A SNF overpack is moved onto an ISFSI pad. While a national repository has been delayed, the DOE continues to plan for the eventual removal of spent fuel from U.S. power plants. (Photo: NAC International)

Getting Rid of Inventory

Studies on moving spent nuclear fuel from several closed nuclear power plants have been prepared for the DOE by Orano's federal services team.

By Tim Gregoire

In the United States, there are currently 73 nuclear power sites with independent spent fuel storage installations (ISFSI) licensed by the Nuclear Regulatory Commission, including Fort St. Vrain and Three Mile Island-2. Seven of those power plants have been fully decommissioned, in some cases leaving only the ISFSI remaining on the site. Along with Connecticut Yankee and Maine Yankee, this includes Big Rock Point in Michigan, Fort St. Vrain in Colorado, Rancho Seco in California, Trojan in Oregon, and Yankee Rowe in Massachusetts. Three additional nuclear power plants are set to complete decommissioning in the next few years, including Humboldt Bay in California (2018), La Crosse in Wisconsin (2019), and Zion in Illinois (2020).

With the nation's program for managing spent nuclear fuel (SNF) and high-level radioactive waste currently stalled, the Department of Energy has been laying the groundwork for

implementing an integrated waste management system to allow it to take possession of SNF from commercial power reactors as required by law. As part of this initiative, the DOE is planning the transportation infrastructure for the eventual large-scale shipments of SNF and greater-than-Class C (GTCC) radioactive waste to storage and disposal sites. The DOE is looking to ship SNF and GTCC waste primarily by rail, but also by road or barge when a railway is not accessible.

To assist with the planning for the eventual removal of SNF and GTCC waste from reactor sites, Orano (formerly Areva Federal Services) developed a number of reports for the DOE assessing the tasks, equipment, and interfaces necessary to remove SNF from the ISFSIs of specific closed nuclear power plants. In the initial site-specific de-inventory reports, Orano performed a multiattribute utility analysis (MUA) to assess and identify favored routes and modes of transportation from ISFSI sites to a railroad hub located in the central U.S. and with connections to all other major rail routes. The hypothetical destination was used purely for planning and budgeting and does not imply a repository or interim storage facility will be located there.

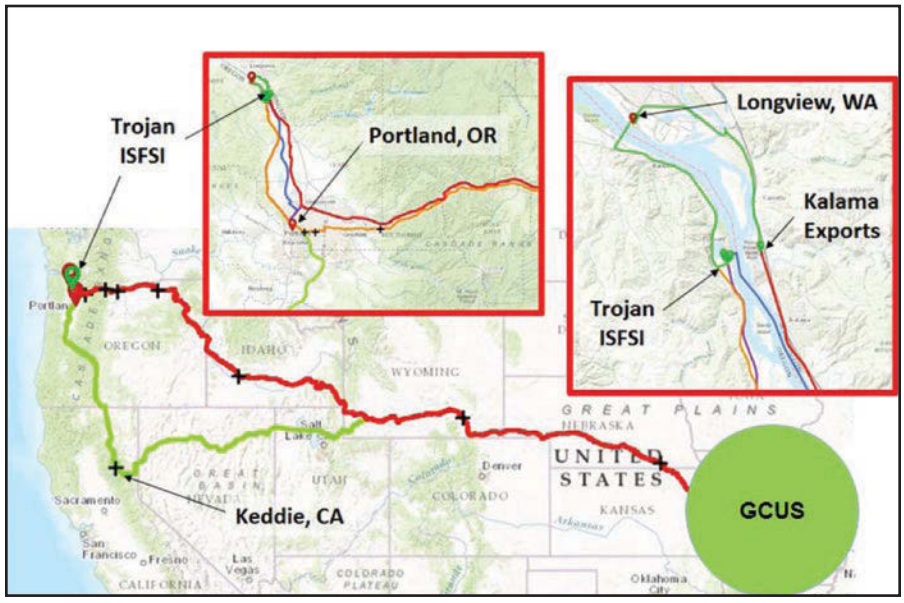

Fig. 1. Routes evaluated for the shipment of SNF from the Trojan site to a point in the geographical center of the U.S. (Image: Orano)

To support the evaluation of the routes in the MUA, Orano used input from industry subject matter experts, along with data from the DOE's Stakeholder Tool for Assessing Radioactive Transportation (START) program. MUA assessments can be performed in the future with input from other stakeholders, either as a separate assessment or in combination with the existing assessment, to examine their preference on the feasible routes.

As of this writing, Orano has developed reports for six power reactor ISFSI sites, including Trojan, Humboldt Bay, Big Rock Point, Kewaunee, Maine Yankee, and Connecticut Yankee. Each report begins by examining the existing pertinent information for each site, including a description of the site and its characteristics, the characteristics of the SNF to be shipped from the site, and a description of the multipurpose canisters that would be shipped. A transportation route analysis was then performed to identify transportation routes from each ISFSI to a Class I railroad, which would then be used for subsequent shipment to a repository or interim storage facility.

Various routes and modes of transportation, including rail, barge, and heavy-haul truck, were assessed through the MUA and ranked from high to low according to their favorability, as established by industry experts. Based on the results from the MUA, a concept of operations and recommended budget and spending plan were detailed for the highest ranked shipment route. This assessment also includes information on a security plan and procedures, along with an emergency response and preparedness plan for the prospective shipments. Finally, the reports identify the next steps recommended for the process of initiating the removal of the SNF from each ISFSI.

The six site-specific de-inventory reports are technical reports of concepts that could support future decision-making by the DOE and, according to Orano, cannot be used to draw inferences on future actions by the department. To the extent the discussions or recommendations in the reports conflict with U.S. regulations, the provisions of Part 961 of Title 10 of the Code of Federal Regulations, *Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste,* prevail.

Results of the de-inventory reports are summarized below.

Trojan

The Trojan site is located in northwestern Oregon along the Columbia River, about 42 miles north of Portland, Ore. There is about 345 metric tons of uranium at the Trojan ISFSI currently loaded into 34 Holtec International multipurpose canisters stored in 34 TranStor concrete storage casks.

From the Trojan ISFSI site itself, direct rail transport from the site, as well as heavy-haul truck and barge transport to rail transfer sites, were considered viable options for the shipment of the SNF. The report evaluated six transportation routes (see Fig. 1). While a rail spur would need to be built to the Trojan ISFSI, the two routes with the highest ratings (based on average weighting method) were by railroad from the site following the Columbia River to the central U.S and by railroad via Keddie, Calif., to the central U.S. The routes with the least favored rating were by barge to a transfer facility in Portland and by truck to Portland. According to the report, the direct transfer of SNF to rail appears to be the least complicated approach, with the minimum number of times the SNF canister and overpack cask is handled, whereas the truck and barge scenarios appear to be more complicated, with multiple canister and cask handling activities.

Trojan's 34 SNF canisters would be loaded into HI-STAR 100 casks and transported over seven separate shipments, with five casks moved in the first six shipments and four casks in the last shipment. The ISFSI boundary will need to be extended to accommodate the transfer operations and loading of the HI-STAR 100 casks onto the railcars. The report estimates that the Trojan campaign would take more than 45 weeks (including one iteration for procedure writing, dry run, testing, and training purposes before the first shipment) at a cost of $11.8 million.

Humboldt Bay

Currently nearing the end of its decommissioning, the closed Humboldt Bay power reactor is located near the town of Eureka, Calif., about 260 miles north of San Francisco. The boiling water reactor's full inventory of SNF and GTCC waste has already been transferred to the site's ISFSI and is contained in six Holtec HI-STAR HB transportation casks. There are a total of 390 SNF

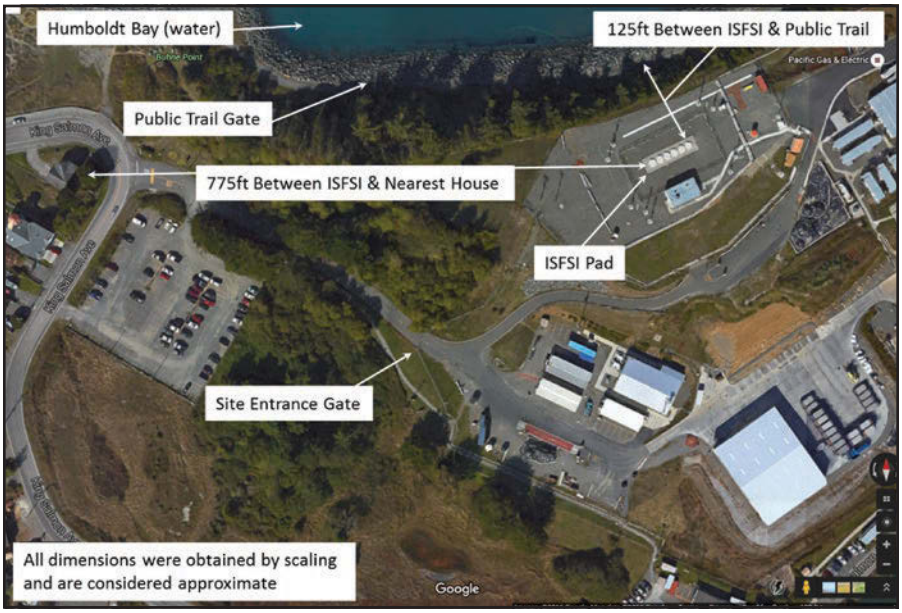

Fig. 2. Access points around the Humboldt Bay ISFSI. (Image: Orano)

assemblies and fuel debris loaded in five of the casks and the GTCC waste is loaded in the sixth cask.

While, as in the other reports, multiple modes of transportation were considered, the casks would need to be initially taken off the ISFSI site by truck due to the lack of direct access to rail and barge (Fig. 2). Of the eight transportation routes evaluated, the highest ranking route would take the SNF and GTCC waste by truck to Fields Landing about 1.5 miles south of the Humboldt Bay site, where it would be shipped by barge to Port Chicago in Concord, Calif., about 300 miles away near San Francisco. From Port Chicago, the casks could be transferred to railcars for rail shipment to the central U.S. location.

It would take an estimated 12 days to move all six casks from the ISFSI to Port Chicago and another 14 days to ship the casks by rail to their final destination. Based on the limited number of casks to be shipped, the report recommends a one-time movement of all six casks from the ISFSI. The total estimated budget for the Humboldt Bay campaign planned over five weeks (including one week of preparation before the first shipment) is $2.7 million.

Big Rock Point

The Big Rock Point site is located on the eastern shore of Lake Michigan, about 4 miles north of Charlevoix and 11 miles west of Petoskey, Mich. (Fig. 3). A boiling water reactor, the Big Rock Point nuclear power plant ceased operations in 1997 and its SNF and GTCC waste were moved to the ISFSI by May 2003 after the plant was decommissioned. There are a total of eight FuelSolutions W74 canisters loaded into W150 concrete storage casks on the ISFSI. The equipment needed to transfer the W74 canisters from the storage casks to a TS125 transportation cask is in place and is tested and maintained on a periodic basis, according to the report.

While Big Rock Point originally had rail access, the track and switches were removed in 1988 and the cost of reinstalling the approximately 20 miles of track would be prohibitive. Instead, the report recommends shipping the casks using a heavy-haul truck to one of two available railroad transfer sites in Petoskey (Clarion Avenue or Washington Street). From there the casks would go by rail to the central U.S. location via either Durand or Annpere, Mich. A barge route to a railroad transfer facility in Milwaukee was also evaluated but was the lowest ranked of the seven routes considered.

Transferring a W74 canister to a TS125 cask and preparing it for shipment will take about three days, while hauling the cask from the Big Rock Point ISFSI to the rail spur is estimated to take one day. Loading operations to transfer the cask from the transport trailer to the railcar will take another two days. The report's timeline of operations is broken down into eight transportation campaigns, with each campaign being a shipment of one single cask moving on one dedicated train. It is estimated that a single campaign will take 3.5 weeks. The total estimated budget to de-inventory the Big Rock Point site of SNF and GTCC waste organized over 36 weeks (about eight months) is $7.3 million.

Fig. 3. Access locations to the Big Rock Point ISFSI. (Image: Orano)

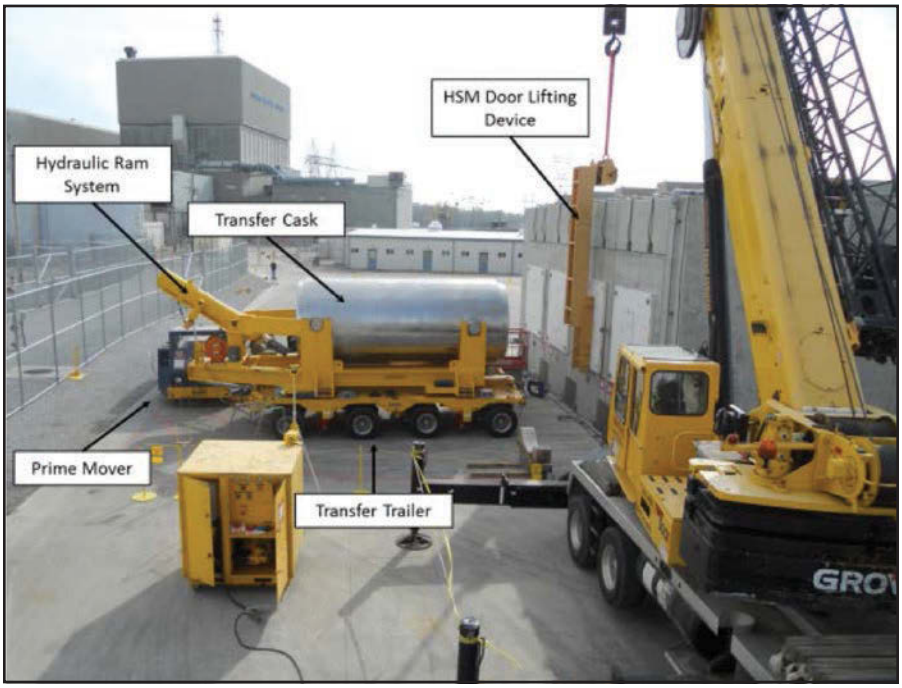

Fig. 4. Staged NUHOMS transfer equipment at the Kewaunee ISFSI. (Image: Orano)

Kewaunee

Located in Carlton, Wis., about 30 miles southeast of Green Bay and 90 miles north of Milwaukee, the Kewaunee nuclear power plant ceased operations in May 2013 and is currently undergoing decommissioning under the NRC's SAFSTOR method. Transfer of the reactor's spent fuel to the ISFSI was completed in June 2017, and it is estimated that two canisters of GTCC waste will be loaded onto the ISFSI in the near future. There are two storage systems in use on the Kewaunee ISFSI, including 14 NUHOMS horizontal storage modules supplied by TN Americas (Fig. 4) and 24 NAC MAGNASTOR vertical concrete casks from NAC International. The 14 NUHOMS dry storage canisters contain a total of 448 SNF assemblies, while the 12 MAGNASTOR canisters contain 887 SNF assemblies. The canisters would be shipped to their final destination using the TN MP197HB and NAC MAGNATRAN transport casks, respectively.

For shipping the SNF from the Kewaunee ISFSI to a railcar on a Class I railroad that can take the SNF to its final destination, the MUA ranked five routes. In the highest ranked route, the SNF would by transported by truck from the ISFSI to a rail transfer site in Green Bay, and then travel by rail on the Canadian National Railway south along the Fox River toward Chicago, and then to the central U.S. This route was slightly favored over the second ranked route, which would ship the SNF by barge to the Port of Milwaukee, where it would be loaded onto a Union Pacific train. This route was ranked lower primarily due to public resistance to shipping radioactive materials by barge on the Great Lakes.

The following two routes also were closely ranked, and according to the report, the slight difference between the top four routes indicate that there are multiple viable, similar routes from Kewaunee, and an actual selection will depend on the conditions of these routes and transfer sites when the time to ship grows near. The total estimated budget for the whole campaign organized over 56 weeks (about 13 months) is $19.3 million.

Maine Yankee

The Maine Yankee site is located in the midcoast region of Maine, about 25 miles south of Augusta and 45 miles northeast of Portland. Once the home of a 931-MWe pressurized water reactor power plant, which ceased operations in December 1996, the site license was reduced to just the ISFSI in 2005. The inventory of SNF and GTCC waste intended to be shipped from Maine Yankee is contained in 64 NAC International Universal Multi-Purpose Canister System (UMS) storage units, which includes transportable storage canisters and vertical concrete casks. There are a total of 1,434 SNF assemblies and fuel debris loaded in 60 UMS units, and GTCC waste is loaded in the remaining four UMS units.

The highest of six ranked routes would use an on-site rail spur, which has been partially paved over and would require some refurbishment (Fig. 5). The casks would be moved by rail about 135 miles to Worcester, Mass., where an interchange between the Class II rail carrier and the Class I carrier would take place. The casks would then go by rail to their final destination. A truck and trailer would be needed to first move the casks to the on-site rail spur, which is about 500 feet from the gate of the Maine Yankee ISFSI.

The SNF and GTCC waste would be transported in 13 round-trip shipments of five UMS universal transport casks over a period of six weeks each. An additional six weeks of planning and preparation also would be needed before the start of the first campaign. The total estimated budget for the Maine Yankee

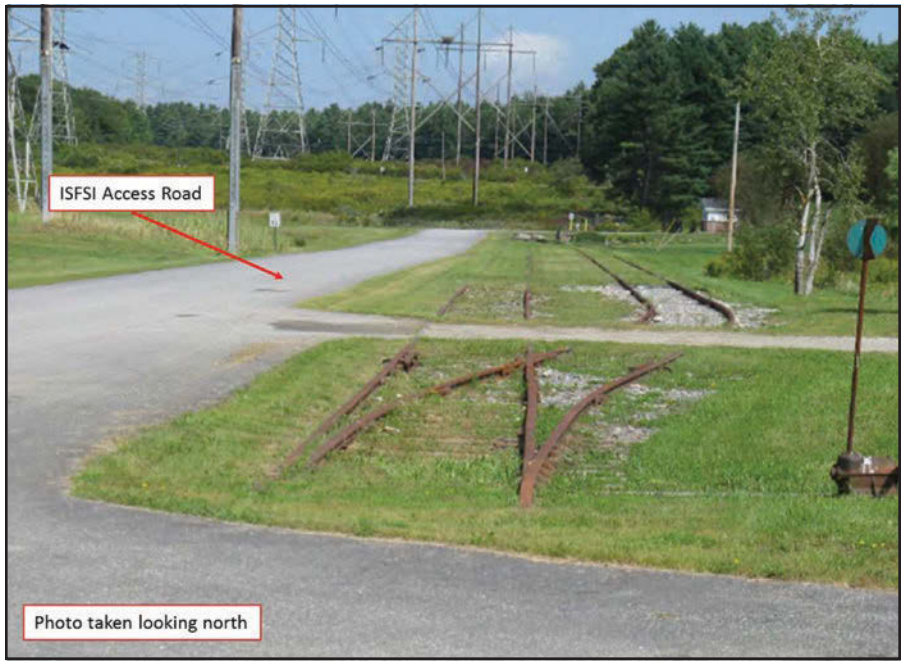

Fig. 5. The condition of the railroad spur at Maine Yankee. (Photo: DOE)

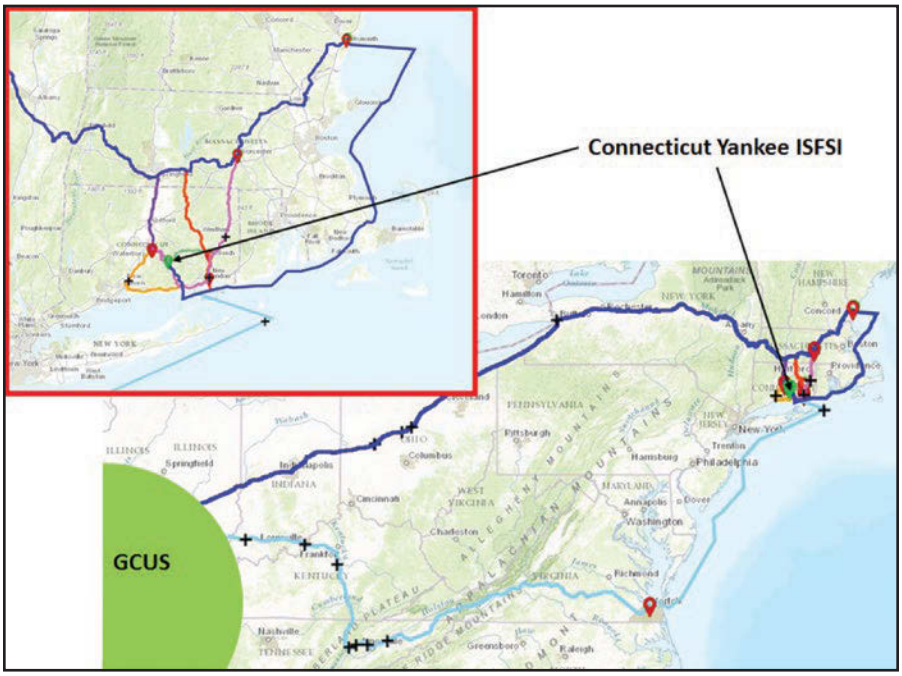

Fig. 6. Routes evaluated for the shipment of SNF from Connecticut Yankee to the central U.S. (Image: Orano)

campaign organized over 84 weeks (about 19 months) (including one iteration for procedure writing, dry run, testing, and training before the first shipment) is $24.1 million.

Connecticut Yankee

Similar to Maine Yankee, the Connecticut Yankee nuclear power plant ceased operations in 1996, and the site license is limited to the 5.7 acres the ISFSI occupies. Located on the eastern shore of the Connecticut River near Haddam Neck, Conn., the site is about 13 miles southeast of Middletown and 25 miles southeast of Hartford. There are 43 storage casks at the Connecticut Yankee ISFSI, with 40 of the casks containing SNF and three containing GTCC waste. For shipping, the NAC International multipurpose canisters holding the SNF and GTCC waste would be loaded into NAC Storable Transport Casks.

As the Connecticut Yankee site is not served by rail, the three highest ranked routes would all transport the casks by heavy-haul truck from the ISFSI to a rail transfer site in Portland, Conn., about 13 miles away. In the first route, the casks would travel by rail southwest from Portland to New Haven, then to the Worcester, Mass., interchange before moving on to the central U.S. Rail routes southeast through New London and northwest through Hartford were also highly ranked. Of the seven routes evaluated (Fig. 6), the three lowest ranked routes would ship the casks by barge to railroad sites in New London; Portsmouth, Maine; and Norfolk, Va., respectively.

Campaign operations would be broken down into eight round-trip shipments of five casks and one one-way shipment of three casks over a period of six weeks each. An additional eight to nine weeks of planning and preparation would be needed before the start of the first campaign. The total estimated budget for the entire Connecticut Yankee campaign organized over 60 weeks (about 14 months) is $17 million.

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