rod Warner, and Terry V. Wetz. Mar./Apr. 2004: 30-37.

UMTRA—A Learning Experience. By John E. Elmer. Nov. 1996: 43-48.

Uranium Mine Cleanup in Australia. Nov./Dec. 1998: 6-13.

### Minimization

Building a Mixed-Waste Prevention Program at Comanche Peak. By R. B. McCamey. May 1995: 21-28.

A Diablo Canyon Double Feature: When Less Is Less, by Clint Miller; Consolidation of Waste Correlation Factors, by Clint Miller and L.T. Claytor. Mar. 1996: 64-70.

Four Key Elements for Radioactive Waste Minimization: Preplanning, Equipment and Facilities, Training. By Gene Henry. Jan. 1994: 20-24.

### Mixed Wastes

The Changing Adventures of Mixed Low-Level Waste Disposal at the Nevada Test Site. By G. L. Pyles, J. T. Carilli, S. K. Krenzien, and J. K. Wrapp. March/April 2008: 56-65.

The TRU and Mixed Waste Focus Area: Bridging the Gap between Waste Inventory and Disposal Methodologies. By Jodi Townsend. Jan./Feb. 2001: 20-24.

Solidification/Stabilization Treatability Study of a Mixed-Waste Sludge. By Roger D. Spence and Ernie F. Stine. Nov. 1997: 40-44.

Responding to the New Realities: Thinking outside the Box to Solve the Mixed Waste Problem. By Gerald Boyd, Mark Gilbertson, William Owca, and Edward Rizkalla. May/June 2001: 49-53.

### **Monitored Retrievable Storage (See also Storage, Spent Fuel)**

BANANAS, Alligators, and "Hot Rocks That Shoot Ghost Bullets": Sitings Along the Path to an MRS. By Vic Trebules and Dan Kane. Apr. 1994: 23-28.

The MRS and the Mescalero Apaches. By Fred Peso. Apr. 1994: 29-31.

### **National Aeronautics and Space Administration**

Community Relations—The NASA Way. By Burt Peretsky. July/Aug. 2002: 34-39.

Here's the Dirt on Soil Assay at Plum Brook. By Alex Lopez. July/August 2010: 56-59.

Lending an Ear and a Voice: NASA's Plum Brook Station Community Workgroup. By Michael Morgan. July/Aug. 2007:47-52.

Offsite Contamination in Plum Brook»From Discovery and Characterization to Demonstration of Regulatory Compliance. By Keith M. Peacock. Sept./Oct. 2010: 20-27.

### **Natural Analogs**

Analogues and Dialogs: Integrating Natural Analogue Studies into a National Confidence-Building Program. By I. McKinley and T. Tsuboya. Nov./Dec. 2001: 24-27.

Artifact to Analogue: Archeology of Arid Environments Points to Management Options for Yucca Mountain. By Neil Chapman, Amy Dansie, and Charles McCombie. Mar./Apr. 2007: 22-31.

Cigar Lake: A Natural Example of Long-Term Isolation of Uranium. By Jan Cramer. May 1995: 36-40.

Confidence-Building Tools for HLW Repositories: An Introduction to the Series. By Charles McCombie and Ian McKinley. Jan. 1995: 26-31.

The Fossil Nuclear Reactors of Oklo, Gabon. By John Smellie. Mar. 1995: 18-27.

Natural Analogs for Yucca Mountain. By William M. Murphy. Nov. 1995: 44-50.

Natural Cements: How Can They Help Us Safely Dispose of Radioactive Waste? By W. Russell Alexander. Sept. 1995: 61-69.

Poços de Caldas: Testing Models of Radionuclide Transport Processes. By Ian G. McKinley. July 1995: 34-38.

Postcards from the Past: Archaeological and Industrial Analogs for Deep Repository Materials. By Bill Miller and Neil Chapman. Jan. 1995: 32-42.

### **Packaging**

IAEA Compatibility Regulations Overview. By Charles H. Smith. Apr. 1994: 62-65.

The Potential Impact of Using TAD Canisters on Yucca Mountain Preclosure Operations. By Leah Spradley, Mark Abkowitz, and James H. Clarke. Mar./Apr. 2009: 56-62.

Shielded Payload Containers for WIPP Remote-Handled Waste. By Roger A. Nelson and D. Sean White. Mar./Spr. 2009: 64-72.

WIPP's Mobile Loading Unit: Loading Shipments Using Mobile/Modular Systems. By Bryan Howard. May/June 2009: 42-46.

WIPP's Unique Fleet of Packages Delivers. By Robert Johnson and Todd Sellmer. May/June 2009: 47-53.

Wrapping Up a Waste Problem: Innovative Use of Polyurea Coating at Rocky Flats Reduces Risk, Saves Money. By Jackie Powers. May/June 2004: 40-43.

### **Perspectives**

Are Deep Geologic Repositories Really Necessary? By Christopher M. Timm and Cassandra Mueller. July-Aug. 2012: 61-66.

Breaking the High-Level Waste/Spent Fuel Logjam. By Dade W. Moeller. May/June 2006: 18-20.

Decommissioning: Thinking Through to the End. By Russell Mellor. Sept./Oct. 2001: 26-28.

Deep Disposal of Irradiated Nuclear Fuel: An Alternate Viewpoint. By Björn Cornhjort. Mar./Apr. 2002: 19-22.

Insights and Perspective on the Blending Issue. By Michael H. Mobley. May/June 2010: 32-33.

It's Time for Radioactive Waste Disposal in Salt. By Ray Funderburk. May-June 2013: 54-56.

The Paradox of Nuclear Waste: Understanding Nuclear Waste and its Role in the Coming Nuclear Expansion. By Harold F. McFarlane. Sept./Oct. 2006: 32-36.

Planning for Decommissioning: What, How, When, and Why? By W. W. Bixby and W. J. Manion. Sept./Oct. 1999: 66-68.

Radioactive Waste Disposal in the United States. By Aubrey V. Godwin. July-Aug. 2011: 66-67.

Rethinking the Disposition of Hanford Tank Wastes: A Perspective. By Frank L. Parker, Donald E. Clark, and Nabil Morcos. Nov./Dec. 2001: 35-39.

The State of Affairs in the Wasteland. By Jack K. Lemley. May/June 1999: 65-66.

The Tragedy of Yucca Mountain. By Dade W. Moeller. Sept./Oct. 2010: 52-57.

The Tragedy of Yucca Mountain: Part II. By Dade W. Moeller. Jan.-Apr. 2011: 54-58.

We're from the Government, and We're Here To Help Ourselves: Low-Level Waste, the Act, Cabbages, and Kings. By Peter J. Pastorelle. Nov./Dec. 1998: 53-54.

### **Plutonium**

Hanford Pu Process Vessels out the Door—A Year Ahead of Schedule. By Todd Nelson. July/Aug. 2002: 30-33.

More Hanford Firsts: Demolition of a Hanford Plutonium Facility. By Geoff Tyree, Tom Orgill, Jeff Riddelle, and Andrea Harper. July/Aug. 2004: 11-14.

The Plutonium Issue: Materials Science Aspects of Going MOX and Alternative Solutions. By Hansjoachim Matzke and Jacques van Geel. Mar. 1996: 71-76.

Plutonium: Requiem or Reprieve. By K. K. S. Pillay. Jan. 1996: 59-65.

Turning the Corner at Hanford: Hanford Plutonium Finishing Plant Completes Plutonium Stabilization; Key Safety Issues Closed. By Michele Gerber. May/June 2004: 18-27.

### **Recordkeeping**

Informing Future Societies About Nuclear Waste Repositories. By Mikael Jensen. Apr. 1994: 53-61.

Lessons from the Vatican Archives for Repository Recordkeeping. By Suzanne B. Pasztor and Stephen C. Hora. July 1994: 39-47.

WIPP Marker Development. By Kathleen M. Trauth. Apr. 1994: 46-52.

### **Recycling and/or Reuse**

Advanced Fuel Cycles, Cleanup Progress, and Other Issues: A Report from the 2006 ANS Summer Meeting. By Nancy J. Zacha. Sept./Oct. 2006: 62-64.

The Ashland 2 Cleanup. By Bruce K. Howard, David J. Conboy, Michelle R. Rehmann, and Harold R. Roberts. Mar./Apr. 1999: 39-44.

The Best Kind of Recycling: Building 7602 at ORNL. By Angie Brill, James Berger, Andy Kelsey, and Ken Plummer. July/Aug. 2002: 12-20.

Controlled Recycle: An Alternative to the Burial of Low-Level Radioactive Waste. By J. Mark Price. Sept./Oct. 2008: 44-48.

Fernald Scrap Metal Recycling and Beneficial Reuse. By Gerald P. Motl and Daniel D. Burns. Jan. 1994: 50-55.

Getting the Lead Out: Recycling and Decontamination at the INEL. By Erik A. Simpson. July 1994: 49-51.

Moving to Another Stage of Life: Shipping, Decontaminating, and Final Disposition of the Maine Yankee Large Components. Sept./Oct. 2000: 50-55.

A New Life for Recycling—And Other Decommissioning and Waste Management Updates: A Report from the 2005 ANS Winter Meeting. By Nancy J. Zacha. Mar./Apr. 2006: 58-65.

Nuclear Fuel Recycling: ANS Position Statement. Mar./Apr. 2006: 68.

Potential Radioactive Scrap Metal Quantities from Nuclear Power Plants Worldwide. By Leslie A. Nieves and Roger W. Tilbrook. Jan. 1996: 45-53.

Recycling Hits the Big Time: Reactor Coolant Pump Decontamination and Refurbishment at Oconee. By Tom Shiel. Jan./Feb. 2000: 44-48.

Recycling the Cotter Concentrate. By Colleen T. O'Laughlin, Michelle R. Rehmann, Harold R. Roberts, and Peter A. Sanders. Mar./Apr. 1999: 58-66.

The Risk of CERCLA Liability Associated with DOE-Generated Scrap Metal. By J. Michael Sowinski Jr. Mar./Apr. 2001: 48-55.

### **Reduction**

Decreasing Dry Active Waste Generation by 50% in One Year. By Steven M. Lorenz. Sept. 1995: 47-49.

An Operating Philosophy for Volume Reduction. By Frederic J. Mis. Apr. 1994: 42-45.

Waste Reduction at the Source—The Next Step. By Katie Redd and Tracy Barker. Sept. 1995: 50-53.

### **Regulatory Issues**

Catching Up with Clearance Criteria. By Nancy J. Zacha. Sept./Oct. 2001: 57-58.

Cutting the Gordian Knot That Binds WIPP: Sampling and Analysis to Validate Acceptable Knowledge on LANL Transuranic, Heterogeneous, Debris Waste. By Stanley T. Kosiewicz,

Daniel I. Michael, Paul K. Black, Inez Triay, and Lawrence A. Souza. Mar./Apr. 2000: 55-64.

Data Needs for Storage and Transportation of High-Burnup Fuel. By R. E. Einziger, C. L. Brown, G. P. Hornsby, and C. G. Interrante. Mar./Apr. 2005: 44-57.

Doin' the D&D: Dancing to the Regulatory Tune. By John D. Haseltine and Stephen J. Milioti. Jan./Feb. 1999: 44-49.

Full Burnup Credit in Transport and Storage Casks—Benefits and Implementation. By C. V. Parks, J. C. Wagner, D. E. Mueller, and I. C. Gauld. Mar./Apr. 2007: 32-41.

In Pursuit of Risk-Informing Low-Level Waste Disposal Regulations. By David James, Thomas Kalinowski, and Phung Tran. May/June 2010: 13-19.

Independent Oversight at WIPP. By Christopher M. Timm. May/June 2009: 66-70.

The Inspector Calls: Inspection Planning, Feedback, and Results on Decommissioning. By Nancy J. Zacha. Jan./Feb. 2001: 44-45.

License Termination, Unrestricted Release Criteria, and More: A Radwaste Magazine Interview. Jan./Feb. 1999: 20-22.

NRC's D&D Regulations. By Anthony J. Thompson. Mar. 1998: 47-54.

Please Release Me . . . : Materials and Site Free-Release Issues. By Nancy J. Zacha. Jan./Feb. 2001: 46-47.

Radiation Exposure: Overcoming Vested Interests That Block Good Science. By Stanley E. Logan. Mar./Apr. 2000: 50-54.

Some Views on Closing the Fuel Cycle. By Dale E. Klein. Sept./Oct. 2008: 13-15.

Spent Fuel, Nuclear Waste on the Regulatory Radar Screen. By Nancy J. Zacha. May/June 2007: 42-47.

Staged Licensing and the Need to Assure Issue Closure in New NRC Regulations for Licensing the Yucca Mountain Repository. By F. Stanley Echols. July 1998: 10-14.

State of New York, et al., Petitioners., v. Nuclear Regulatory Commission and United States of America, Respondents. July-Aug. 2012: 54-60.

Streamlining the NRC's Waste Management Program. By Margaret V. Federline. Mar. 1996: 55-58.

Waste Confidence, Waste Packaging, and Other Issues. By Dale E. Klein. Sept./Oct. 2009: 36-37.

Why We Need Better Management of Low-Activity Radioactive Waste. By John R. Wiley. May/June 2005: 20-26.

WIPP Certification: A DOE Success Story. By George E. Dials. Jan./Feb. 1999: 15-19.

Yucca Mountain Repository Standards: What Does the EPA Not Understand? By Dade W. Moeller. Sept./Oct. 2008: 10-12.

## Reprocessing

Advanced Fuel Cycles, Cleanup Progress, and Other Issues: A Report from the 2006 ANS Summer Meeting. By Nancy J. Zacha. Sept./Oct. 2006: 62-64.

A New Life for Recycling—And Other Decommissioning and Waste Management Updates: A Report from the 2005 ANS Winter Meeting. By Nancy J. Zacha. Mar./Apr. 2006: 58-65.

Nuclear Fuel Recycling: ANS Position Statement. Mar./Apr. 2006: 68.

Some Views on Closing the Fuel Cycle. By Dale E. Klein. Sept./Oct. 2008: 13-15.

Taking Another Look at Reprocessing: Design Considerations for New Facilities. By Ted Breitmayer. Sept./Oct. 2001: 49-53.

## Robotics and Remote Systems

The Arm from MARS. Jan.-Apr. 2012: 52-53.

Bringing Robotics Technology Down to Earth. By Brian R. Fuller. Mar. 1997: 23-27.

Build It Fast, Use It Faster: The Story of the DWPF Melt Cell Crawler. By Clyde R. Ward, Montenius Collins, Thomas A. Nance, and Michael C. Prather. Jan./Feb. 2004: 20-25.

Down, ROVer, Down. July-Aug. 2012: 51-53.

In-Tank Pipe Cropping a Great Success at Sel-lafeld. By Steve McGowan. July/Aug. 2007: 30-33.

Konan to the Rescue. By Eric Shen, Eric Gerber, and Judith Graybeal. Mar./Apr. 1999: 7-14.

Managing It Remotely: IAEA Review of Remote Technology in Spent-Fuel Management. By Jae Sol Lee. Mar./Apr. 2002: 24-29.

Pit Viper Strikes at the Hanford Site: Pit Maintenance Using Robotics at the Hanford Tank Farms. By Lynne Roeder-Smith. May/June 2002: 33-39.

Radioactive Waste Sampling Supports Processing. By Thomas A. Nance. Mar. 1997: 18-22.

Remote Automatic Control Scheme for Plasma Arc Cutting of Contaminated Waste. By Aed M. Dudar, Clyde R. Ward, and Eric M. Krikku. Jan. 1994: 56-62.

A Remotely Operated Tank Waste Retrieval System for ORNL. By B. L. Burks, D. D. Falter, R. L. Glassell, S. D. Van Hoesen, M. A. Johnson, P. D. Lloyd, and J. D. Randolph. Mar. 1997: 10-16.

Robotic Arm to Speed Hanford Tank Waste Removal. By Mike Berriochoa. Jan./Feb. 2010: 31-33.

Robotic Inspection of Nuclear Waste Storage Facilities. By Ron Fulbright and Larry M. Stephens. Nov. 1995: 36-43.

Robotic System Cleans Underground Storage Tank at Oak Ridge. By S. Dirk Van Hoesen, Cavanaugh S. Mims, and Barry L. Burks. Mar. 1998: 55-61.

Robotics Down on the (Tank) Farm. By Michele Gerber. Mar./Apr. 1999: 21-25.

Robots Provide Valuable Tools for Waste Processing at Millstone Nuclear Power Station. By Kirk Miles and Kathy Volpe. Mar. 1997: 28-30.

The Visual and Radiological Inspection of a Pipeline Using a Teleoperated Pipe Crawler. By Robert F. Fogle, Kevin Kuelske, and Robert A. Kellner. July 1996: 42-49.

WRAPping It Up at Hanford. By Bryan Kidder and Mark French. Mar./Apr. 1999: 15-19.

## Safety

The ABCs of Decommissioning Safety. By Bill Grubilowicz and Janenne Irene Harrington. Jan./Feb. 2002: 8-11.

Advancing Worker Safety at Hanford's Tank Farms. By Mike Berriochoa. May/June 2006: 23-27.

Andros and Rosie and Other Friends to D&D Workers: Decommissioning Technologies that Improve Worker Safety. By Steven Bossart and Danielle Blair. Jan./Feb. 2002: 16-10.

MADness and Spent-Fuel Cask Safety. By Charles W. Pennington and Michael S. McGough. May/June 2002: 25-30.

Making Safety Work: Safety-Enhancing Technologies and Practices at INEEL Decommissioning Projects. By Richard Meservey. Jan./Feb. 2002: 20-24.

A Partnership for PCE Reduction. By Scott Griffin. May-June 2013: 30-33.

Talk the Talk and Walk the Walk: Focusing on Safety during Fusion Reactor Decommissioning. By Keith Rule, Erik Perry, and Jerry Levine. Jan./Feb. 2002: 12-15.

## Sampling

The Importance of Radiological Data Validation. By Kendra K. Grega and LeRoy F. Wenrick. Mar. 1995: 28-32.

Notes from the Vadose Zone. By Joseph R. Hearst, John R. Brodeur, and John G. Conaway. July 1994: 74-76, 78.

## Siting

The Added-Value Approach in Siting Nuclear Waste Facilities. By Matti Kojo and Phil Richardson. Jan.-Apr. 2012: 38-50.

Boon or Bane? A Repository's Effects on the Local Community. By Timo Seppälä. Jan./Feb. 2010: 34-37.

Consent-Based Siting . . . and Other BRC Issues. By Nancy J. Zacha. May-June 2013: 44-46.

Consent-Based Siting: What Have We Learned? By Daniel Metlay. July-Aug. 2013: 28-36.

Endless Search, Endless Failure, Endless Conflict: The Siting of a Radioactive Waste Disposal Facility in South Korea. By Yearn Hong Choi. May/June 2002: 20-24.

Informing Future Societies About Nuclear Waste Repositories. By Mikael Jensen. Apr. 1994: 53-61.

It's Time for Radioactive Waste Disposal in Salt. By Ray Funderburk. May-June 2013: 54-56.

Radioisotopes, Medicine, and Low-Level Waste Disposal. By Rosalyn S. Yalow. Jan. 1994: 48-49.

The Volunteer Approach: A Siting Partnership. By Domenic Forcella and Ronald E. Gingerich. Jan. 1994: 30-35.

Ward Valley and the Federal Low-Level Radioactive Waste Policy Act. By Alan D. Pasternak. Mar. 1996: 39-43.

Ward Valley: Heading for the Finish Line and Picking Up Speed. By Nicki Hobson. Jan. 1996: 55-58.

WIPP Marker Development. By Kathleen M. Trauth. Apr. 1994: 46-52.

## Soil Processing

Air Classification Methods at the Nevada Test Site. By Mark J. Harper, Martin E. Nelson, and Andrew D. Buckon. Oct. 1994: 28-32.

Building Dismantlement and Site Remediation at the Apollo Fuel Plant: When Is Technology

the Answer? By Lewis Walton. Jan. 1995: 20-25.

*In Situ* Redox Manipulation: Fierce Energy of Groundwater VOCs and Heavy Metals. By Mary H. Ace. July/Aug. 2001: 24-27.

Processing Plutonium-Contaminated Soil on Johnston Atoll. By Kathleen Moroney, John Moroney III, John Turney, and Nels Johnson. July 1994: 69-73, 91-92.

Putting Plants to Work: The ANL-West Phytoremediation First-Year Field Season Demonstration. By Scott Lee. May/June 2000: 49-54.

A Road Map to Cleanup Success: Hanford's Groundwater/Vadose Zone Integration Project. By Steven P. Sautter and Geoffrey L. Harvey. May/June 2001: 31-35.

Soil Washing: Its Potential Application to the Treatment of Radioactively Contaminated Soils, Rubble, and Rocks from UKAEA Sites. By Mike Pearl. Jan./Feb. 2004: 46-52.

### Sources

Disposal of Disused Radioactive Sources. By R. Dayal and J. M. Potier. July/Aug. 2004: 39-47.

New Hope for Disused Sealed Source Disposal. May-June 2013: 4.

Unwanted and Orphan Sources: Disposition Efforts and Challenges. By R. E. McBurney, C. R. Meyer, and D. B. Gilley. May-June 2011: 12-14.

### Spent-Fuel Processing

EBR-II Spent Fuel Treatment Demonstration Project Status. By Robert W. Benedict and Harold F. McFarlane. July 1998: 23-27, 30.

### Spent-Fuel Management/Storage

An Aging Management Plan for Spent Fuel Dry Storage and Transportation. By Robert E. Einziger. July-Aug. 2013: 38-45.

All Dressed Up with No Place To Go: The Disposition of Spent Nuclear Fuel. By Nancy J. Zacha. Jan./Feb. 1999: 41-42.

Analyzing the Blue Ribbon Commission Report. By Nancy J. Zacha. May-June 2012: 55-58.

Appeals Court: DOE Must Take Spent Fuel or Pay the Consequences. By Michael A. Bauser. Sept. 1996: 15-18.

Breaking Good: Study Examines Durability of Glass with Ties to Nuclear Waste Storage. By Eric Pierce, Wendy Shaw, Charity Plata, and Kristin Manke. Jan.-Apr. 2011: 42-46.

Breaking the High-Level Waste/Spent Fuel Logjam. A Perspective by Dade W. Moeller. May/June 2006: 18-20.

Business as Usual . . . Only More So. By Nancy J. Zacha. Nov./Dec. 2001: 9-14.

Calling in the Pool Guys: Decontamination of a Spent-Fuel Storage Pool. By K. A. Szlis, J. F. Jablonski, and A. m. Al-Daouk. July/Aug. 2002: 21-25.

Can DOE Canister Containment Be Maintained After Accidental Drop Events? A National Spent Nuclear Fuel Program Study. By Dana K. Morton, Spencer D. Snow, Tommy E. Rahl, Robert K. Blandford, and Thomas J. Hill. Sept./Oct. 2007: 51-56.

Centralized Interim Storage: Past, Present, and Future. By Steven P. Nesbit. Nov.-Dec. 2012: 14-23.

Consent-Based Siting . . . and Other BRC Issues. By Nancy J. Zacha. May-June 2013: 44-46.

Consent-Based Siting: What Have We Learned? By Daniel Metlay. July-Aug. 2013: 28-36.

Cost-Saving Potential for Transport and Storage of Spent Nuclear Fuel Available from Burnup Credit. By William H. Lake. Sept. 1997: 35-36.

The Costs of Prolonging the Status Quo. By Kris Sanda. May 1997: 10-12.

Courts Say Take or Pay: Litigation Related to the U.S. Department of Energy's Failure to Accept Spent Nuclear Fuel. By Michael A. Bauser. July/Aug. 2000: 15-19.

Data Needs for Storage and Transportation of High-Burnup Fuel. By R. E. Einziger, C. L. Brown, G. P. Hornseth, and C. G. Interrante. Mar./Apr. 2005: 44-57.

Does Utility Spent Fuel Storage Affect Local Property Values? By William C. Metz, Tim Allison, and David E. Clark. May 1997: 27-33.

Draft Report from the Blue Ribbon Commission on America's Nuclear Future—Executive Summary. Sept.-Oct. 2011: 46-55.

The Evolution of Spent-Fuel Waste Packages: Designing the Means to Permanently Dispose of U.S. High-Level Nuclear Waste. By Hugh Benton and Judy Connell. Mar./Apr. 2001: 34-42.

The Final Report of the Blue Ribbon Commission on America's Nuclear Future—January 2012: Executive Summary. May-June 2012: 45-54.

Fire in the Tunnel! A Study of Effects on a Spent Fuel Transportation Cask. By C. S. Bajwa. Mar./Apr. 2004: 26-29.

The First Integrated SNF Transshipment/Interim Storage Facility in Northwest Russia. By R. S. Dyer, E. Banes, R. L. Snipes, and S. Hoibraten. July/Aug. 2005: 47-51.

A Forum on the MPC: The Independent Review Group's Comments on the MPC, by John A. Vincent; The Nuclear Waste Technical Review Board's View's on the MPC, by Dennis L. Price; The NRC Perspective on the MPC, by Robert M. Bernero; The MPC System Evaluation Report, Oct. 1994: 34-49.

GAO: Opening Yucca Mountain Cheaper than Storage Alternatives. Mar./Apr. 2010: 40-47.

Historic Testing Relevant to Disposal of Heat-Generating Waste in Salt. By Kristopher L. Kuhlman. Sept.-Oct. 2013: 22-28.

Impact Analyses and Tests of a Metal Cask in the Event of an Aircraft Engine Crash. By Sanghoon Lee, Woo-Seok Choi, Ki-Young Kim, Je-Eon Jeon, and Ki-Seog Seo. Jan.-Apr. 2013: 86-92.

Integrating Storage, Transportation, and Disposal. By Nancy J. Zacha. July-Aug. 2013: 60-66.

International Collaboration and Continuous Improvement. By Nancy J. Zacha. May-June 2013: 48-53.

International Storage of Commercial Spent Fuel and High-Level Waste. By Alex. R. Burkart. Sept./Oct. 2002: 29-33.

It's Time for Radioactive Waste Disposal in Salt. By Ray Funderburk. May-June 2013: 54-56.

La Crosse Fuel Is Moved to an ISFSI. Nov.-Dec. 2012: 24-27.

Lessons from Sergeant Schultz: The Honest Facts about Spent Fuel. By Commissioner Jeffrey S. Merrifield. July/Aug. 2006: 39-43.

MADness and Spent-Fuel Cask Safety. By Charles W. Pennington and Michael S. McGough. May/June 2002: 25-30.

Managing It Remotely: IAEA Review of Remote Technology in Spent-Fuel Management. By Jae Sol Lee. Mar./Apr. 2002: 24-29.

A New Entity to Manage Nuclear Fuel. By Nancy J. Zacha, Jan.-Apr. 2013: 70-75.

Occupational Radiation Dose Assessment for a Non-Site-Specific Spent-Fuel Storage Facility. By Jennifer Hadley and Robert G. Eble, Jr. Mar. 1998: 10-18.

Oh, Give Me A Home . . . : Spent-Fuel Dry Cask Storage Update. By Nancy J. Zacha. Jan./Feb. 2001: 48-50.

On-Site Dry Spent-Fuel Storage: Becoming More of a Reality. By Betsy Tompkins. Jan. 1994: 63-70.

The Owl Creek Energy Project—A Solution for Temporary Storage of Spent Fuel. By Ivan F. Stuart and Robert O. Anderson. Sept. 1998: 26-30.

Private Fuel Storage: Finding Real Solutions for Centralized Spent-Fuel Storage. By Scott Northard. Jan./Feb. 2000: 35-39.

Private Offsite Spent Fuel Storage: A Report from the ANS Executive Conference. By Nancy J. Zacha. May/June 2006: 49-54.

Postirradiation Fuel Assembly Dimensions for Transportation and Storage Cask Designs. By Douglas A. Williamson. Jan. 1994: 42-47.

A Regional Approach to HLW, Spent Fuel, and TRU Waste Disposal in New Mexico. By Christopher M. Timm. Sept.-Oct. 2013: 29-34.

Regulating Dry Cask Storage. A Radwaste Solutions Interview with Susan Shankman and Randy Hall. July/Aug. 2000: 10-14.

Removing the K-Basins Fuel: Down Payment on Protecting the Columbia River. By Michele Gerber. Mar./Apr. 2001: 8-24.

Report of the American Nuclear Society President's Special Committee on Used Nuclear Fuel Management Options—Executive Summary. Sept.-Oct. 2011: 56-58.

Russia to the Rescue? International Spent-Fuel Storage Options Discussed at the ANS Annual Meeting. By Nancy J. Zacha. July/Aug. 2002: 54-56.

Selecting and Applying an Automated Welding System. By Mario Lento. Nov./Dec. 2002: 18-20.

The Sludge Cleanout of Hanford's K Basins. By Michele Gerber. Jan./Feb. 2008: 20-31.

Solving the Spent Fuel Dilemma. By Nancy J. Zacha. Sept.-Oct. 2012: 50-52.

Spent Fuel Disposal Success vs. Failure: A Comparison of the Swedish and U.S. Repository Programs. By Leif G. Eriksson. Jan./Feb. 2010: 22-30.

Spent Fuel Management at the Northern States Power Company. By John Closs and Lon Kress. May 1996: 25-29.

Spent Fuel Overpack Closure Welding: Parameter Development and Qualification. By G. R. Cannell and L. H. Goldmann. Jan./Feb. 2007: 25-30.

Spent Fuel Removal Concludes at Hanford's K Basins—Helping to Restore the Columbia Riv-

er's Hanford Reach. By Michele S. Gerber. Jan./Feb. 2005: 10-22.

Spent-Fuel Storage: Rhetoric, But No Resolution. By Nancy J. Zacha. Sept./Oct. 2001: 54-56.

Spent Fuel Storage in a Post-Fukushima World. By Nancy J. Zacha. Jan.-Apr. 2012: 16-22.

Status of the Multipurpose Canister Project. By J. Pat Hopper. Mar. 1996: 32-38.

Status of the U.S. Foreign Research Reactor Spent Nuclear Fuel Program. By Kenneth C. Chasey, Ibrahim H. Zeitoun, and Elizabeth Saris. May 1997: 14-19.

Strategy for the Management and Disposal of Used Nuclear Fuel and high-Level Radioactive Waste (January 2013). May-June 2013: 34-43.

Take My Spent Fuel . . . Please! By Nancy J. Zacha. July/Aug. 1999: 58-59.

Thoughts on Spent Fuel Storage. By Gregory B. Jaczko. July/August 2008: 26-27.

Transport of Spent Fuel from Reactors to DOE Storage/Disposal Facilities—A Parametric Study. By E. R. Johnson and P. M. Saverot. Sept. 1997: 27-30.

The Universal MPC System: The Evolution of NAC Spent-Fuel Technology. By Bill Lee and Doug Walker. Sept. 1997: 31-34.

Very Long Term Dry Fuel Storage . . . and Other Issues. By Nancy J. Zacha. Sept.-Oct. 2011: 59-64.

What Now for Permanent Disposal of Used Nuclear Fuel and HLW in the United States? By Andrew Sowder, John Kessler, Mick Apted, and Matt Kozak. Jan.-Apr. 2013: 26-39.

What We've heard: A Staff Summary of Major Themes in Testimony and Comments Received to Date by the Blue Ribbon Commission on America's Nuclear Future. May-June 2011: 51-58.

The Zaporozhye ISFSI. By David G. Marcelli and Tommy B. Smith. Jan./Feb. 2002: 28-32.

### Stewardship

The 48-Hour Job. By Nancy J. Zacha. May-June 2012: 59-64.

From Test Site to Wildlife Refuge: Tatum Salt Dome Test Site Transferred to State. September-October 2011: 26-29.

Legacy Management at the Rocky Flats Site. By Bob Darr, John Boylan, Rick DiSalvo, George Squibb, Jody Nelson, and Scott Surovchak. Sept./Oct. 2010: 12-19.

Long-Term Stewardship—Part I: The Nature of the Problem. July/Aug. 2000: 35-44.

Long-Term Stewardship—Part II: Analysis and Planning. Sept./Oct. 2000: 34-42.

Revegetating Amchitka Island. By Mark Kautsky and Paul Darr. Jan./Feb. 2009: 25-29.

Trusts for Long-Term Stewardship at Decommissioned Nuclear Facilities. By Anthony J. Thompson and Christopher S. Pugsley. July/Aug. 2002: 45-49.

### Technology Notes

Ceramicrete Radioactive Waste Forms—The New Kid on the Block. By Arun S. Wagh and Dileep Singh. Jan. 1998: 46-49.

First Simulation of PID Controller Helps Validate New Hazardous Waste Treatment Technique. May 1998: 35-37.

MICROBasix Dry Active Radioactive Waste Reduction System. By John B. Steward. July/Aug. 2001: 53-56.

Particle Detection: A New Mindset. By Alejandro U. Lopez, Michael R. Marcial, and Michael P. McDonald. July/Aug. 2009: 42-50.

Robotics and Virtual Reality System to Help Stabilize the Chernobyl-4 Reactor. May 1998: 39-40.

Simulating Pulse Jet Mixing in Nuclear Waste. By Brigitte Rosendall. May/June 2008: 52-56.

Solucorp and BNL Tackle Mixed Radwaste Problems. May 1998: 41.

Synroc: Progress and Future Prospects. By Adam Jostsons. Mar./Apr. 2002: 58-62.

Well Simultaneously Samples Groundwater and Soil Vapor. May 1998: 38.

### Technologies

Andros and Rosie and Other Friends to D&D Workers: Decommissioning Technologies that Improve Worker Safety. By Steven Bossart and Danielle Blair. Jan./Feb. 2002: 16-10.

Complex Problem, Simple Solution: Complex Waste Sorting Issue Solves with Simple Detector. By Todd A. Nelson. Sept./Oct. 2006: 51-55.

Here's the Dirt on Soil Assay at Plum Brook. By Alex Lopez. July/August 2010: 56-59.

Microwave In-Drum Drying: A New Volume-Reduction Process for Radioactive and Toxic Liquid Waste. By Christian Giessmann. Jan./Feb. 2007: 21-24.

Making Safety Work: Safety Enhancing Technologies and Practices at INEEL Decommissioning Projects. By Richard Mesurvey. Jan./Feb. 2002: 20-24.

New Technologies in the SRS "Toolbox." By David Yannitell. July/Aug. 2000: 28-34.

The PACT System: A Radwaste Treatment Solution. By M. W. Shuey and D. W. Reaney. Jan./Feb. 2007: 11-15.

Science, Technology, and Workforce Innovations: Keys to a Successful D&D of Hanford's Plutonium Finishing Plant. By Stacy Charboneau, Andrea Hopkins, Bruce Klos, Robert Heineman, and Brian Skeels. Mar./Apr. 2007: 60-66.

A Whole Zoo of new Technologies: Innovative Waste Retrieval Technologies Advance Hanford's Environmental Protection Mission. By Mike Berriochoa. Jan./Feb. 2007: 16-20.

### Training/Education

Fueling Up for the Long Haul: Training for Decommissioning. By Larry Boing. Jan./Feb. 2001: 25-27.

Growing Young Minds Through EM Site Tours. July-Aug. 2013: 56-58.

HAMMERing It Out: Training As Real As It Gets. By Jean McKenna, Karin Nickola, and Richard N. Smith. Jan./Feb. 2000: 8-12.

How to HAMMER Home Hazardous Materials Training. By June Ollero. Oct. 1994: 50-57.

The Electronic Teacher: Considerations for Implementation of a Computer-Based Training Program. By Mike Nolan. Nov./Dec. 2000: 16-20.

### Transmutation

The Answer Is No: Does Transmutation of Spent Nuclear Fuel Produce More Hazardous Material Than It Destroys? By Holly R. Trelue. July/Aug. 2002: 40-44.

### Transportation

An Aging Management Plan for Spent Fuel Dry Storage and Transportation. By Robert E. Einziger. July-Aug. 2013: 38-45.

"And the Train Pulls Out from . . ." Fernald's Waste Pits Cleanup. By Julie Loerch and Dave Lojek. Mar./Apr. 2000: 32-37.

Assessment of Spent Nuclear Fuel Transport Accident Risk Using RADTRAN 5.5. By Eileen M. Supko and John H. Kessler. Jan./Feb. 2009: 19-24.

The Big Rock Vessel Goes to Barnwell. By Tim Petrosky. Jan./Feb. 2004: 15-19.

Big Wheels Keep on Rolling: The Transportation Side of WIPP. By Angela Johnson, Lynn Eaton, and Phil Gregory. May/June 2009: 54-59.

Can DOE Canister Containment Be Maintained After Accidental Drop Events? A National Spent Nuclear Fuel Program Study. By Dana K. Morton, Spencer D. Snow, Tommy E. Rahl, Robert K. Blandford, and Thomas J. Hill. Sept./Oct. 2007: 51-56.

A Commentary on the 1995 DOT/NRC Amendments to the U.S. Nuclear Transportation Regulations. By Al Grella. July 1996: 31-34.

Communicating Safety Every Step of the Way: What We Have Learned from the Public. By Ann S. Bisconti. Sept. 1997: 20-21.

Compliance Concerns in the U.S. with the New DOT/NRC Shipping Regulations. By Clint Miller and Michael Wang. Sept. 1997: 10-12, 14.

Cost-Saving Potential for Transport and Storage of Spent Nuclear Fuel Available from Burnup Credit. By William H. Lake. Sept. 1997: 35-36.

Cruisin' Up the River: The Final Journey of the Trojan Reactor Vessel. Nov./Dec. 1999: 48-53.

D&D, Spent Fuel Transport Discussed at ANS Sessions. By Nancy J. Zacha. Sept./Oct. 2008: 52-54.

Data Needs for Storage and Transportation of High-Burnup Fuel. By R. E. Einziger, C. L. Brown, G. P. Hornsesh, and C. G. Interrante. Mar./Apr. 2005: 44-57.

DOE/EPRI Spent Nuclear Fuel Dry Transfer System. By Mikal A. McKinnon, Leroy Steward, David C. Koelsch, Albert Machiels, and Dennis A. Brown. July 1998: 19-21.

DOE Strategic Plan for the Safe Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to Yucca Mountain. Mar./Apr. 2004: 18-24.

Engineering for Transportation and Disposal of Low-Level Radioactive Wastes in Japan. By Yutaka Suzuki, Yoshihiro Akagawa, and Hiroo Ohno. Oct. 1994: 64-70.

Fernald Cleanup Effort on the Move Again: K-65 Materials Shipped to WCS. Sept./Oct. 2005: 30-31.

Fire in the Tunnel! A Study of Effects on a Spent Fuel Transportation Cask. By C. S. Bajwa. Mar./Apr. 2004: 26-29.

- Forty-Year-Old Reactive Mixed Waste from Historic Reactor Is Transported Without Mishap. By Charlie G. Dietz. July 1996: 35-37.
- Full Burnup Credit in Transport and Storage Casks—Benefits and Implementation. By C. V. Parks, J. C. Wagner, D. E. Mueller, and I. C. Gauld. Mar./Apr. 2007: 32-41.
- IAEA Compatibility Regulations Overview. By Charles H. Smith. Apr. 1994: 62-65.
- Innovative Approaches to Rail Transport of Radioactive Waste. By Gene Gleason. May/June 2004: 34-39.
- The Journey of the MCL Trader: Ship Modification for Spent Fuel Transport. By Michael Tyacke, Igot Bolshinsky, Włodzimierz Tomczak, Sergey Nalotov, and Oleg Pichugin. July-Aug. 2011: 46-58.
- Just How Risky Is It? Comparisons of the Risks of Transporting Radioactive Waste. By Earl P. Easton and Christopher S. Bajwa. Jan.-Apr. 2011: 64-72.
- La Crosse BWR Reactor Vessel Shipped to Barnwell. Sept./Oct. 2007: 30-32.
- Logistics Case Study for Shipping Used Nuclear Fuel from Shutdown Reactor Sites. By E. A. Kalinina, I. K. Busch, P. E. McConnell, and S. J. Maheras. Sept.-Oct. 2013: 35-42.
- Low-Level Radioactive Waste Transportation Safety History. By James D. McClure. Sept. 1997: 22-25.
- Midwestern Radioactive Materials Transportation Project. May/June 2006: 21-22.
- The National Transportation Program and Three-Tier Planning. By Kelvin J. Kelkenberg, Paul T. Dickman, Judith A. Holm, and Glenda E. Oakley. Sept. 1998: 15-19.
- Old Rail Spur Reactivated: Railroad Moved Radioactive Materials from San Onofre. By David Gilson. Mar./Apr. 2005: 20-26.
- Postirradiation Fuel Assembly Dimensions for Transportation and Storage Cask Designs. By Douglas A. Williamson. Jan. 1994: 42-47.
- The Potential Impact of Using TAD Canisters on Yucca Mountain Preclosure Operations. By Leah Spradley, Mark. Abkowitz, and James H. Clark. Mar./Apr. 2009: 56-62.
- Radioactive and Hazardous Materials Transportation Risk Assessment Using a Geographic Information System. By John E. Moore, Gary M. Sandquist, and David M. Slaughter. Jan. 1994: 75-76, 78.
- Returning HEU Fuel From the Czech Republic to Russia. By Michael Tyacke and Igor Bolshinsky. Sept./Oct. 2009: 39-50.
- Railroads 101: A Primer—Everything You Ever Wanted to Know about Railroads. By Gene Gleason. Mar./Apr. 2005: 10-18.
- Risk Assessments for Transporting Radioactive Material within Idaho. By Cindy Deng, Steven Oberg, Jerry Downs, Douglas Wells, and Veneta Murray. July 1996: 23-26.
- Safe from Start to Finish: The 1100-Mile Journey of the Yankee Rowe Reactor Pressure Vessel. By Leo Lessard. Mar./Apr. 2000: 44-49.
- Shielded Payload Containers for WIPP Remote-Handled Waste. By Roger A. Nelson and D. Sean White. Mar./Apr. 2009: 64-72.
- Shipping Saxton's Large Components. By James E. Hildebrand. Sept./Oct. 1999: 63-65.
- Shipping Spent Nuclear Fuel from the Czech Republic's NRI to the Russian Federation for Reprocessing. By Josef Podlaha. Mar./Apr. 2010: 48-62.
- Shipping TRU Waste in Today's Regulatory Climate. By Wesley G. Estill and David L. Langley. Sept. 1998: 8-10, 12-14.
- The Shoreham to Limerick Fuel Transfer Project. By Rich Wolters, Kevin Theriault, and Bob Jones. Oct. 1994: 19-26.
- SMAC on the Track or on the Road: New Intermodal Containers for LLW. By Scott Dempsey. May/June 2005: 27-28.
- Smooth Shipping: Mitigating and Avoiding Conflict in Shipping Radioactive Waste. By Ellen L. Watson. Mar./Apr. 1999: 33-38.
- Transport of Spent Fuel from Reactors to DOE Storage/Disposal Facilities—A Parametric Study. By E. R. Johnson and P. M. Saverot. Sept. 1997: 27-30.
- Transport of Spent Nuclear Fuel from the High Flux Beam Reactor. By Michael Holland, Joseph Carelli, and Thomas Shelton. Jan. 1998: 41-45.
- Transportation Cooperation: Involving Corridor States in Decision Making Contributes to the Success of the DOE's Transportation Program. By Lisa R. Sattler. Mar./Apr. 2004: 13-17.
- Transportation of Radioactive Materials Is Environmentally Benign—Let's Quit Analyzing It to Death. By L. G. Blalock and L. H. Harmon. July 1996: 38-41.
- Transporting Large Volumes of Residual Radioactive Material: FUSRAP Solutions. By Tammy Pressnell, Preston McDaniel, and Jason Darby. Sept. 1997: 15-19.
- Transporting the Moab Uranium Mill Tailings to White Mesa Mill by Slurry Pipeline. By Ron F. Hochstein, Rod Warner, and Terry V. Wetz. Mar./Apr. 2004: 30-37.
- The U Is Outta Here! July/Aug. 2002: 50-53.
- The Universal MPC System: The Evolution of NAC Spent-Fuel Technology. By Bill Lee and Doug Walker. Sept. 1997: 31-34.
- Waste Maximization: Economical Use of Railroad Transport. By Kenneth M. Grumski. Nov./Dec. 2001: 16-20.
- Waste Not, Spend Not: The PUREX Radioactive Nitric Acid Shipping Campaign. By H. R. Penn, W. G. Jasen, and R. A. Duncan. July 1996: 16-22.
- Why the DOE's Messages on Transportation Don't Resonate with the Public (and What the DOE Can Do to Fix the Problem). By Lisa R. Janairo and Ken Niles. Jan./Feb. 2009: 8-18.

## U.S. Department of Energy

### General

- Andros and Rosie and Other Friends to D&D Workers: Decommissioning Technologies that Improve Worker Safety. By Steven Bossart and Danielle Blair. Jan./Feb. 2002: 16-10.
- Back to the Future: A Rationalized Rock Salt Repository. By Leif G. Eriksson and George E. Dials. Jan.-Apr. 2011: 24-34.
- Bored Board? Membership and Motivation in Site-Specific Advisory Boards. By Richard G. Telfer. Jan./Feb. 2000: 30-34.
- The Characterization, Monitoring, and Sensor Technology Crosscutting Program. By Jerry J. Lorenz. May/June 2001: 38-43.
- The Contract Reform Initiative at the U.S. Department of Energy. By Jerry L. Bellows. Nov. 1995: 22-26.
- Courts Say Take or Pay: Litigation Related to the U.S. Department of Energy's Failure to Accept Spent Nuclear Fuel. By Michael A. Bausser. July/Aug. 2000: 15-19.
- The D&D Focus Area: Bringing New Technologies to the D&D Toolbox. By William Lupichuk. Mar./Apr. 2001: 43-47.
- Deactivation and Decommissioning Knowledge Management: A Partnership Among the DOE, Contractors, and Academia. By Himanshu Upadhyay and Leonel Lagos. Sept.-Oct. 2012: 46-49.
- The DC Plasma-Arc Furnace: A High-Temperature Solution to Waste Treatment. By Ronald W. Goles, William F. Bonner, and Whitney D. St. Michel. Jan./Feb. 2000: 40-43.
- DOE Cleanup Programs Pushing toward Closure—And Other Radwaste Updates. By Nancy J. Zacha. May/June 2005: 51-54.
- DOE's Decommissioning Policy and Framework. By Stephen Warren, Jann Buller, and Tracie Gross. Mar. 1996: 82-88.
- DOE Reclamation Work at the Moab Site. Sept.-Oct. 2012: 34-39.
- Emerging Technologies for Environmental Characterization and Monitoring. By Paul W. Wang, Caroline B. Purdy, and Eric M. Lightner. Nov. 1996: 27-34.
- Growing Young Minds Through EM Site Tours. July-Aug. 2013: 56-58.
- An Industry Response to Recycle 2000. By Gerald P. Motl and Val Loiselle. Mar. 1996: 59-63.
- Managing the DOE's Weapons Program Legacy: The Role of the Efficient Separations and Processing Crosscutting Program in S&P Initiatives. By Alexander Livnat. July/Aug. 2001: 35-41.
- The Nuclear Materials Focus Area: Meeting End-User Needs through Technology Development and Deployment. By Elizabeth Thiel. Sept./Oct. 2001: 40-46.
- Nuclear Waste and Radioactive Cleanup: An Issue that Won't Stay Buried. By Don Mausshardt. May 1996: 39-43.
- On the Lookout for Subsurface Solutions: The DOE's Subsurface Contaminants Focus Area. By Virginia Kay. Nov./Dec. 2000: 26-30.
- Revegetating Amchitka Island. By Mark Kautsky and Paul Darr. Jan./Feb. 2009: 25-29.
- The Risk of CERCLA Liability Associated with DOE-Generated Scrap Metal. By J. Michael Sowinski Jr. Mar./Apr. 2001: 48-55.
- Status of the U.S. Foreign Research Reactor Spent Nuclear Fuel Program. By Kenneth C. Chasey, Ibrahim H. Zeitoun, and Elizabeth Saris. May 1997: 14-19.
- Strategy for the Management and Disposal of Used Nuclear Fuel and high-Level Radioactive Waste (January 2013). May-June 2013: 34-43.
- A Team of Seven—The Tanks Focus Area: Providing Technical Solutions for Cleaning up the DOE's Radioactive Tank Wastes. By Wayne Cosby. Sept./Oct. 2000: 43-49.
- Transition to Private Ownership: Lessons Learned during the Grand Junction Office Site Transfer. By Donna Bergman-Tabbert and Tracy B. Plessinger. Mar./Apr. 2002: 36-43.

The TRU and Mixed Waste Focus Area: Bridging the Gap between Waste Inventory and Disposal Methodologies. By Jodi Townsend. Jan./Feb. 2001: 20-24.

Waste Management Policy Development from the AEC to the DOE. By James E. Dieckhoner. Mar. 1996: 48-54.

Who's Who at the Nuclear Waste Technical Review Board. By Nancy J. Zacha. Jan./Feb. 2005: 23-28.

### Argonne

Fueling Up for the Long Haul: Training for Decommissioning. By Larry Boing. Jan./Feb. 2001: 25-27.

Getting It Right At Weldon Spring. By Margaret MacDonell, Mary Picel, and John Peterson. Nov. 1996: 12-18.

A Glitch Caught in Time Saves . . . : Lessons Learned During Reactor D&D at Argonne National Laboratory. By Charles R. Fellhauer. Jan./Feb. 2000: 22-29.

Putting Plants to Work: The ANL-West Phytoremediation First-Year Field Season Demonstration. By Scott Lee. May/June 2000: 49-54.

### Brookhaven

Team Completes Dismantlement and Layup of Two Brookhaven Reactors. By Fran Poda. Sept./Oct. 2010: 44-50.

### Fernald

"And the Train Pulls Out from . . ." Fernald's Waste Pits Cleanup. By Julie Loerch and Dave Lojek. Mar./Apr. 2000: 32-37.

Breaking the Mold: FERMCO and the DOE Embrace Contract Reform. By Jeffrey Ritchie. Nov. 1995: 27-30.

Changing Public Participation at Fernald: Not an Easy (or Popular) Task. By Jeff Wagner. Mar./Apr. 2007: 54-58.

Cleaning Up and Closing Down the Fernald Site. By Michele Gerber. July/Aug. 2006: 16-29.

DOE Pursuing Accelerated Cleanup at Fernald. By Terry Borgman. Jan. 1996: 42-44.

Changing the Fernald Skyline: The Demolition of the Site's Production-Era Water Tower. Nov./Dec. 2003: 36-41.

Ecological Restoration with Native Grasses and Forbs: The Fernald Preserve and Weldon Spring Restoration Projects. By Jane Powell, Frank Johnston, John Homer, and Yvonne Deyo. July/August 2008: 12-18.

Environmental Restoration: Fernald Ecologists and Engineers Integrate Restoration and Cleanup. By Eric Woods and John Homer. Sept./Oct. 2002: 12-19.

A Farewell at Fernald. By Nancy J. Zacha. May/June 2007: 26-30.

Fernald Cleanup Effort on the Move Again: K-65 Materials Shipped to WCS. Sept./Oct. 2005: 30-31.

Fernald Scrap Metal Recycling and Beneficial Reuse. By Gerald P. Motl and Daniel D. Burns. Jan. 1994: 50-55.

Fernald's New Enriched Uranium Repackaging Station. Nov./Dec. 2001: 28-31.

Full Speed Ahead at Fernald. By Kathy Graham. Mar./Apr. 1999: 26-32.

Groundwater Re-injection at Fernald: Its Role in Accelerating the Aquifer Remedy. By Kenneth A. Broberg and Robert Janke. Sept./Oct. 2000: 19-23.

Now There Are None: The Last Uranium Production Building at Fernald Has Been Toppled, the Culmination of a 10-Year Demolition Project. By Jeffrey Wagner. July/Aug. 2004: 24-28.

A Project for the Birds: The Habitat Area Project at Fernald. By Eric Woods and Gary Stegner. Jan./Feb. 1999: 35-36.

Redistributing Fernald's Government Assets. By Deborah Dunn. Sept./Oct. 2007: 34-39.

Three Years and Thirty-Three Thousand Truckloads: Fernald Eliminates Groundwater Contamination Source. Mar./Apr. 2002: 44-47.

The U Is Outta Here! July/Aug. 2002: 50-53.

Visitors Flock to the Remediated Fernald Preserve. By Gary Stegner and Stacey Elza. Sept./Oct. 2010: 28-35.

Wetland Mitigation at the Fernald Preserve. By Jane Powell and John Homer. Sept.-Oct. 2013: 14-16.

Wetlands Restoration at Fernald: Reconstructing Natural History with Ecological Restoration Principles. By Craig Straub. Sept./Oct. 1999: 9-13.

### Hanford

15 Million Miles and Counting. July/August 2010: 60-62.

3-D Imaging Gives Hanford Scientists a Better View of Waste Plumes. By Michael V. Berriochoa. Mar./Apr. 2010: 14-22.

309 Building Demolition at Hanford. May-June 2011: 48-50.

55-Inch Hole Safely Cut into the Dome of Hanford's Tank C-107. Jan.-Apr. 2011: 48-53.

Advancing Worker Safety at Hanford's Tank Farms. By Mike Berriochoa. May/June 2006: 23-27.

The Arm from MARS. Jan.-Apr. 2012: 52-53.

Bats, Owls, and Cocoons: Hanford's F Reactor Interim Storage Project Complete. Mar./Apr. 2004: 48-50.

Battling Groundwater Contamination at Hanford. By Michele Gerber. Sept./Oct. 2006: 17-28.

Beginning the Cocooning Process at Hanford's N Reactor. July/Aug. 2009: 38-41.

CH2M Hill Turns Safety Around at Hanford. By Mike Berriochoa. July/August 2008: 32-39.

Characterizing Solids in Residual Wastes from Single-Shell Tanks at the Hanford Site. By Kenneth M. Krupka, Kirk J. Cantrell, H. Todd Schaefer, Bruce W. Arey, Steve M. Heald, William J. Deutsch, and Michael J. Lindberg. Mar./Apr. 2010: 64-75.

Cleaning Up Hanford: The Environmental Research Project. By Linda K. McClain and Joseph F. Nemec. Nov. 1996: 36-41.

Cocooning Hanford's N reactor—And Other River Corridor Closure Activities. By Mark McKenna. Sept.-Oct. 2012: 24-32.

The "Cocooning" of C Reactor: A Hanford Success Story. By John Crigler. Sept./Oct. 1999: 29-31.

Comparing Hanford and Savannah River Site Tank Wastes. By R. C. Philip Hill, Jacob G.

Reynolds, and Paul L. Rutland. Jan.-Apr. 2012: 32-36.

Complex Problem, Simple Solution: Complex Waste Sorting Issue Solves with Simple Detector. By Todd A. Nelson. Sept./Oct. 2006: 51-55.

Construction Progress at Hanford's Waste Treatment Plant. Sept./Oct. 2009: 32-35.

Creating a Desert Oasis: Hanford Gravel Pit Converted to Wetland. By Todd Nelson. Jan./Feb. 2001: 28-29.

Dedicated to Cleanup: Environmental Remediation at Hanford. By Todd A. Nelson. July/Aug. 2001: 17-23.

Drum Integrity Assessment at Hanford. By Gary Cannell and Walter Josephson. July/Aug. 2005: 22-27.

Enhanced "Interrogation" Techniques: Soil Contamination Imaging at Hanford. By Mike Berriochoa. Sept.-Oct. 2011: 21-25.

Environmental Remediation of Hanford's River Corridor. By Todd Nelson. Sept./Oct. 2009: 12-16.

Everything Old Is New Again. By Michael V. Berriochoa. Jan.-Apr. 2011: 36-40.

Everything You Ever Wanted to Know about the Hanford Waste Tanks. By Elizabeth Heaston, Jim Poppiti, Herb Sutter, Dan Knutson, and Maureen Hunemuller. Nov./Dec. 1999: 27-34.

The Evolution in Hanford Tank Waste Sampling Technologies. By John Britton. Jan./Feb. 2009: 32-36.

First Double-Shell Tank Leak Discovered at Hanford. By Rob Roxburgh and John Britton. Jan.-Apr. 2013: 40-42.

Focus on Waste Retrieval Continues at Hanford Tank Farms. July/August 2010: 44-47.

Foundation Pouring Begins for Hanford Vit Plant. Sept./Oct. 2002: 49.

Gimme Shelter! An "Out-of-the-Box Structure Helps a Hanford Cleanup Project. By Tod Burington. Sept./Oct. 2007: 47-50.

The Good, the Bad, and the Money; Or, What's Right and Wrong with Privatization. By Nancy J. Zacha. Jan./Feb. 1999: 38-40.

HAMMERing It Out: Training As Real As It Gets. By Jean McKenna, Karin Nickola, and Richard N. Smith. Jan./Feb. 2000: 8-12.

Hanford Bulk Vitrification Technology Status. By Keith S. Witwer, E. J. Dysland, L. M. Bagaasen, S. Schlahta, D-S. Kim, M. J. Schweiger, and P. Hrma. March/April 2008: 42-54.

Hanford: Evolution of a Dinosaur. By John Fulton. Nov. 1995: 31-35.

Hanford Environmental Restoration Disposal Facility: An Operation and Privatization Success. By Joel A. Eacker and Vernon Dronen. July 1998: 32-37.

Hanford Groundwater Contamination Areas Shrink as EM Exceeds Cleanup Goals. Sept.-Oct. 2013: 20-21.

Hanford Pu Process Vessels out the Door—A Year Ahead of Schedule. By Todd Nelson. July/Aug. 2002: 30-33.

Hanford Scores Another Successful Open-Air Demolition: 232-Z Plutonium Incinerator Facility Demolished in July. By Michele Gerber. Jan./Feb. 2007: 31-39.



- Hanford's C Reactor Large-Scale Demonstration Project. By James D. Goodenough and Jeremiah J. McGuire. Mar. 1997: 31-35.
- Hanford's Latest Achievements: Mixer Pump and New Long-Term Waste Treatment Plans. By Harry D. Harmon and Marilyn C. Druby. Jan. 1994: 36-41.
- Hanford's Tank C-106 Project: The First of Many. By Ed Aromi. Sept./Oct. 2004: 24-30.
- How to HAMMER Home Hazardous Materials Training. By June Ollero. Oct. 1994: 50-57.
- Improving Efficiency with 3-D Imaging: Technology Essential in Removing Plutonium Processing Equipment from Plutonium Finishing Plant Gloveboxes. By Stephen Crow, Richard Kyle, and Michael Minette. Sept./Oct. 2008: 26-31.
- In Situ Redox Manipulation: Fierce Energy of Groundwater VOCs and Heavy Metals. By Mary H. Ace. July/Aug. 2001: 24-27.
- Integrated Demonstrations Provide Quick Solutions to Problems of Defense Waste. By Ronald C. Eschenbaum and Felicia R. La Barge. July 1994: 52-56.
- K East Reactor Basin Gone for Good. Jan./Feb. 2010: 38-41.
- Konan to the Rescue. By Rick Shen, Eric Gerber, and Judith Graybeal. Mar./Apr. 1999: 7-14.
- Like a Box of Chocolates? At the Hanford Burial Grounds, You Never Know What You're Gonna Get. By Laurie Campbell and Ken Powers. Mar./Apr. 2005: 28-34.
- More Hanford Firsts: Demolition of a Hanford Plutonium Facility. By Geoff Tyree, Tom Orgill, Jeff Riddelle, and Andrea Harper. July/Aug. 2004: 11-14.
- Multiple Waste Retrievals at Hanford's C Tank Farm. Sept.-Oct. 2012: 40-45.
- Pictures of a Suspect-TRU Retrieval. By Rodney R. Gadd. July/Aug. 2007: 34-38.
- Pit Viper Strikes at the Hanford Site: Pit Maintenance Using Robotics at the Hanford Tank Farms. By Lynne Roeder-Smith. May/June 2002: 33-39.
- Preventing Groundwater Contamination from Early Operations at Hanford's Waste Treatment Plant. By Ben Unterreiner, Tom Crawford, and Fred Mann. Sept./Oct. 2008: 36-43.
- Putting Bulk Vitrification to the Test: Stage Set for Full-Scale Testing at Hanford's Tank Farms. By Mike Berriochoa. Mar./Apr. 2005: 58-61.
- Radiofrequency Technology Tracks Mixer Efficiency. By Brenda Pittsley. Jan./Feb. 2006: 36-38.
- Reducing the Risk of Hanford's Legacy: Completing Cleanup at the Last Big Liquid Waste Site near the Columbia River. Sept./Oct. 2006: 29-31.
- Removing the K-Basins Fuel: Down Payment on Protecting the Columbia River. By Michele Gerber. Mar./Apr. 2001: 8-24.
- Rethinking the Disposition of Hanford Tank Wastes: A Perspective. By Frank L. Parker, Donald E. Clark, and Nabil Morcos. Nov./Dec. 2001: 35-39.
- A Road Map to Cleanup Success: Hanford's Groundwater/Vadose Zone Integration Project. By Steven P. Sautter and Geoffrey L. Harvey. May/June 2001: 31-35.
- Robotic Arm to Speed Hanford Tank Waste Removal. By Mike Berriochoa. Jan./Feb. 2010: 31-33.
- Robotics Down on the (Tank) Farm. By Michele Gerber. Mar./Apr. 1999: 21-25.
- Saving Millions by Saving Time. By Jean McKenna. Jan./Feb. 1999: 31-34.
- Science, Technology, and Workforce Innovations: Keys to a Successful D&D of Hanford's Plutonium Finishing Plant. By Stacy Charboneau, Andrea Hopkins, Bruce Klos, Robert Heineman, and Brian Skeels. Mar./Apr. 2007: 60-66.
- Six Science Secrets of the Subsurface. By Kristin Manke and Julie Wiley. Mar./Apr. 2010: 30-35.
- The Sludge Cleanout of Hanford's K Basins. By Michele Gerber. Jan./Feb. 2008: 20-31.
- Small Business Tackles BIG Challenge: Hanford Contracts with Small Businesses on D&D Projects. By Ken Powers and Mark Lesinski. Sept./Oct. 2004: 36-40.
- Spent Fuel Overpack Closure Welding: Parameter Development and Qualification. By G. R. Cannell and L. H. Goldmann. Jan./Feb. 2007: 25-30.
- Spent Fuel Removal Concludes at Hanford's K Basins—Helping to Restore the Columbia River's Hanford Reach. By Michele S. Gerber. Jan./Feb. 2005: 10-22.
- The Strontium Garden: Cleanup of One of Hanford F Area's Last Research Stations. By Todd Nelson. Sept./Oct. 2002: 20.
- Summertime Forecast: Major Upgrades and Process Improvements at Hanford's ERDF. By Todd A. Nelson. July/August 2008: 19-25.
- Tackling the Central Plateau: The Final Frontier at Hanford. By Michele S. Gerber. May/June 2008: 26-38.
- Targeting Chromium in Hanford's 100-D Area. By Scott W. Petersen, John G. Morse, K. Michael Thompson, and M. J. Tonkin. Jan.-Apr. 2011: 74-81.
- Technical and Policy Challenges in Deep Vadose Zone Remediation of Metals and Radionuclides. By Dawn M. Wellman, Michael J. Truex, Mark Freshley, P. Evan Dresel, and Kirk J. Cantrell. Jan.-Apr. 2013: 76-84.
- Testing, Testing . . . : Simple Technology Improves Groundwater Monitoring along the Columbia River. By Judy Graybeal. May/June 2006: 28-33.
- T(h)anks for the Technology. By Mike Berriochoa. July/Aug. 2005: 18-21.
- Turning the Corner at Hanford: Hanford Plutonium Finishing Plant Completes Plutonium Stabilization; Key Safety Issues Closed. By Michele Gerber. May/June 2004: 18-27.
- The Ultimate Hanford Challenge. By Mike Berriochoa. May 1996: 18-24.
- Vitrifying the Hanford Tank Wastes: New Team, New Vision, New Energy. By Sue Kuntz. May/June 2001: 26-30.
- A Whole Zoo of new Technologies: Innovative Waste Retrieval Technologies Advance Hanford's Environmental Protection Mission. By Mike Berriochoa. Jan./Feb. 2007: 16-20.
- Wireless Technology Advances Hanford Cleanup Safety. By Mike Berriochoa. March/April 2008: 36-40.
- Work at the DOE's Largest Closure Site Is 75 Percent Complete. By Todd Nelson. May-June 2011: 37-47.
- The World's Largest Construction Project: Designing and Constructing Hanford's Waste Treatment Plant. By Garth M. Duncan. Sept./Oct. 2005: 14-22.
- WRAPPING It Up at Hanford. By Bryan Kidder and Mark French. Mar./Apr. 1999: 15-19.

## INL

Getting the Lead Out: Recycling and Decontamination at the INEL. By Erik A. Simpson. July 1994: 49-51.

Helping HANDSS for Sorting Waste. By Reuel Smith. Nov./Dec. 2002: 47-52.

Innovative Technique Accelerates Waste Disposal at Idaho Site. July-Aug. 2013: 52-54.

In Situ Buried Waste Stabilization Technologies at INEEL. By Guy G. Loomis, Richard K. Farnsworth, and Jim J. Jessmore. July 1998: 38-43.

Journey to the Center of the . . . Vadose Zone. By Mary Beckman. July/Aug. 1999: 55-27.

Making Safety Work: Safety-Enhancing Technologies and Practices at INEEL Decommissioning Projects. By Richard Meservey. Jan./Feb. 2002: 20-24.

Monitored Natural Attenuation for an Aerobic TCE Plume. By Ryan A Wymore, Lance N. Peterson, Lee O. Nelson, and Kent S. Sorenson Jr. Mar./Apr. 2006: 50-57.

Nuclear Waste Takes a TRIP: Electronic Signature Technology to Revolutionize Document Tracking. By Ben Groeneveld. Sept. 1998: 20-21.

Performance Test of a Gamma/Neutron Mapper on TRU Waste Drums. By Robert J. Gehrke and Nicholas E. Josten. May 1996: 48-53.

Saving D&D \$\$\$: New D&D Technologies at the INEEL. By Julia Tripp, Richard H. Meservey, and Ann-Marie Phillips. Nov./Dec. 2000: 36-41.

Taking Aim at Unique Wastes: INEEL's Waste Elimination Team is Finding Solutions. Jan./Feb. 2002: 25-27.

## Los Alamos

It Takes a Team: The Omega West Reactor D&D. By Stephen F. Mee, Keith R. Rendell, Martin J. Peifer, John A. Gallagos, and Joe B. Stringer. Mar./Apr. 2004: 52-60.

Keeping Our WITS About Us: LANL's Cradle-to-Grave Waste Tracking System. By Ed Lorusso. Sept./Oct. 2002: 38-39.

## Mound

Leading the Way in Community Transfer: The Economic Development and Commercialization of Mound. By Dottie Atkins. Nov./Dec. 2000: 42-45.

Remote Sight to Monitor Mound Site: Applying Machine Visions for Long-Term Stewardship. By David Reichhardt and Andrea T. Hart. Jan./Feb. 2005: 29-33.

## Nevada National Security Site (Nevada

### Test Site)

Air Classification Methods at the Nevada Test Site. By Mark J. Harper, Martin E. Nelson, and Andrew D. Buckon. Oct. 1994: 28-32.

The Case of the Transuranic-Loving Squirrels: The Decontamination of the XF-90A. By James Seals. Nov./Dec. 2004: 41-45.

The Changing Adventures of Mixed Low-Level Waste Disposal at the Nevada Test Site. By G. L. Pyles, J. T. Carilli, S. K. Krenzien, and J. K. Wrapp. Mar./Apr. 2008: 56-65.

D&D at the Nevada Test Site: Facility History, Regulatory Framework, and Lessons Learned. By Jerel G. Nelson and Michael R. Kruzic. May/June 2005: 33-40.

Innovative Technique Accelerates Waste Disposal at Idaho Site. July-Aug. 2013: 52-54.

A New Role for the Nevada Test Site. By Richard G. Telfer. Mar./Apr. 2002: 48-53.

NNSS Waste Disposal Proves Vital Resource for DOE Complex. By Angela Ramsey. Jan.-Apr. 2013: 50-57.

### Oak Ridge

The Best Kind of Recycling: Building 7602 at ORNL. By Angie Brill, James Berger, Andy Kelsey, and Ken Plummer. July/Aug. 2002: 12-20.

Decontaminating 30 Million Square Feet. By Anne Smith. Nov./Dec. 2004: 28-33.

Defueling the ORNL Molten Salt Reactor Experiment Facility. By Michael R. Jugan, Andrew P. Kelsey, Mahmoud H. Haghighi, and E. Paul Larson. Nov./Dec. 1999: 35-39.

Getting Remediation Done at ORNL. By Malinda Conger, Amy Harkey, Ken Schneider, and Dirk Van Hoesen. Sept.-Oct. 2011: 15-20.

Isotopes Facilities Deactivation Project at ORNL. By Robert E. Eversole. Nov. 1997: 49-57.

K-25 Challenges Met. By Fran Smith. July-Aug. 2013: 16-23.

Low Tech Meeting High Tech: Remediating Two Basins Containing Radioactive Sludge at ORNL. By Angie Brill, Elizabeth Krispin, Lynn Whitehead, and John Julius. July/Aug. 2001: 11-16.

New Life for an Old Lab: Commercializing a DOE Laboratory. By Barry A. Stephenson. Mar./Apr. 2009: 30-37.

Oak Ridge Day at Waste Management 2012. By Nancy J. Zacha. May-June 2012: 23-28.

Radwaste Source Control By Surgical Strike—A Cost-Effective Strategy. By Dale D. Huff, John D. Long, and Alex A. M. C. Naudts. Nov. 1996: 20-26.

A Remotely Operated Tank Waste Retrieval System for ORNL. By B. L. Burks, D. D. Falter, R. L. Glassell, S. D. Van Hoesen, M. A. Johnson, P. D. Lloyd, and J. D. Randolph. Mar. 1997: 10-16.

Robotic System Cleans Underground Storage Tank at Oak Ridge. By S. Dirk Van Hoesen, Cavanaugh S. Mims, and Barry L. Burks. Mar. 1998: 55-61.

Sheer Grit: ARRA Transforms Y-12. By Gail Powell. July-Aug. 2011: 22-31.

Stream Reconstruction: Designing for Natural Stream Stability. By Robert Spurling and Jason Darby. Sept./Oct. 1999: 15-21.

Technology and Teamwork Equal Empty Tanks. By Belinda Schwart and Karen Billingsley. Sept. 1998: 22-25.

Working Toward a New Beginning: Using Innovative Methods at ETPP to Clean Up the Manhattan Project Legacy. By Wayne McKinney. May-June 2012: 17-22.

Y-12's Mercury Problem. By Nancy J. Zacha. Jan.-Apr. 2013: 62-63.

### Paducah

The End of Drum Mountain. Nov./Dec. 2000: 34-35.

How Should We Clean Up the Water? Groundwater Remediation Plans at the Paducah Gaseous Diffusion Plant. By Gary Bodenstien and Mark Gage. Sept./Oct. 2000: 24-29.

A Snapshot of Paducah Remediation and Cleanup. By Dennis Ferrigno, Joe Tarantino, and Reinhard Knerr. Sept./Oct. 2010: 36-43.

### Portsmouth Gaseous Diffusion Plant

DOE, Fluor-B&W Portsmouth Clear Way for D&D in Piketon. By Julie Doering. Jan.-Apr. 2012: 58-63.

Navigating a Year of Decisions in Piketon. By Julie Doering. May-June 2012: 13-16.

A "Poplar" Solution to Groundwater Contamination: Phytoremediation at the Portsmouth Gaseous Diffusion Plant. By Amy C. Lewis, Del R. Baird, and Scott Burton. Sept./Oct. 2004: 15-19.

The "Poplar Solution: How's It Working? A Radwaste Solutions Followup. By Amy C. Lewis and Del R. Baird. Sept./Oct. 2005: 34-37.

### Rocky Flats

And the Walls Came Tumbling Down . . . Rocky Flats Building 779 Closure Project. By Mark Zachary, Kelly Trice, and Tom Dieter. Sept./Oct. 2000: 56-64.

Cleaning Up Trench 1 at Rocky Flats. Sept./Oct. 1999: 38-41.

Closing the Most Dangerous Building in America. By Greg Meyer and Doug Hamrick. Sept./Oct. 1999: 43-48.

Decontamination of Radioactive Concrete: A Permanent Solution That's RCRA Friendly. By Michael Simmons. Jan. 1994: 25-29.

Eyes on the Numbers: A Report on Spectrum '98. By Nancy J. Zacha. Nov./Dec. 1998: 47-52.

From Collaboration to Compliance to Campaign Completion: Lessons Learned from the Rocky Flats TRU Shipping Campaign. By Gerald O'Leary and William Badger. May/June 2009: 60-65.

In-Process Characterization is a SNAP at Rocky Flats. By William R. Salazar. July/Aug. 2004: 15-23.

Legacy Management at the Rocky Flats Site. By Bob Darr, John Boylan, Rick DiSalvo, George Squibb, Jody Nelson, and Scott Surovchak. Sept./Oct. 2010: 12-19.

Making the Impossible Possible: Closing Rocky Flats—Ahead of Schedule and under Budget. By Ed Bodey. Sept./Oct. 2005: 39-45.

Now Appearing at an Airport Near You: Adapting Aviation Ground Support Equipment for Removing Nuclear Waste at Rocky Flats. By Bill Badger. Jan./Feb. 2004: 42-45.

100 and Counting: Rocky Flats is the Nation's Top Shipper to WIPP. May/June 2001: 36-37.

Stakeholders Can Help: Improving D&D Policy Decisions at Rocky Flats. By Jack Hoopes. July/Aug. 1999: 45-48.

The Rocky Flats Challenge: Driving Worker Exposures As Low As Reasonably Achievable During Decommissioning. By Jennifer Thompson. July/Aug. 2001: 42-47.

Thinking Outside the (Glove) Box: The Evolution of Decommissioning at Rocky Flats. By Jeanna Blatt. July/Aug. 2002: 26-29.

Wrapping Up a Waste Problem: Innovative Use of Polyurea Coating at Rocky Flats Reduces Risk, Saves Money. By Jackie Powers. May/June 2004: 40-43.

### Sandia

Remediating the Past and Preparing for the Future at Sandia National Laboratories. By Thomas L. Sanders. Jan. 1996: 32-41.

A Serendipitous Discovery at Sandia: New Compound May Immobilize Certain Radionuclides. Nov./Dec. 2002: 45-46.

### Savannah River Site

Accelerating SRS Tank Closure with Help from Partners, Technology. By Rick Kelley. Sept./Oct. 2009: 25-30.

Build It Fast, Use It Faster: The Story of the DWPF Melt Cell Crawler. By Clyde R. Ward, Montenius Collins, Thomas A. Nance, and Michael C. Prather. Jan./Feb. 2004: 20-25.

Building on a Tradition of Environmental Concern: The Evolution of Environmental Remediation at the Savannah River Site. By W. Dean Hoffman and Bruce Cadotte. Sept./Oct. 2000: 9-18.

The Burial Ground Complex at the Savannah River Site: Large-Scale Remediation. By J. Michael Griffith. Nov. 1997: 35-39.

Cadmium Control/Safety Rod Disposal at the Savannah River Site. By Steve H. McInnis. May 1995: 30-34.

Can-in-Canister Demonstration at DWPF. By Nicholas H. Kuehn III, Jeffery R. Brault, David T. Herman, M. John Plodinec, Mary K. Andrews, Jeffery T. Coughlin, Poh-Sang Lam, and W. Gene Ramsey. May 1997: 20-22, 24, 26.

Celebrating SRS's First Area Closure. By Fran Poda. July/Aug. 2007: 11-16.

Closing High-Level-Waste Tanks at the Savannah River Site. By Thomas B. Caldwell, Paul D. d'Entremont, Christine A. Langton, Jeffery L. Newman, Eloy Saldivar, Jr., and Narasimhan Rajendran. Mar. 1998: 19-26.

Closing Waste Tanks at the Savannah River Site: It's Never As Easy As It Looks. By Madeline Blair. Sept.-oct. 2012: 18-23.

Comparing Hanford and Savannah River Site Tank Wastes. By R. C. Philip Hill, Jacob G. Reynolds, and Paul L. Rutland. Jan.-Apr. 2012: 32-36.

Control Room Consolidation Improves SRS Liquid Waste Operations. Jan./Feb. 2007: 40-41.

Decommissioning at Savannah River—With a Focus on F Canyon Deactivation. By Nancy J. Zacha. Mar./Apr. 2005: 62-63.

Developing a Gamma Spectroscopy System at the Savannah River Site. By David A. Filler and Brian S. Crandall. Nov. 1996: 49-52.

Digging in the Canyons: Simplifying Waste Removal from Chemical Separations Operations at the Savannah River Site. By Eric V. Szendrei. Jan./Feb. 2002: 33-36.

Doin' What Comes Naturally: Natural Remediation at Savannah River Site. By Catherine M. Lewis and Robert Van Pelt. Sept./Oct. 2002: 22-28.

DWPF: Old Work Horse, New Tricks. By John N. Lindsay. May-June 2011: 23-29.

Experts Test Agencies' Skills at Radiological Detection and Control. July-Aug. 2012: 46-50.

Further Development of Modified Monosodium Titanate, an Improved Sorbent for Pretreatment of High-Level Nuclear Waste at the Savannah River Site. By Kathryn M. L. Taylor-Pashow, Fernando F. Fondeur, Samuel D. Fink, and David T. Hobbs. Jan.-Apr. 2012: 64-81.

The Good, the Bad, and the Money; Or, What's Right and Wrong with Privatization. By Nancy J. Zacha. Jan./Feb. 1999: 38-40.

Innovative Mercury Treatment Benefits Stream, Fish. Jan.-Apr. 2013: 58-60

Interim Salt Disposition Processing at SRS: Construction Complete, Startup Testing Continues. By "DT" Townsend. May/June 2007: 31-36.

Let's Model It: Using Computer Simulation to Improve Waste Processing Safety. By Jerry Fireman. Nov./Dec. 2000: 31-33.

The Little Facility That Could: SRS's Effluent Treatment Project Celebrates 20 Years of Successful Operation. Jan./Feb. 2009: 30-31.

The Lowdown on L-Lake: A GIS Evaluation of Proposed Savannah River Site L-Lake Drawdown. By James S. Bollinger and David L. Dunn. Mar./Apr. 1999: 53-57.

Magazine, Rack, and Canister: Designing the Savannah River Site Plutonium Immobilization Program System. By Mitchell W. Stokes, Gregory L. Hovis, E. Lee Hamilton, James B. Fiscus, and Robert H. Jones. July/Aug. 1999: 49-54.

New Era of Salt Waste Processing Begins at SRS. By Dale Townsend. July/August 2008: 28-31.

A New Era of Waste Vitrification at SRS. By Dean Campbell. July/Aug. 2005: 30-34.

New Technologies in the SRS "Toolbox." By David Yannitell. July/Aug. 2000: 28-34.

Precise Cleaning Inside Tanks. Sept./Oct. 2005: 32-33.

Processing High-Level Waste at the Savannah River Site. By Austin B. Scott, Jr., and Neil R. Davis. May 1996: 34-38.

Putting the Stimulus to Work. By Fran Poda. Sept./Oct. 2009: 18-24.

Radioactive Waste Sampling Supports Processing. By Thomas A. Nance. Mar. 1997: 18-22.

Remote Automatic Control Scheme for Plasma Arc Cutting of Contaminated Waste. By Aed M. Dudar, Clyde R. Ward, and Eric M. Krikku. Jan. 1994: 56-62.

SRNL Precision Models Aid Recovery Act Cleanup at SRS. By Angeline French. May/June 2010: 42-45.

SRS/Clemson University Partnership Overcomes Challenge to Future Tank Closures. By Dean Campbell. Sept./Oct. 2008: 49-51.

SRS Demolishes Massive K Cooling Tower. July/August 2010: 41-43.

SRS's P Area Closure Work Reaches milestones: Area Cold and Dar, Moderator Removed, Demolition Complete. By Fran Poda. July/August 2008: 40-44.

Tackling Tough Challenges at SRS: Deactivation and Materials Disposition at F Area. By Fran Poda. Sept./Oct. 2005: 23-29.

Teamwork Solves Bottleneck in TRU Waste Disposition at SRS. By Fran Poda. May/June 2007: 20-25.

Unique Team Gets the Job Done—And Then Some: 247F Decommissioning and Demolition at the Savannah River Site. By Fran Poda. Jan./Feb. 2006: 31-35.

Watching the Grass Grow: Closing SRS's Highest Risk Waste Unit. By Fran Poda. July/Aug. 2007: 17-21.

### **Tokamak Fusion Test Reactor**

Diamonds Are a Cutter's Best Friend: Diamond Wire Cutting the Tokamak Fusion Test Reactor. By Keith Rule, Erik Perry, and Robert Parsells. May/June 2002: 40-45.

Talk the Talk and Walk the Walk: Focusing on Safety during Fusion Reactor Decommissioning. By Keith Rule, Erik Perry, and Jerry Levine. Jan./Feb. 2002: 12-15.

### **West Valley Demonstration Project**

Calling in the Pool Guys: Decontamination of a Spent-Fuel Storage Pool. By K. A. Szlis, J. F. Jablonski, and A. M. Al-Daouk. July/Aug. 2002: 21-25.

Dismantling the Vitrification Facility at the West Valley Demonstration Project. By Michael J. Cain, Cynthia Dayton, and Ahmad M. Al-Daouk. Mar./Apr. 2005: 36-42.

Disposition of the West Valley Demonstration Project Vitrification Melter. By Jim McNeil, David Kurasch, Daniel Sullivan, and Thomas Crandall. July-Aug. 2012: 20-29.

Finding (and Counting) the Needles in a Haystack: Estimating the Radioactivity in the XC1 Hot Cell at West Valley. By Jeffrey A. Choroser, Cynthia Dayton, and Herman R. Moore. Sept./Oct. 2004: 31-35.

Getting "Fired" Up: Size-Reduction with an Oxy Gasoline Torch. By K. A. Szlis, K. R. Schneider, S. W. Chase, J. A. Choroser, and H. R. Moore. Sept./Oct. 2001: 10-15.

Getting Pumped: Lessons Learned from the Decontamination and Removal of High-Level Waste Pumps at the West Valley Demonstration Project. By William F. Hamel Jr., Kimberly J. Mansfield, and Paul J. Valenti. Jan./Feb. 1999: 5-14.

Hands Off! New West Valley Facility Cuts Rad Components Down to Size. By Jim Hurst, Kathy Szlis, and Tom Vero. July/Aug. 2004: 29-33.

How to "Do" Windows: Refurbishment of Shield Windows at the West Valley Demonstration Project. By K. R. Schneider, M. J. Fizzano, J. L. Drake, and C. Kalkwarf. Jan./Feb. 2001: 37-40.

Just Tooling Around . . . Conventional Equipment Makes Light Work of Decontamination

Challenges. By Scott Chase, John Drake, Kathy Szlis, and Peter Vlad. Mar./Apr. 2004: 38-46.

Starting from the Bottom: Lessons in Sampling Sludge from a Working Vitrification Melter. By C. S. Feuz, R. A. Palmet, and W. F. Hamel. Jan./Feb. 2002: 37-45.

Tapping into Lessons Learned at West Valley: High-Risk Decon Experience Leads to Repeat Success. By Helene Houston, Ken Schneider, Kathy Szlis, and John Drake. Nov./Dec. 2004: 34-40.

Thinking "Inside" the Box at West Valley: Decontaminating a Cell Tower. By Jeff Choroser, Helene Houston, Ken Schneider, Kathy Szlis, and Ahman Al-Daouk. May/June 2004: 28-33.

Vitrification at the West Valley Demonstration Project. By William F. Hamel Jr., Michael J. Sheridan, and Paul J. Valenti. Mar. 1998: 27-40.

Wrapping Up the Leftovers: Management of Expended Materials Relating to the West Valley Demonstration Project High-Level Waste Vitrification Facility. By L. E. Krieger, R. DiBiase, W. F. Hamel, and P. J. Valenti. Mar./Apr. 2000: 12-20.

### **WIPP**

Awaiting a New Permit at WIPP. By Susan Scott. Sept./Oct. 2006: 56-61.

Big Wheels Keep on Rolling: The Transportation Side of WIPP. By Angela Johnson, Lynn Eaton, and Phil Gregory. May/June 2009: 54-59.

Contrasting the WIPP and Yucca Mountain. By Chris G. Plfum. July 1995: 25-33.

Cutting the Gordian Knot That Binds WIPP: Sampling and Analysis to Validate Acceptable Knowledge on LANL Transuranic, Heterogeneous, Debris Waste. By Stanley T. Kosiewicz, Daniel I. Michael, Paul K. Black, Inez Triay, and Lawrence A. Souza. Mar./Apr. 2000: 55-64.

Eyes on the Numbers: A Report on Spectrum '98. By Nancy J. Zacha. Nov./Dec. 1998: 47-52.

From Collaboration to Compliance to Campaign Completion: Lessons Learned from the Rocky Flats TRU Shipping Campaign. By Gerald O'Leary and William Badger. May/June 2009: 60-65.

Going Mobile: How WIPP's CCP Revolutionized Nuclear Waste Characterization. By Bill Keeley. May/June 2009: 38-41.

Improvements to Alpha Continuous Air Monitoring Systems at the WIPP. By H. Bates Estabrooks, Sheila G. Clayton, and Richard F. Farrell. Oct. 1994: 80-85.

Independent Oversight at WIPP. By Christopher M. Timm. May/June 2009: 66-70.

Monitoring Human Activities near a Waste Repository: Valuable for Performance Confirmation. By Richard L. Beauheim. July/Aug. 2007: 39-46.

The Moving Target of WIPP's TRU Waste Inventory. By Beverly Crawford. May/June 2009: 26-31.

100 and Counting: Rocky Flats is the Nation's Top Shipper to WIPP. May/June 2001: 36-37.

Ready, Set . . . : A Process for Operational Readiness at the Waste Isolation Pilot Plant. By Joseph L. Epstein. Mar./Apr. 1999: 67-73.

Repackaging a Transuranic Waste Stream for WIPP Disposal. By David R. Yeaman, Kapil K. Goyal, and Matthew J. Roybal. Mar./Apr. 2001: 26-32.

The Salt of the Earth: 25 Years of Experience in WIPP Underground Operations. By John D. Vandekraats and Stanley J. Patchet. May/June 2009: 20-25.

Shielded Payload Containers for WIPP Remote-Handled Waste. By Roger Nelson and D. Sean White. Mar./Apr. 2009: 64-72.

Tracking the Trash: Characterization and Certification of Waste for Disposal at WIPP. By Dave K. Ploetz, Charles Turner, and Robert F. Kehrman. May/June 2009: 32-37.

Waste in Its Proper Place. By Nancy J. Zacha. Mar./Apr. 2007: 73-75.

WIPP @ 10: Securing the Past—Piloting the Future. By Dave Moody and Farok Sharif. May/June 2009: 16-19.

WIPP: 2010 and Beyond. By Susan McCauslin. July/August 2010: 48-55.

WIPP Celebrates 10 Years of Safe Operations. By Roger Nelson. May/June 2009: 15.

WIPP Certification: A DOE Success Story. By George E. Dials. Jan./Feb. 1999: 15-19

WIPP Marker Development. By Kathleen M. Trauth. Apr. 1994: 46-52.

WIPP's Mobile Loading Unit. By Bryan Howard. May/June 2009: 42-46.

WIPP's Unique Fleet of Packages Delivers. By Robert Johnson and Todd Sellmer. May/June 2009: 47-53.

WIPP-WIPP-Hoo-Ray! World's First TRU Disposal Facility Begins Operations, Receives First Wastes. By Chuan-Fu Wu. May/June 1999: 22-27.

## Yucca Mountain

Alternative Uses for the Yucca Mountain Site: A GAO Report. Jan.-Apr. 2012: 24-30.

Artifact to Analogue: Archeology of Arid Environments points to Management Options for Yucca Mountain. By Neil Chapman, Amy Dansie, and Charles McCombie. Mar./Apr. 2007: 22-31.

Breaking the High-Level Waste/Spent Fuel Logjam. A Perspective by Dade W. Moeller. May/June 2006: 18-20.

Collaborating for Success: Performance Culture Turnaround in the Federal Government. By Leopoldo Seguel, Fred Valentino, and High Diamond. May-June 2012: 34-44.

Contrasting the WIPP and Yucca Mountain. By Chris G. Pflum. July 1995: 25-33.

DOE Strategic Plan for the Safe Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to Yucca Mountain. Mar./Apr. 2004: 18-24.

The EIS at a Glance: An Overview of the DOE's Yucca Mountain Draft Environmental Impact Statement. Nov./Dec. 1999: 43-47.

The Evolution of Spent-Fuel Waste Packages: Designing the Means to Permanently Dispose of U.S. High-Level Nuclear Waste. By Hugh Benton and Judy Connell. Mar./Apr. 2001: 34-42.

GAO: Opening Yucca Mountain Cheaper than Storage Alternatives. Mar./Apr. 2010: 40-47.

Interview with Wesley E. Barnes, Yucca Mountain Project Manager. By David A. Schabes. July 1995: 20-24.

Licensing of Yucca Mountain as a Geological Repository for Radioactive Wastes: An ANS Position Statement. July/Aug. 2009: 34-35.

Natural Analogs for Yucca Mountain. By William M. Murphy. Nov. 1995: 44-50.

OCRWM's Inaugural Science and Technology Program for Yucca Mountain. By Thomas Kiess, Robert Budnitz, Douglas Duncan, Mark Peters, John Wengle, and Jeffrey Williams. May/June 2005: 41-48.

The Potential Impact of Using TAD Canisters on Yucca Mountain Preclosure Operations. By Leah Spradley, Mark. Abkowitz, and James H. Clark. Mar./Apr. 2009: 56-62.

Repository Heat and Hydrological Behavior at Yucca Mountain. By Thomas A. Buscheck and John J. Nitao. Apr. 1994: 71-76.

Staged Licensing and the Need to Assure Issue Closure in New NRC Regulations for Licensing the Yucca Mountain Repository. By F. Stanley Echols. July 1998: 10-14.

Stumping for Yucca Mountain: Grassroots Efforts to Secure Congressional Support for the High-Level Waste Repository. By Janenne Irene Harrington. May/June 2002: 46-51.

The Tragedy of Yucca Mountain. By Dade W. Moeller. Sept./Oct. 2010: 52-57.

The Tragedy of Yucca Mountain: Part II. By Dade W. Moeller. Jan.-Apr. 2011: 54-58.

Transportation Cooperation: Involving Corridor States in Decision Making Contributes to the Success of the DOE's Transportation Program. By Lisa R. Sattler. Mar./Apr. 2004: 13-17.

What's Next for Yucca Mountain? By Richard G. Telfer. Sept./Oct. 2002: 40-48.

What's Next for Yucca Mountain? By Nancy J. Zacha. May/June 2006: 12-17.

Yucca Mountain: Dumped and Wasted? By Nancy J. Zacha. July/Aug. 2009: 12-18.

Yucca Mountain: Healthy or on Its Deathbed? A Meeting Report from the 2008 Regulatory Information Conference. By James F. Mallay. May/June 2008: 44-46.

Yucca Mountain: Solving an Existing Environmental Problem. By J. Russell Dyer. July 1998: 16-18.

Yucca Mountain Repository Standards: What Does the EPA Not Understand? By Dade W. Moeller. Sept./Oct. 2008: 10-12.

Yucca Mountain Updates—And Other Spent Fuel Issues. By Nancy J. Zacha. May/June 2005: 49-50.

## Utilities

The ABCs of Decommissioning Safety. By Bill Grubilowicz and Janenne Irene Harrington. Jan./Feb. 2002: 8-11.

Adapt, Be Nimble, Be Open-Minded: Reducing Radwaste Volumes and Costs at Diablo Canyon. By Bill Keyworth. Nov./Dec. 1999: 17-22.

Advanced Approaches to Reduce Waste, Slash Costs. July-Aug. 2012: 17-19.

And Now for Something Completely Different: An Innovative Path Toward Zion Decommissioning. By Nancy J. Zacha. May-June 2012: 29-33.

ASCA Cleanup with Membrane Technology. By Billy Cox, Charles Jensen, and Dennis Brunsell. Jan./Feb. 2010: 9-15.

Bidding Farewell to Saxton. Mar./Apr. 2006: 43-45.

The Big Cleanout at Big Rock Point. By Tim Petrosky. Jan./Feb. 2000: 14-21.

The Big Rock Vessel Goes to Barnwell. By Tim Petrosky. Jan./Feb. 2004: 15-19.

Bit by Bit . . . Taking It Apart: The Incremental Dismantlement of the Rancho Seco Secondary System. By Dennis E. Gardiner and John M. Newey. July/Aug. 1999: 9-14.

Bringing Best Industry Operating Practices to New Nuclear Plant Designs: An EPRI Radwaste Review. By Sean Bushart. Mar./Apr. 2006: 18-24.

Building a Mixed-Waste Prevention Program at Comanche Peak. By R. B. McCamey. May 1995: 21-28.

Business as Usual . . . Only More So. By Nancy J. Zacha. Nov./Dec. 2001: 9-14.

Bye-Bye Big Rock: Greenfield Celebration Highlights Plant's Successful Decommissioning. By Dan Gretzner. Nov./Dec. 2006: 12-16.

Cleaning an Entire Plant: Full Reactor Coolant System Chemical Decontamination at Indian Point 2. By Stephen A. Trovato and John O. Parry. July 1995: 13-19.

Connecticut Yankee Decommissioning: Removing Restoring, and Reusing. By Michael D. Cavanaugh. Mar./Apr. 2001: 59-61.

Cruisin' Up the River: The Final Journey of the Trojan Reactor Vessel. Nov./Dec. 1999: 48-52.

D&D . . . and Now Demolition. By Janenne Irene Harrington. Sept./Oct. 2001: 24-25.

Decide, Design, and Dewater de Waste: A Blueprint from FitzPatrick. By Dennis E. Robert. Apr. 1994: 21-22.

The Decommissioning of Zion: A Status Update. By Patrick Daly. Nov.-Dec. 2013: 18-27.

Decommissioning One, Operating Two: At San Onofre, Breaking Up Is Hard To Do. By Ray Golden. July/Aug. 2000: 20-23.

Decommissioning the Next Generation of Nuclear Plants. By John Newey. Mar./Apr. 2006: 26-28.

Decommissioning "The Rock": A Photo Tour of the Big Rock Point Restoration Project. Sept./Oct. 1999: 60-62.

Decommissioning Trojan: A Step-by-Step Tour of a Landmark Process. By Stephen Quennoz. May/June 1999: 17-21.

A Decommissioning Wrapup: Commercial Reactor Decommissioning Status in 2006. By Edward C. Doubleday. Mar./Apr. 2007: 46-52.

Decommissioning Yankee Rowe. By Kenneth J. Heider and Russell A. Mellor. July 1994: 26, 28-32.

Designing Decommissioning into New Reactor Designs. By Jas S. Devgun. Sept./Oct. 2007: 40-46.

DfD at Big Rock Point. By Jane Dunshee and Lisa Wheat. May/June 1999: 28-30.

A Diablo Canyon Double Feature: When Less Is Less, by Clint Miller; Consolidation of Waste Correlation Factors, by Clint Miller and L.T. Claytor. Mar. 1996: 64-70.

Dismantling the Recirculation Pump Room at Big Rock Point. By Janenne Irene Harrington. Mar./Apr. 2001: 56-58.

Doin' the D&D: Dancing to the Regulatory Tune. By John D. Haseltine and Stephen J. Milioti. Jan./Feb. 1999: 44-49.

End-of-Life-Cycle Issues for Reactors Yet to Be Built. By Jas Devgun. Jan./Feb. 2010: 16-21.

- Engineering for Transportation and Disposal of Low-Level Radioactive Wastes in Japan. By Yutaka Suzuki, Yoshihiro Akagawa, and Hiroo Ohno. Oct. 1994: 64-70.
- EPRI's Decommissioning Technology Program. By Christopher J. Wood and Sean Bushart. July/Aug. 2006: 30-35.
- EPRI's Groundwater Protection Program. By Karen Kim. Sept./Oct. 2008: 16-17.
- Evolving Requirements for Waste Management Software. By David W. James. Nov./Dec. 2003: 20-23.
- Fast Track Steam Generator Disposal at Salem Generating Station. By Herb Cruickshank, John Gomeriger, and Robert Killen. Jan. 1998: 50-54.
- Fermi-1 Update: Impact of a Decommissioning Evaluation and the Decommissioning Rule. By Lynne S. Goodman. Nov. 1997: 45-48.
- Five Sites, One Team, One Standard: The Energy Approach to Radwaste Management. By Cyndy Moore. Nov./Dec. 1999: 14-16.
- A Forum on the MPC: The Independent Review Group's Comments on the MPC, by John A. Vincent; The Nuclear Waste Technical Review Board's View's on the MPC, by Dennis L. Price; The NRC Perspective on the MPC, by Robert M. Bernero; The MPC System Evaluation Report. Oct. 1994: 34-49.
- Fostering Community Participation in Decommissioning. By Maureen Brown. Sept. 1998: 31-35.
- Four Key Elements for Radioactive Waste Minimization: Preplanning, Equipment and Facilities, Training. By Gene Henry. Jan. 1994: 20-24.
- From the Bottom Up: Tank Removal at Trojan. By Brian D. Clark and Roger M. Lewis. Mar./Apr. 2000: 22-31.
- Getting It Right: New Hampshire's State-of-the-Art Nuclear Decommissioning Law. By Bruce J. Musico and Harold T. Judd. Nov./Dec. 2001: 21-23.
- Getting the Head Out: RPV Head Characterizing, Packaging, and Disposal. By Dean M. Wheeler, Bruce Geddes, and Ed Posivak. Nov./Dec. 2003: 14-19.
- Goodbye, Golden Goose: The Effects of Connecticut Yankee Decommissioning on the Surrounding Community. By Terry Concannon. Jan./Feb. 1999: 54-57.
- Groundwater Protection at Nuclear Plants. By Karen Kim, Brozia Clark, and Steven Swilley. July-Aug. 2011: 37-43.
- Handling the Unexpected: Connecticut Yankee's Concrete Block Recovery Effort. By Richard Sexton. Jan./Feb. 1999: 58-59.
- Have Pipe Cleaning System, Will Travel: Innovative, Cooperative Effort at Big Rock Point. By Janenne Irene Harrington. Nov./Dec. 2000: 21-25.
- Here's a TIP: The Advanced Resin Cleaning System Is Success for Grand Gulf. By Philip Theibert. Nov./Dec. 1998: 43-46.
- Heroes for Zeros—Developing a High-Performance Team. By Christopher A. Lewis. Sept. 1998: 36-39.
- How More Means Less: The Use of a New Ion Exchange Resin at the South Texas Project. By Milton F. Rejcek. Nov./Dec. 2002: 10-14.
- The Importance of Radiological Data Validation. By Kendra K. Grega and LeRoy F. Wenrick. Mar. 1995: 28-32.
- The Industry Ground Water Protection Initiative: A Watershed Moment. By Kathleen C. Yhip, George J. Oliver, and Ralph L. Andersen. Mar./Apr. 2010: 24-28.
- Interview with Andrew C. Kadak. By David A. Schabes. Jan. 1996: 17-24.
- Keeping an Eye on the Bottom Line. By Michael S. Terrell. Sept./Oct. 2000: 30-32.
- La Crosse BWR Reactor Vessel Shipped to Barnwell. Sept./Oct. 2007: 30-32.
- La Crosse Fuel Is Moved to an ISFSI. Nov.-Dec. 2012: 24-27.
- Large Component Disposal: Do It Now or Do It Later? By Paul J. Larsen and Jay K. Vance. Jan./Feb. 2006: 20-25.
- Laser Cleaning Process Demonstrated for Power Plant Component Refurbishment. By Dwight Hostetter and Greg Frederick. Nov./Dec. 2002: 15-17.
- The Legacy of Three Mile Island: Implications for Today's DOE Challenges. By Richard P. Coe, Michael S. Williams, and William T. Conaway. May 1996: 30-33.
- Less Means Less: Duke's Liquid Radwaste Solution. By Tom Shiel. Nov./Dec. 1998: 37-42.
- Liquid Waste Processing at Comanche Peak. By Lisa M. Hughes-Edwards and Jeffrey M. Edwards. Sept. 1996: 26-30.
- Looking to the STARS to Reduce Class B/C Waste: EPRI's Waste Logic-Solid Waste Manager Can Help. By Clint Miller. Nov./Dec. 2003: 24-28.
- Low-Level Radwaste Storage Facility at Hope Creek and Salem. By Larry C. Oyen, Kristen K. Lee, Richard Bravo, and Bruce Bovanovich. Jan. 1994: 71-74.
- Managing Steam Generator Chemical Waste at Palo Verde. By Varcel Huntsman. Nov./Dec. 2004: 12-16.
- Michigan Historical Marker for Big Rock Point Site. By Tim Petrosky. Nov./Dec. 2007: 10-12.
- Moving to Another Stage of Life: Shipping, Decontaminating, and Final Disposition of the Maine Yankee Large Components. Sept./Oct. 2000: 50-55.
- New Waste Management Solutions at Hungary's Paks Nuclear Power Plant. By P. Ormai and J. Schunk. Jan./Feb. 2004: 33-41.
- The Next Stage for EPRI'S DFD Process: Decontamination and Recycling of Radioactive Material from Retired Components. By Chris Wood, Sean Bushart, David Bradbury, and George Elder. Nov./Dec. 2004: 17-21.
- Old Rail Spur Reactivated: Railroad Moved Radioactive Materials from San Onofre. By David Gilson. Mar./Apr. 2005: 20-26.
- On-Site Dry Spent-Fuel Storage: Becoming More of a Reality. By Betsy Tompkins. Jan. 1994: 63-70.
- On-Site Low-Level Waste Storage at D.C. Cook. By Walter T. MacRae. Apr. 1994: 66-70.
- On-Site Waste Minimization Programs at McGuire Nuclear Station. By Graham T. Johnson. May 1998: 21-23.
- Onsite Storage: Reducing the Burden. By Lisa Edwards. May/June 2010: 20-23.
- An Operating Philosophy for Volume Reduction. By Frederic J. Mis. Apr. 1994: 42-45.
- A Partnership for PCE Reduction. By Scott Griffin. May-June 2013: 30-33.
- Pathfinder: The Long Road Toward Decommissioning. By C. E. Burtoff, J. W. Closs, J. M. Gushue, J. J. Holthaus, K. Lucken, and J. C. Seitz. March/April 2008: 18-27.
- Planning Ahead: Preparing for the Early Retirement and Decommissioning of Oyster Creek. By James E. Hildebrand. Nov./Dec. 1998: 31-36.
- Post-Barnwell Disposal of Class B and C Resins and Filters. By Charles Jensen and Clint C. Miller. Jan./Feb. 2008: 14-18.
- Postirradiation Fuel Assembly Dimensions for Transportation and Storage Cask Designs. By Douglas A. Williamson. Jan. 1994: 42-47.
- Potential Radioactive Scrap Metal Quantities from Nuclear Power Plants Worldwide. By Leslie A. Nieves and Roger W. Tilbrook. Jan. 1996: 45-53.
- Private Fuel Storage: Finding Real Solutions for Centralized Spent-Fuel Storage. By Scott Northard. Jan./Feb. 2000: 35-39.
- A Radwaste Magazine Interview: Managing LLW at the Palo Verde Nuclear Power Plant. July 1997: 10-13.
- Radwaste Management at U.S. Nuclear Power Plants: Where We Are Today (and How We Got There). By C. C. Miller. Nov./Dec. 1999: 8-13.
- Radwaste Operations at Diablo Canyon: A Photo Essay. Nov./Dec. 1999: 23-26.
- The Rancho Seco Eleven: A Story of Spent Fuel Racks from Removal to Burial. By Robert A. Snyder. Jan./Feb. 2004: 26-32.
- Recycling Hits the Big Time: Reactor Coolant Pump Decontamination and Refurbishment at Oconee. By Tom Shiel. Jan./Feb. 2000: 44-48.
- Resuming Decommissioning Activities at Fermi-1: Problems Encountered and Lessons Learned. By Danny Swindle, Jon Couillard, and Lynne Goodman. July/Aug. 1999: 15-19.
- Reverse-Osmosis Applications for PWR Liquid Radwaste Processing. By Pete Gunderson, Tom Jamieson, Billy Cox, and Charles Jensen. Jan./Feb. 2008: 10-13.
- Robots Provide Valuable Tools for Waste Processing at Millstone Nuclear Power Station. By Kirk Miles and Kathy Volpe. Mar. 1997: 28-30.
- Safe from Start to Finish: The 1100-Mile Journey of the Yankee Rower Reactor Pressure Vessel. By Leo Lessard. Mar./Apr. 2000: 44-49.
- Saving \$\$ at SONGS with Disposable Media Filters. By Daniel L. Cox, Lee Clark, and Mike Venier. Nov./Dec. 2003: 10-13.
- The Search for Something Better: Improvements to Radwaste Processing at Oyster Creek. By Robert J. Artz and Robert J. Hillman. Nov./Dec. 2000: 9-15.
- Segmenting and Disposing of the Rancho Seco Reactor Vessel Internals. By Karl Johnson. Sept./Oct. 2006: 37-50.
- Segmenting the Rancho Seco Reactor Head—A Cost-Effective Option. By Michael Snyder. Nov./Dec. 2004: 22-27.
- Selecting and Applying an Automated Welding System. By Mario Lento. Nov./Dec. 2002: 18-20.
- The Shoreham to Limerick Fuel Transfer Project. By Rich Wolters, Kevin Theriault, and Bob Jones. Oct. 1994: 19-26.

Silica Removal with Membrane Technology. By Clint Miller, Subrene Morris, Mike Frala, and Charles Jensen. Jan./Feb. 2006: 26-30.

Softening Things Up at Big Rock Point: Controlled Blasts Assist Demolition. Mar./Apr. 2006: 46-49.

Spent Fuel Management at the Northern States Power Company. By John Closs and Lon Kress. May 1966: 25-29.

Striking the Right COD: Decontamination for Decommissioning at Connecticut Yankee. By Scott Watson, Richard N. McGrath, Horst-Otto Bertholdt, Edmund Friedrich, William J. Szymczak, and Ed Ruzauskas. Mar./Apr. 1999: 46-51.

Stud Cleaning Made Easier: Reducing Time, Effort, and Radwaste at the South Texas Project. By Edward Conaway. July/Aug. 2000: 24-25.

Taking Down the Maine Yankee Containment Building. By Eric Howes. Jan./Feb. 2005: 40-43.

A Team Effort: Reducing the Volume of Low-Level Radioactive Waste. By Kerry Zimmermann. Sept. 1996: 39-41.

Tell Them What They Want To Know: Designing a Community Outreach Program. By Darrell M. Lankford. Jan./Feb. 1999: 50-53.

Ten Spectacular Seconds: Successful Cooling Tower Implosion at Trojan Reflects Careful Planning. July/Aug. 2006: 36-38.

Tests, Tests, and More Tests at Rig Rock Point: Soil and Water Testing Helps Ensure Public Safety. By Tim Petrosky. Sept./Oct. 2004: 20-23.

To DOC or Not To DOC: Managing Power Plant Decommissioning. By Nancy J. Zacha. July/Aug. 1999: 60-61.

To Decommission or Not To Decommission? A Guide for Utilities. By Leo Lessard. Sept./Oct. 1999: 32-36.

To Toss or Not to Toss—That Is the Question. By J. Mark Price. Jan./Feb. 2006: 12-19.

Up for Decades, Down in Seconds: Completing the Demolition of a Sphere Enclosure Building. Mar./Apr. 2009: 28-29.

A Video Look in the Pool: Spent-Fuel Characterization for Dresden-1 Decommissioning. By Coleman McDonough, Linwood Ray, John J. Villanueva, and Ed Ruzauskas. July/Aug. 1999: 20-23.

Vogtle's New Radwaste Processing Facility. By Paul Jackson. Sept./Oct. 2002: 34-37.

What If We Lose Barnwell? By Nancy J. Zacha. July/Aug. 1999: 62-63.

Whatever Happened to TMI-2, and Other Nuclear Waste Issues. By Nancy J. Zacha. Mar./Apr. 2007: 68-72.

Where Are You Going—And How Are You Going to Get There? Creating a Virtual Organization for Nuclear Power Plant D&D. By Carroll Eichhorn. Jan./Feb. 2000: 52-54.

Where the Utilities Go. Nov./Dec. 2000: 4.

#### Vitrification

Dismantling the Vitrification Facility at the West Valley Demonstration Project. By Michael J. Cain, Cynthia Dayton, and Ahmad M. Al-Daouk. Mar./Apr. 2005: 36-42.

Disposition of the West Valley Demonstration Project Vitrification Melter. By Jim McNeil, David Kurasch, Daniel Sullivan, and Thomas Crandall. July-Aug. 2012: 20-29.

DWPF: Old Work Horse, New Tricks. By John N. Lindsay. May-June 2011: 23-29.

Foundation Pouring Begins for Hanford Vit Plant. Sept./Oct. 2002: 49.

Multiple Aspects of Cold Crucible Melting. By Antoine Jouan, Jean-Pierre Moncouyoux, Serge Merlin, and Patrice Roux. Mar. 1996: 77-81.

A New Era of Waste Vitrification at SRS. By Dean Campbell. July/Aug. 2005: 30-34.

Putting Bulk Vitrification to the Test: Stage Set for Full-Scale Testing at Hanford's Tank Farms. By Mike Berriochoa. Mar./Apr. 2005: 58-61.

Starting from the Bottom: Lessons in Sampling Sludge from a Working Vitrification Melter. By C. S. Feuz, R. A. Palmet, and W. F. Hamel. Jan./Feb. 2002: 37-45.

Vitrification at the West Valley Demonstration Project. By William F. Hamel Jr., Michael J. Sheridan, and Paul J. Valenti. Mar. 1998: 27-40.

Vitrifying the Hanford Tank Wastes: New Team, New Vision, New Energy. By Sue Kuntz. May/June 2001: 26-30.

The World's Largest Construction Project: Designing and Constructing Hanford's Waste Treatment Plant. By Garth M. Duncan. Sept./Oct. 2005: 14-22.

# Radwaste Solutions

THE MAGAZINE OF RADIOACTIVE WASTE MANAGEMENT AND FACILITY REMEDIATION

**Radwaste Solutions** is a specialty magazine containing articles that discuss practical approaches and solutions to everyday problems and issues in all fields of radioactive waste management and environmental restoration. Included is coverage of the generation, handling, removal, treatment, cleanup, and disposal of radioactive (including mixed) waste. Articles are contributed by people working with utilities and those involved in U.S. Department of Energy site

#### 2014 Editorial Topics Include:

- High-Level Waste/Spent Fuel
- Low-Level Waste
- Environmental Remediation
- Annual Buyers Guide/ DD&R

work, in the medical, legal, university, consulting, and commercial areas, as well as from all levels of government. Also included are articles on radwaste management programs and practices outside the United States, as well as perspective pieces by industry experts and letters to the editor, shorter thought-pieces, and articles on recent academic/technical advances detailing their immediate or planned practical applications.

Your subscription also includes the annual **Buyers Guide**. The **Radwaste Solutions** Products, Materials, and Services Directory remains *the* commercial reference publication for the business of radioactive waste management and site cleanup and remediation.

## SUBSCRIBE TODAY!

**\$530 for Print and Online # RWS14A**  
(Add \$35 for postage if outside North America)

**\$480 for Online Only # RWS14**

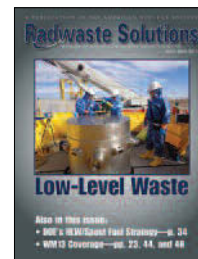
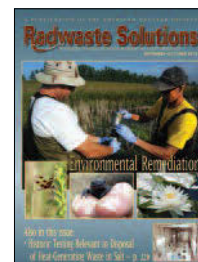
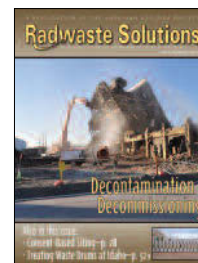
Phone: **708-579-8207**

Online: **www.ans.org/store/i\_RWS14A**

**Online electronic access** includes an unlimited IP Range of desktop users at your location. All past issues from 2003 to present are archived online and fully searchable.



Discounted professional rate for ANS Member (individual subscription) remains only \$45. Call the ANS Membership Department today and ask to add a subscription to *Radwaste Solutions*: 1-708-579-8266 or e-mail [members@ans.org](mailto:members@ans.org)



# Radwaste Solutions

THE MAGAZINE OF RADIOACTIVE WASTE MANAGEMENT AND FACILITY REMEDIATION



*Radwaste Solutions* was created to meet the needs of radioactive waste management and facility remediation professionals and contractors. Published by the American Nuclear Society since 1994, the magazine connects radwaste professionals with nearly 500 companies that provide products and services to this specialized segment of the nuclear industry.

Over the last two years, more than 100 companies have advertised in *Radwaste Solutions* to promote their capabilities and products!

If your company performs work within these industry subsets—ADVERTISE!

- Department of Energy's (DOE's) remediation of its weapons production and research facilities
- Civilian radioactive waste activities
- Nuclear utilities
- Nonpower, non-DOE activities
- Cleanup and decommissioning of nuclear facilities outside of the United States

**WWW.ANS.ORG/ADVERTISING**  
**1-800-682-6397**



**Meetings of interest ▼****February**

Feb. 16–19 **Public Information Materials Exchange (PIME 2014)**, Ljubljana, Slovenia. Organized by the European Nuclear Society in collaboration with Foratom. Contact: Kirsten Epskamp, ENS, phone +32 2 505 30 54; fax +32 2 502 39 02; e-mail [pime2014@euronuclear.org](mailto:pime2014@euronuclear.org); web [www.euronuclear.org/events/pime/pime2014/index.htm](http://www.euronuclear.org/events/pime/pime2014/index.htm).

**March**

Mar. 2–6 **Waste Management Conference (WM2014)**, Phoenix, Ariz. Presented by WM Symposia. Contact: WM Symposia, phone 480/557-0263; e-mail [onlineereg@wmarizona.org](mailto:onlineereg@wmarizona.org); web [www.wmsym.org/](http://www.wmsym.org/).

Mar. 10–11 **NCRP 50th Annual Meeting**, Bethesda, Md. Sponsored by the National Council on Radiation Protection and Measurements. Contact: James Cassata, NCRP, phone 301/657-2652; fax 301/907-8768; e-mail [cassata@ncrponline.org](mailto:cassata@ncrponline.org); web <http://civclients.com/ncrp/>.

Mar. 24–27 **Facility Decommissioning Training Course**, Las Vegas, Nev. Sponsored by Argonne National Laboratory. Contact: Larry Boing, ANL, phone 630/252-6729; fax 630/252-7577; e-mail [lboing@anl.gov](mailto:lboing@anl.gov); web [www.dd.anl.gov/ddtraining/](http://www.dd.anl.gov/ddtraining/).

**April**

Apr. 8–10 **Symposium on Recycling of Metals Arising from Operation and Decommissioning of Nuclear Facilities**, Nyköping, Sweden. Organized by Studsvik Nuclear, the International Atomic Energy Agency, and the OECD Nuclear Energy Agency. Contact: Anders Appelgren, Studsvik, phone +46 0 155 22 12 57; e-mail [anders.appelgren@studsvik.se](mailto:anders.appelgren@studsvik.se); web [www.studsvik.com/en/about-studsvik/news-archive/2013/sweden/symposium-on-recycling-of-metals-/](http://www.studsvik.com/en/about-studsvik/news-archive/2013/sweden/symposium-on-recycling-of-metals-/).

Apr. 8–10 **World Nuclear Fuel Cycle 2014**, San

Francisco, Calif. Organized by the Nuclear Energy Institute and the World Nuclear Association. Contact: Linda Wells, NEI, phone 202/739-8039; e-mail [ljw@nei.org](mailto:ljw@nei.org); web [www.wnfc.info/](http://www.wnfc.info/).

Apr. 29–May 1 **51st Annual SRP Conference**, Southport, England. Sponsored by the Society for Radiological Protection. Contact: SRP, phone +44 0 1803 866 743; fax +44 0 8442 724 892; e-mail [unity.stuart@srp-uk.org](mailto:unity.stuart@srp-uk.org); web [www.srp-uk.org/event/18/annual-conference-2014](http://www.srp-uk.org/event/18/annual-conference-2014).

**May**

May 6–8 **Used Fuel Management Conference**, St. Petersburg, Fla. Sponsored by the Nuclear Energy Institute. Contact: NEI, phone 202/739-8000; fax 202/785-4019; e-mail [conferences@nei.org](mailto:conferences@nei.org); web [www.nei.org/conferences](http://www.nei.org/conferences).

May 12–14 **7th International Conference on Waste Management and the Environment (Waste Management 2014)**, Ancona, Italy. Organized by the Wessex Institute of Technology and the Università Politecnica delle Marche. Contact: Genna West, Wessex Institute, phone +44 0 238 029 3223; fax +44 0 238 029 2853; e-mail [gwest@wessex.ac.uk](mailto:gwest@wessex.ac.uk); web [www.wessex.ac.uk/waste2014](http://www.wessex.ac.uk/waste2014).

May 25–29 **CRPA-ACRP Annual Conference**, Vancouver, British Columbia, Canada. Organized by the Canadian Radiation Protection Association (Association Canadienne de Radioprotection). Contact: CRPA-ACRP, phone 613/253-3779; fax 888/551-0712; e-mail [secretariat@crpa-acrp.ca](mailto:secretariat@crpa-acrp.ca); web <http://crpa-acrp.org/conference/>.

**June**

June 3–6 **2nd International Symposium on Cement-based Materials for Nuclear Wastes (NUWCEM 2014)**, Avignon, France. Organized by the Commissariat à l'Énergie Atomique et aux Énergies Alternatives and the Société Française d'Énergie Nucléaire. Contact: Patricia Hamel-Bloch, SFEN, e-mail [phamel-bloch@sfen.fr](mailto:phamel-bloch@sfen.fr); web [www.sfen.fr/nuwcem-2014](http://www.sfen.fr/nuwcem-2014).

June 15–19 **2014 ANS Annual Meeting**, Reno, Nev. Sponsored by the American Nuclear Society. Contact: John Grossenbacher, Idaho National Laboratory,

Meetings listed in the Calendar section that are not sponsored by the American Nuclear Society do not have the endorsement of ANS, nor does ANS have any financial or legal responsibility for these meetings.



phone 208/526-9021; e-mail [john.grossenbacher@inl.gov](mailto:john.grossenbacher@inl.gov); web [www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1).

June 15–19 **Embedded Topical: Advances in Thermal Hydraulics 2014 (ATH '14)**, Reno, Nev. Sponsored by the ANS Thermal Hydraulics Division. Contact: Kurshad Muftuoglu, GE Hitachi Nuclear Energy, phone 910/338-1467; e-mail [kurshad.muftuoglu@ge.com](mailto:kurshad.muftuoglu@ge.com); web [www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1).

June 15–19 **Embedded Topical: Decommissioning and Remote Systems (D&RS 2014)**, Reno, Nev. Sponsored by the ANS Robotics & Remote Systems and Decommissioning & Environmental Sciences Divisions. Contact: Thomas Sanders, Savannah River National Laboratory, phone 803/725-8111; e-mail [thomas.sanders@srnl.doe.gov](mailto:thomas.sanders@srnl.doe.gov); web [www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1).

June 15–19 **Embedded Topical: Nuclear Fuels and Structural Materials for the Next Generation Nuclear Reactors**, Reno, Nev. Sponsored by the ANS Fusion Energy and Materials Science & Technology Divisions. Contact: Todd Allen, Idaho National Laboratory, phone 208/526-8096; e-mail [todd.allen@inl.gov](mailto:todd.allen@inl.gov); or Lance Snead, Oak Ridge National Laboratory, phone 865/288-3116; fax 865/241-3650; e-mail [sneadll@ornl.gov](mailto:sneadll@ornl.gov); web [www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1).

June 24–26 **IGD-TP Geodisposal 2014**, Manchester, England. Sponsored by the Implementing Geological Disposal–Technology Platform. Contact: Raymond Kowe, Nuclear Decommissioning Authority's Radioactive Waste Management Directorate, e-mail [geodisposal2014@manchester.ac.uk](mailto:geodisposal2014@manchester.ac.uk); web [www.meeting.co.uk/confercare/geodisposal2014](http://www.meeting.co.uk/confercare/geodisposal2014).



**ANS 2014 Annual Meeting**

**Join us in Reno, NV**  
June 15-19, 2014  
Grand Sierra Resort

**Register today**  
[ans.org/meetings/m\\_136](http://ans.org/meetings/m_136)

**EMBEDDED TOPICAL MEETING**  
*Decommissioning and Remote Systems (D&RS 2014)*

The ANS Topical D&RS Meeting is a forum for the discussion of the social, regulatory, scientific, and technical aspects of decommissioning and remote systems.

 **ANS DESD**  
 **ANS RRS D**

General Chair: **Tom Sanders**, Savannah River National Laboratory  
DE&S Technical Program Co-Chair: **Sue Aggarwal**, NMNT International  
RRS Technical Program Co-Chair: **Steve Tibrea**, Savannah River National Laboratory



**EPRI** | ELECTRIC POWER RESEARCH INSTITUTE

**2014 ASME/EPRI Radwaste Workshop**  
June 9–10, 2014  
Loews Royal Pacific Hotel – Orlando, Florida

**EPRI International Low-Level Waste Conference & Exhibit Show**  
June 10–12, 2014  
Loews Royal Pacific Hotel – Orlando, Florida

For more details go to [www.epri.com](http://www.epri.com)>Events or contact Linda Nelson, CMP at 828.318.8428 or via e-mail [lnelson@toplanthead.com](mailto:lnelson@toplanthead.com)

Electric Power Research Institute (EPRI), Inc.  
3420 Hillview Avenue, Palo Alto, CA 94304  
1.800.313.3774 • [askepri@epri.com](mailto:askepri@epri.com)  
Together...Shaping the Future of Electricity

## Meetings of interest ▼

### July

July 20–24 **INMM 55th Annual Meeting**, Atlanta, Ga. Sponsored by the Institute of Nuclear Materials Management. Contact: INMM, phone 847/480-9573; fax 847/480-9282; e-mail [inmm@inmm.org](mailto:inmm@inmm.org); web [www.inmm.org](http://www.inmm.org).

### And coming up (ANS meetings) . . .

18th Topical Meeting of the Radiation Protection & Shielding Division of ANS (RPSD 2014), Sept. 14–18,

2014, Knoxville, Tenn.

2014 American Nuclear Society Winter Meeting and Nuclear Technology Expo, Nov. 9–13, 2014, Disney Resort & Hotel, Anaheim, Calif.

Embedded Topical: 21st Topical Meeting on the Technology of Fusion Energy (TOFE), Nov. 9–13, 2014, Disney Resort & Hotel, Anaheim, Calif.

2015 American Nuclear Society Annual Meeting, June 7–11, 2015, Grand Hyatt San Antonio, San Antonio, Texas. ■



## ANS National Meeting

### 2014 Winter Meeting and Technology Expo



**Mark your calendars!** Exhibitor registration opens June 16

### ***Nuclear-The Foundation of Clean Energy***

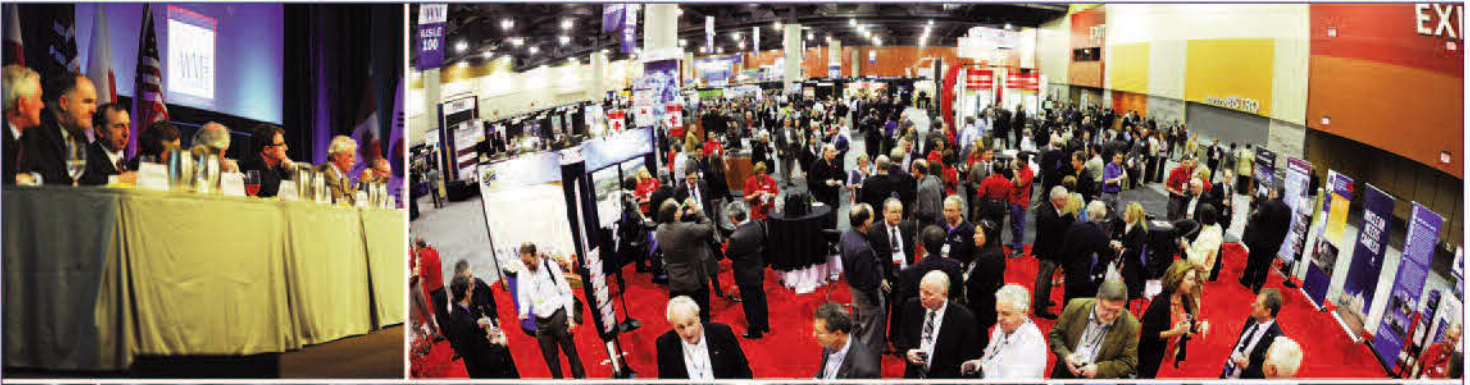
November 9-13 (Expo November 9-11)  
At the *Disneyland®* Hotel - Anaheim, CA

**Exhibitors:** Don't miss the chance to network and display your services & technology to a targeted industry audience! Last year's meeting drew 1,500 attendees.

For more information contact:  
Earl Beckwith & Associates  
301-570-7766 or 800-250-3678  
[AnsExpo@earlbeckwith.com](mailto:AnsExpo@earlbeckwith.com)

[ANS.org/meetings](http://ANS.org/meetings)





## EDUCATION & OPPORTUNITY IN WASTE MANAGEMENT



**REGISTER  
NOW!**



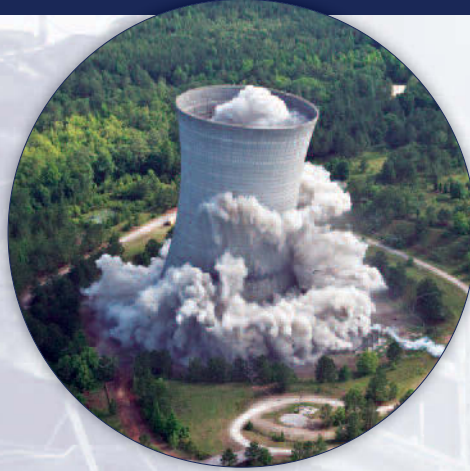
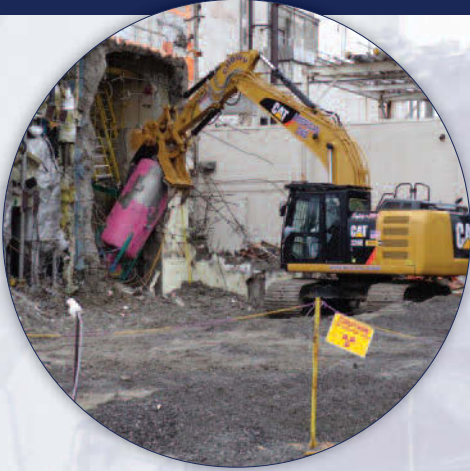
**MARCH 15-19, 2015**  
**AT THE PHOENIX CONVENTION CENTER**

### CONNECT ON A GLOBAL LEVEL

This is the premier international conference for the management of radioactive material and related topics. Don't miss this opportunity to exchange ideas, technical information and solutions with nuclear waste industry attendees from more than 35 countries. Visit [wmsym.org](http://wmsym.org) for conference registration and details.

**wmsym.org**  
A NON-PROFIT ORGANIZATION

Looking for **Safe** and **Compliant** Decommissioning Services?  
Please, check us out: [www.AmericanDND.com](http://www.AmericanDND.com)



**Experience** where it matters most:  
PLANNING • DESIGN • EXECUTION

E-mail: [ADND@AmericanDND.com](mailto:ADND@AmericanDND.com)

Visit: [www.AmericanDND.com](http://www.AmericanDND.com)

Call: **866-699-5515**

**Safety is Job #1**



**American Demolition and Nuclear Decommissioning**

It's no accident your project is performed safely when you hire American DND, Inc.