Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites

Fuel Cycle Research & Development

Prepared for
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Nuclear Fuels Storage and
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EXECUTIVE SUMMARY

This report fulfills the M3 milestone M3FT-15PN0912038, "Revised Final Shutdown Sites Report." Changes from Revision 2 (October 2014) of the report include adding the recently shut down Vermont Yankee site to the report; updating of Google Earth imagery; incorporating revisions to transportation certificates of compliance; revising the estimated number of canisters stored at the Crystal River and San Onofre sites; and adding information obtained from site visits to Kewaunee, Crystal River, and San Onofre.

In January 2013, the U.S. Department of Energy (DOE) issued the *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (DOE 2013). Among the elements contained in this strategy are siting, designing, licensing, constructing and operating a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shutdown reactor sites. This focus is consistent with the recommendations of the Blue Ribbon Commission on America's Nuclear Future, which identified removal of stranded used nuclear fuel at shutdown sites as a priority so that these sites may be completely decommissioned and put to other beneficial uses (BRC 2012). The strategy also includes a phased, adaptive, and consent-based approach to siting. New statutory authority would be required to construct an interim storage facility, but DOE's existing authorities would allow the DOE to begin a consent-based siting process. Shutdown sites are defined as those commercial nuclear power reactor sites where the nuclear power reactors have been shut down and the site has been decommissioned or is undergoing decommissioning. In this report, a preliminary evaluation of removing used nuclear fuel from 13 shutdown sites was conducted. The shutdown sites evaluated were Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, San Onofre, and Vermont Yankee.[1] These sites have no operating nuclear power reactors at their sites and have also notified the U.S. Nuclear Regulatory Commission (NRC) that their reactors have permanently ceased power operations and that nuclear fuel has been permanently removed from their reactor vessels. Shutdown reactors at sites also having operating reactors are not included in this evaluation.

The evaluation was divided into four components:

- characterization of the used nuclear fuel and greater-than-Class C (GTCC) low-level radioactive waste inventory[2]
- a description of the on-site infrastructure and conditions relevant to transportation activities
- an evaluation of the near-site transportation infrastructure and experience relevant to shipping transportation casks containing used nuclear fuel from the shutdown sites, including gaps in information

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[1] To the extent the discussions or recommendations in this report conflict with the provisions of the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste, 10 CFR § 961.11, the Standard Contract provisions prevail.

[2] Removal of GTCC low-level radioactive waste at shutdown sites was analyzed in this report because the Court of Appeals for the Federal Circuit (Fed. Cir. 2008a, 2008b) has held that because the NRC has determined by rule that, unless the NRC approves an alternative method, GTCC low-level radioactive waste requires disposal in a geologic repository, such waste is considered high-level radioactive waste under the terms of the Standard Contract.

- an evaluation of the actions necessary to prepare for and remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

Using these evaluations, the authors developed time sequences of activities and time durations for removing the used nuclear fuel and GTCC low-level radioactive waste from a single shutdown site and from the Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion sites. The Crystal River, Kewaunee, San Onofre, and Vermont Yankee sites were not included because these sites only recently shut down. Because these four sites are at the beginning stages of the decommissioning process, they generally do not have fully developed irradiated fuel management plans or post-shutdown decommissioning activities reports, making estimates of time durations for removing the used nuclear fuel and GTCC low-level radioactive waste from these sites less certain.

The 13 shutdown sites use designs from 4 different suppliers, including 11 different (horizontal and vertical) storage systems that would require 9 different transportation cask designs. At the 13 shutdown sites, a total of 17,963 used nuclear fuel assemblies and a total of 6227.7 metric tons heavy metal (MTHM) of used nuclear fuel are forecast to be stored in 506 to 512 storage canisters (actual plus estimated). In addition, 35 canisters (actual plus estimated) containing GTCC low-level radioactive waste are forecast to be stored at these sites. Several issues were identified during the characterization of the used nuclear fuel and GTCC low-level radioactive waste inventory at the shutdown sites. The most important of the issues was at the Rancho Seco site, where six damaged fuel assemblies in five of the storage canisters were not placed in failed fuel dry shielded canisters (FF-DSCs). Further evaluation would be needed to determine if the canisters containing this damaged fuel can be shipped in the MP187 transportation cask without repackaging. In addition, the transportation certificate of compliance for the HI-STAR HB cask would need to be revised to allow transport of 44 used nuclear fuel assemblies at the Humboldt Bay site with initial enrichments of 2.08 weight percent, which is less than the minimum initial enrichment of 2.09 weight percent authorized by the transportation certificate of compliance for the HI-STAR HB cask.

The lists of approved contents in the certificates of compliance for the TS125, HI-STAR HB, HI-STAR 100, and MP187 transportation casks do not include GTCC low-level radioactive waste. For GTCC low-level radioactive waste to be shipped from the Humboldt Bay, Rancho Seco, San Onofre, and Vermont Yankee sites in these transportation casks, changes to the transportation certificates of compliance would be required. Also, the certificates of compliance for the TS125 and MP187 transportation casks would need to be updated from a -85 to a -96 designation before the casks or impact limiters could be fabricated. In addition, the used nuclear fuel or GTCC low-level radioactive waste that may be stored in 32PTH2 canisters at San Onofre would not be transportable without changes to the list of approved contents in the certificate of compliance for the MP197HB transportation cask.

Six of the sites, Maine Yankee, Zion, Crystal River, Kewaunee, San Onofre, and Vermont Yankee, have high burnup (>45 gigawatt-day per metric ton heavy metal [GWd/MTHM]) used nuclear fuel assemblies in storage. At Maine Yankee and Zion, these high burnup used nuclear fuel assemblies are packaged in damaged fuel cans, which eliminates the concern over the transportability of this high burnup fuel. High burnup used nuclear fuel stored in 32PTH1 canisters at Crystal River and 24PT4 canisters at San Onofre would be transportable in the MP197HB transportation cask. High burnup used nuclear fuel that will be stored in MPC-68 canisters at the Vermont Yankee site would not be transportable without changes to the list of approved contents in the certificate of compliance for the HI-STAR 100 transportation cask. An application for a certificate of compliance for the HI-STAR 190 transportation cask has been submitted to the NRC; high burnup used nuclear fuel that will be stored in MPC-37 canisters at San Onofre would be transportable if it is included in the list of approved contents in the certificate of compliance for the HI-STAR 190 transportation cask.

All sites were found to have at least one off-site transportation mode option for removing their used nuclear fuel and GTCC low-level radioactive waste, and some sites have multiple options. Table S-1 provides a summary of these transportation mode options for the shutdown sites. Experience with large component removals during reactor decommissioning provided an important source of information in developing Table S-1. In addition, it is assumed that any refurbishment or upgrade of on-site infrastructure required prior to receipt of equipment for loading and transportation would be performed by the shutdown site organization to facilitate timely shipping of used nuclear fuel and GTCC low-level radioactive waste from the site.

The actions necessary to prepare for and remove the used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites are listed as tasks in Table S-2. These identified actions are based on the assumption that DOE or another management and disposal organization would be responsible for shipping to, and the operation of, the pilot interim storage facility, and might differ if a private entity were responsible for shipping to, or the operation of, the pilot interim storage facility. Based on these tasks, the characteristics of the sites' inventories of used nuclear fuel and GTCC low-level radioactive waste, the on-site conditions, and the near-site transportation infrastructure and experience, time sequences of activities and time durations were developed to prepare for and remove the used nuclear fuel and GTCC low-level radioactive waste from a single shutdown site and from nine of the shutdown sites. Figure S-1 presents the ranges in the estimates of time durations for the single-shutdown site scenario. For a single shutdown site, the estimated time to prepare for and remove the used nuclear fuel and GTCC low-level radioactive waste ranged from 6.2 to 11.2 years. These estimates were based on a range of time durations for tasks, and on varying numbers of available transportation casks, which combine to yield the upper and lower estimates in Figure S-1.

Figure S-2 presents the representative durations and sequence of activities to prepare for and remove all used nuclear fuel and GTCC low-level radioactive waste from the nine shutdown sites. In Figure S-2 the cumulative duration of 11.5 to 14.5 years was based on staggered shipping campaigns and optimistic estimates of time durations for tasks and includes the schedule uncertainty associated with procurement of casks and railcars and coordination of shipping campaigns. As mentioned previously, the representative durations and sequence of activities shown in Figure S-2 do not include Crystal River, Kewaunee, San Onofre, and Vermont Yankee.

The estimated durations presented in Figure S-1 and Figure S-2 were most affected by the time required to load and transport the used nuclear fuel and GTCC low-level radioactive waste; procure casks, components, and campaign kits; and the time required to procure railcars that meet Association of American Railroads (AAR) Standard S-2043 (AAR 2008). While the latter two activities could take place in parallel, they still represent a significant fraction of the time it would take to prepare for and remove the used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

Table S-1. Summary of Transportation Mode Options for Shipments from Shutdown Sites

Site	Transportation Mode Options		Comments
Maine Yankee	Direct rail	Barge to rail	The on-site rail spur is not being maintained. The condition of the Maine Eastern Railroad would need to be verified.
Yankee Rowe	Heavy haul truck to rail	–	The shortest heavy haul would be 7.5 miles to the east portal of the Hoosac Tunnel.
Connecticut Yankee	Barge to rail	Heavy haul truck to rail	The on-site barge slip has not been used since decommissioning but remains intact. It is uncertain whether the cooling water discharge canal is deep enough to accommodate barges without dredging. The shortest heavy haul would be about 12.5 miles to the end of the Portland rail spur. The rail infrastructure at the end of the Portland rail spur would need to be evaluated.
Humboldt Bay	Heavy haul truck to rail	Heavy haul truck to barge to rail	The heavy haul distance to a rail siding or spur would be in the range of 160 to 280 miles. The condition of the Fields Landing Terminal located 2 miles from the Humboldt Bay site would need to be verified for barge transport.
Big Rock Point	Heavy haul truck to rail	Barge to rail	The heavy haul would probably be about 52 miles to Gaylord, Michigan. A shorter heavy haul of 13 miles to Petoskey, Michigan may be possible. The rail infrastructure at these locations would need to be evaluated.
Rancho Seco	Direct rail	–	The rail spur is not being maintained. Weight restrictions on the Ione Industrial Lead would require route clearance by the railroad or a track upgrade.
Trojan	Direct rail	Barge to rail	The on-site rail spur was removed.
La Crosse	Direct rail	Barge to rail	An on-site rail spur was used to ship the reactor pressure vessel. The location and method for loading the transportation cask and moving the transportation cask to a rail spur is uncertain.
Zion	Direct rail	Barge to rail	The rail spur was recently refurbished to support reactor decommissioning waste shipments.
Crystal River	Direct rail	Barge to rail	Extensive on-site rail system serves co-located fossil fuel plants.
Kewaunee	Heavy haul truck to rail	Heavy haul truck to barge to rail	Condition of potential heavy haul truck routes, transload locations, and rail infrastructure would need to be evaluated.
San Onofre	Direct rail	Heavy haul truck to barge to rail	The rail spur was recently refurbished to support reactor decommissioning waste shipments for San Onofre-1.
Vermont Yankee	Direct Rail	–	On-site rail spur will be reactivated to support decommissioning.

Table S-2. Activities to Prepare for and Remove Used Nuclear Fuel from Shutdown Sites

Task	Task Activity Description
Programmatic Activities to Prepare for Transport Operations from a Shutdown Site	
1 – Assemble Project Organization	Assemble management teams, identify shutdown site existing infrastructure, constraints, and transportation resource needs and develop interface procedures.
2 – Acquire Casks, Railcars, Ancillary Equipment and Transport Services	Develop specifications, solicit bids, issue contracts, and initiate preparations for shipping campaigns. Includes procurement of transportation casks and revisions to certificates of compliance as may be needed, procurement of AAR Standard S-2043 railcars, and procurement of off-site transportation services.
3 – Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport for shutdown site.
4 – Coordinate with Stakeholders	Assess and select routes and modes of transport and support training of transportation emergency response personnel.
5 – Develop Campaign[a] Plans	Develop plans, policies, and procedures for at-site operational interfaces and acceptance, support operations, and in-transit security operations.
Operational Activities to Prepare, Accept, and Transport from a Shutdown Site	
6 – Conduct Readiness Activities	Assemble and train at-site operations interface team and shutdown site workers. Includes readiness reviews, tabletop exercises and dry run operations.
7 – Load for Off-site Transport	Load and prepare casks and place on transporters for off-site transportation.
8 – Accept for Off-site Transport	Accept loaded casks on transporters for off-site transportation.
9 – Transport	Ship shutdown site casks.

AAR = Association of American Railroads

a. A campaign plan contains step-by-step, real-time instructions for completing a shipment from an origin site.

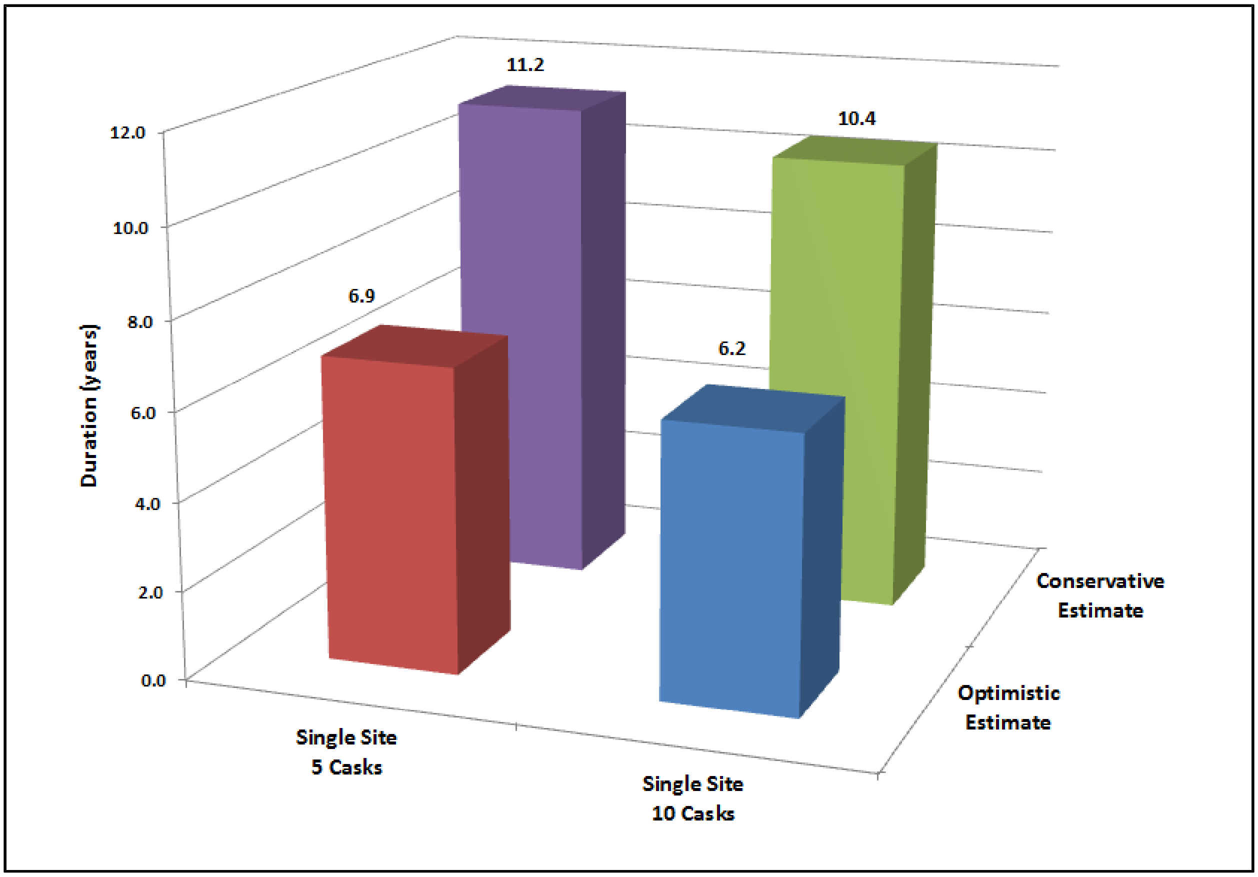

Figure S-1. Estimated Time Durations to Prepare for and Remove Used Nuclear Fuel and GTCC Low-Level Radioactive Waste from a Single Shutdown Site

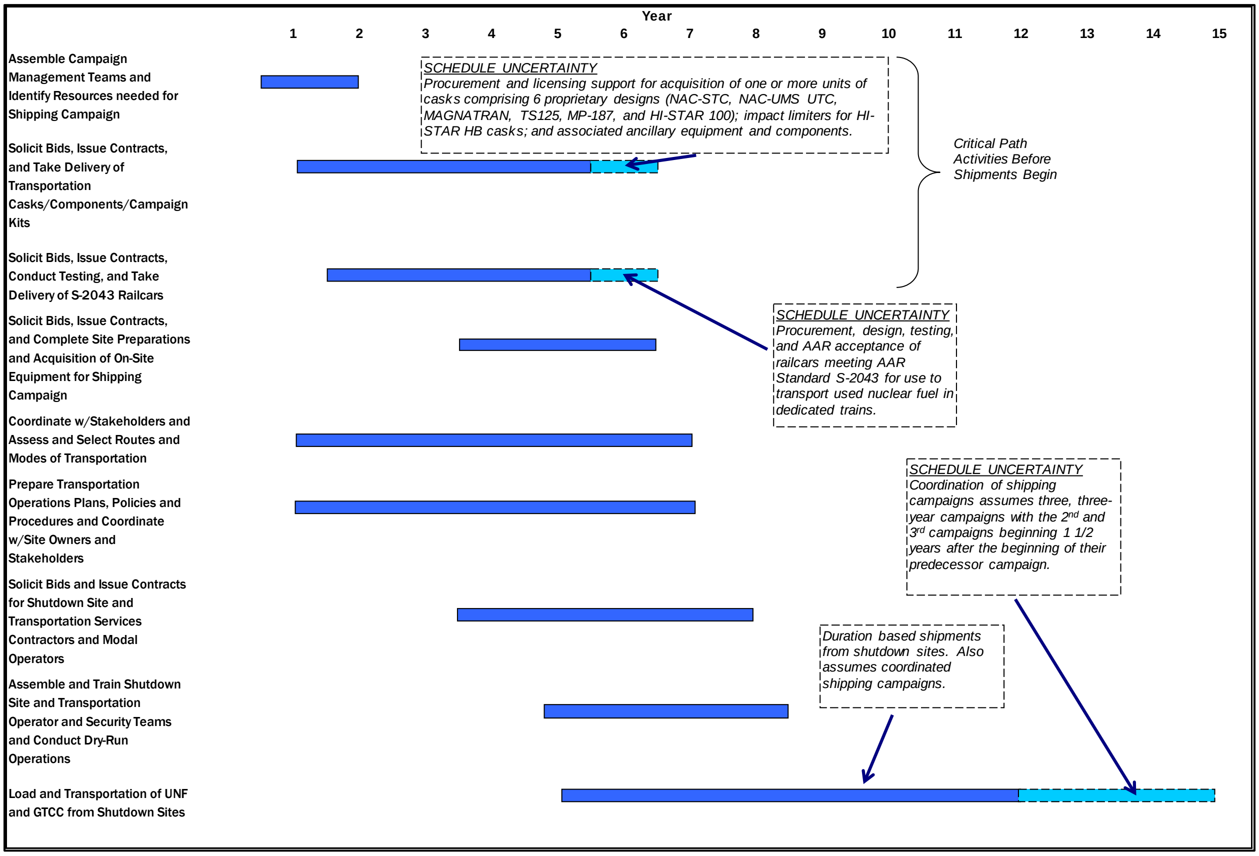

Figure S-2. Estimated Durations of Key Activities to Prepare for and Remove Used Nuclear Fuel and GTCC Low-Level Radioactive Waste from Nine Shutdown Sites

Project activities that would precede shipments from all of the shutdown sites would require only a slightly greater amount of time than that which would be required for one shutdown site. This assumes that project resources (personnel, funding, and functions such as procurement and quality assurance) would be adequate to support concurrent acquisitions of transportation casks and associated components that would include several units of each of the seven transportation casks that would be used at Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion—the NAC-STC, NAC-UMS UTC, MP187, TS125, HI-STAR 100, HI-STAR HB, and MAGNATRAN; and to acquire and certify the fleet of cask, buffer, and escort railcars that would be needed. It also assumes that there would be flexibility in making acquisitions such as limited constraints on procuring casks and associated components from non-domestic suppliers.

As part of this preliminary evaluation, twelve shutdown sites have been visited: Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, and San Onofre. In order to refine the information in this report and to refine the estimates of activities and task durations, the authors recommend that the one remaining shutdown site (Vermont Yankee) be visited. As additional nuclear power reactor sites such as FitzPatrick, Pilgrim, and Oyster Creek shut down, these sites should be included in updates to the report.

The estimates of durations for project tasks presented here are preliminary and depend on the many identified assumptions. Consequently, in preparing a comprehensive project plan to prepare for and remove used nuclear fuel from the shutdown sites it will be necessary to refine the estimates using improved information regarding each of the sites and their near-site transportation infrastructure, and using methods that will allow managers to gauge the importance of assumptions and project considerations. In this regard, it is recommended that DOE or another management and disposal organization use a quantitative risk analysis tool to provide estimates of project risks and opportunities. Such quantitative analyses would support estimating, managing, and funding of contingencies, and would increase confidence that the project would be successfully executed. Risk-informed estimates would also allow the project's managers to anticipate time and funding resources, and alternative courses of action that might be needed to effectively respond to changing circumstances.

DOE or another management and disposal organization should also take advantage of improved information regarding loading and transportation of used nuclear fuel from the shutdown sites to refine the data used by the DOE Transportation Operations Model (TOM) to evaluate optimizations that may be possible in acquiring and using transportation resources. TOM could also be used to conduct sensitivity analyses and identify important gaps in information that could be filled with additional data collected from the shutdown sites. Information developed using TOM could also be used in case studies conducted using the quantitative analysis tools discussed above.

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FIGURES

TABLES

ACRONYMS

AAR	Association of American Railroads
AC&T	American Cranes & Transport
ADAMS	U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System
BRC	Blue Ribbon Commission on America's Nuclear Future
BWR	boiling water reactor
CSI	Criticality Safety Index
CY	Connecticut Yankee
DOE	U.S. Department of Energy
DSI	DeskMap Systems, Inc.
EIA	Energy Information Agency
EPRI	Electric Power Research Institute
FC-DSC	fuel with control component dry shielded canister
FF-DSC	failed fuel dry shielded canister
FO-DSC	fuel only dry shielded canister
GTCC	greater-than-Class C
GWd/MTHM	gigawatt-day per metric ton heavy metal
HBHRCD	Humboldt Bay Harbor, Recreation & Conservation District
IAEA	International Atomic Energy Agency
ISFSI	independent spent fuel storage installation
MCBCP	Marine Corps Base Camp Pendleton
MPC	multipurpose canister
MTHM	metric tons heavy metal
MWe	megawatt electric
MWt	megawatt thermal
NRC	U.S. Nuclear Regulatory Commission
PG&E	Pacific Gas and Electric Company
PWR	pressurized water reactor
QA	quality assurance
STB	Surface Transportation Board
STC	storage transport cask
STRACNET	Strategic Rail Corridor Network

TN	Transnuclear, Inc.
TOM	Transportation Operations Model
TOPO	Transportation Operations Project Office
TSC	Transportable Storage Canister
UNF	used nuclear fuel
USACE	U.S. Army Corps of Engineers
UTC	Universal Transport Cask

NUCLEAR FUELS STORAGE AND TRANSPORTATION PLANNING PROJECT

Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites

1. INTRODUCTION

This report provides a preliminary evaluation of removing stranded used nuclear fuel from 13 shutdown sites.[3] Changes from the Revision 2 (October 2014) of the report include adding the recently shut down Vermont Yankee site to the report; updating of Google Earth imagery; incorporating revisions to transportation certificates of compliance; revising the estimated number of canisters stored at the Crystal River and San Onofre sites; and adding information obtained from site visits to Kewaunee, Crystal River, and San Onofre.

Shutdown sites are defined as those commercial nuclear power reactor sites where the nuclear power reactors have been shut down and the site has been decommissioned or is undergoing decommissioning. The shutdown sites evaluated are Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, San Onofre, and Vermont Yankee. These sites have no other operating nuclear power reactors at their sites and have also notified the U.S. Nuclear Regulatory Commission (NRC) that their reactors have permanently ceased power operations and that nuclear fuel has been permanently removed from their reactor vessels. Shutdown reactors at sites having operating reactors are not included in this evaluation. Reactors that have agreements to shut down in the future but that have not notified the NRC that they have permanently ceased power operations and that nuclear fuel has been permanently removed from their reactor vessels are also not included in this evaluation.

The locations of the shutdown sites are shown in Figure 1-1. The material to be removed from the shutdown sites includes both the used nuclear fuel and the greater-than-Class C (GTCC) low-level radioactive waste[4] that is stored, or will be stored, at the independent spent fuel storage installations (ISFSIs) at each one of the sites.

The preliminary evaluation of removing the used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites was divided into four components:

- characterization of the used nuclear fuel and GTCC low-level radioactive waste inventory

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[3] To the extent the discussions or recommendations in this report conflict with the provisions of the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste, 10 CFR § 961.11, the Standard Contract provisions prevail.

[4] In the used nuclear fuel litigation, the Court of Appeals for the Federal Circuit (Fed. Cir. 2008a, 2008b) has held that because the NRC has determined by rule that, unless the NRC approves an alternative method, GTCC low-level radioactive waste requires disposal in a geologic repository, such waste is considered high-level radioactive waste under the terms of the Standard Contract. Accordingly, for purposes of this report, the removal of GTCC low-level radioactive waste along with used nuclear fuel at shutdown reactor sites was analyzed.

Figure 1-1. Locations of Shutdown Sites

- a description of the on-site infrastructure and conditions relevant to transportation activities
- an evaluation of the near-site transportation infrastructure and experience relevant to shipping transportation casks containing used nuclear fuel from the shutdown sites, including gaps in information
- an evaluation of actions necessary to prepare for and remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

These evaluations are contained in Section 2. Section 3 contains an overview of the requirements for off-site transportation infrastructure.

Section 4 contains time sequences of activities and their durations developed from the lists of actions that are necessary to prepare for and remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites. Total time durations for a single-site scenario are developed for conservative and optimistic estimates of the time durations for tasks, and assuming varying numbers of available casks. Representative durations and sequences of activities to prepare for and remove all used nuclear fuel and GTCC low-level radioactive waste from nine of the shutdown sites are also presented, and include the schedule uncertainty associated with procurement of casks and railcars and coordination of shipping campaigns. Crystal River, Kewaunee, San Onofre, and Vermont Yankee were not included because these sites only recently shut down and are at the beginning stages of the decommissioning process. These sites generally do not have fully developed irradiated fuel management plans or post-shutdown decommissioning activities reports, making estimates of time durations for removing the used nuclear fuel and GTCC low-level radioactive waste from these sites less certain.

2. SITE INVENTORY, SITE CONDITIONS, NEAR-SITE TRANSPORTATION INFRASTRUCTURE AND EXPERIENCE, AND GAPS IN INFORMATION

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the shutdown sites. The primary sources for the inventory of used nuclear fuel and GTCC low-level radioactive waste are the RW-859 database (EIA 2002), industry sources such as *StoreFUEL* and *SpentFUEL*, and government sources such as the NRC. The primary sources for the information on the site conditions and near-site transportation infrastructure and experience include site visits to the Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, and San Onofre sites; information provided by managers at the shutdown sites; Facility Interface Data Sheets compiled for the U.S. Department of Energy (DOE) in 2005 (TriVis Incorporated 2005); Services Planning Documents prepared for DOE in 1993 and 1994; industry publications such as *Radwaste Solutions*; and Google Earth (Google 2015). Where on-site infrastructure upgrades or refurbishments are needed or where specialized equipment is required, they are assumed to be known by the shutdown site organization and that the shutdown site organization will complete the necessary tasks by the time of the delivery of transportation casks and equipment.

Table 2-1 lists the characteristics of the commercial nuclear power reactors that operated at the shutdown sites. These reactors operated between the years 1961 and 2014. Four of the reactors (Humboldt Bay, Big Rock Point, La Crosse, and Vermont Yankee) were boiling water reactors and twelve of the reactors were pressurized water reactors (Maine Yankee, Yankee Rowe, Connecticut Yankee, Rancho Seco, Trojan, Zion 1 and 2, Crystal River, Kewaunee, and San Onofre-1, -2, and -3). The licensed capacities for these reactors ranged from 165 to 3438 MWt (48 to 1130 MWe). Decommissioning has been completed for five of the sites and is ongoing at Humboldt Bay, Rancho Seco, La Crosse, Zion, and San Onofre-1. Decommissioning activities are commencing at Crystal River, Kewaunee, San Onofre-2 and -3, and Vermont Yankee. At these four sites, the used nuclear fuel that was in the reactor vessels at shutdown has been removed from the reactor vessels and transferred to spent fuel pools.

Figure 2-1 illustrates the number of canisters and type of storage canisters containing used nuclear fuel and GTCC low-level radioactive waste that are stored or will be stored at each of the shutdown sites. The number of canisters stored at Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion represent actual canisters in storage. The number of used nuclear fuel canisters at Crystal River, Kewaunee, San Onofre, and Vermont Yankee represents an estimate of the number of canisters that will be stored at the conclusion of canister loading and the number of canisters at Crystal River, Kewaunee, and San Onofre containing GTCC low-level radioactive waste represents an estimate of the number of canisters generated during decommissioning. There are expected to be a total of 541 to 547 canisters in storage at the 13 sites (actual plus estimated). The number of canisters ranges from 5 at La Crosse to an estimated 134 to 140 at San Onofre.

Table 2-1. Characteristics of Shutdown Site Reactors[a]

Site Location	Reactor Type	MWt	MWe (net)	Operating Period[b]	Current Status
Maine Yankee, Wiscasset, Maine	PWR	2700	860	1972-1996	DECON[c] completed
Yankee Rowe, Rowe, Massachusetts	PWR	600	167	1961-1991	DECON completed
Connecticut Yankee, Meriden, Connecticut	PWR	1825	560	1968-1996	DECON completed
Humboldt Bay, Eureka, California	BWR	200	63	1963-1976	DECON in progress
Big Rock Point, Charlevoix, Michigan	BWR	240	67	1963-1997	DECON completed
Rancho Seco, Herald, California	PWR	2772	913	1975-1989	DECON in progress
Trojan, Rainier, Oregon	PWR	3411	1130	1976-1992	DECON completed
La Crosse, Genoa, Wisconsin	BWR	165	48	1969-1987	SAFSTOR[d,e]
Zion 1, Zion, Illinois	PWR	3250	1040	1973-1997	DECON in progress
Zion 2, Zion, Illinois	PWR	3250	1040	1974-1996	DECON in progress
Crystal River, Crystal River, Florida	PWR	2609	860	1977-2009	SAFSTOR in progress UNF removed from reactor vessel 05/28/2011
Kewaunee, Kewaunee, Wisconsin	PWR	1772	574	1974-2013	SAFSTOR in progress UNF removed from reactor vessel 05/14/2013
San Onofre-1, San Clemente, California	PWR	1347	436	1968-1992	SAFSTOR
San Onofre-2, San Clemente, California	PWR	3438	1070	1983-2013	SAFSTOR in progress UNF removed from reactor vessel 07/18/2013
San Onofre-3, San Clemente, California	PWR	3438	1080	1984-2013	SAFSTOR in progress UNF removed from reactor vessel 10/05/2012
Vermont Yankee, Vernon, Vermont	BWR	1912	605	1972-2014	SAFESTOR in progress UNF removed from reactor vessel 12/29/2014

a. Sources: NRC (2013) and IAEA (2012)
b. The operating period represents the date of commercial operation to the date of shutdown.
c. DECON is a method of decommissioning in which structures, systems, and components that contain radioactive contamination are removed from a site and safely disposed of at a commercially operated low-level radioactive waste disposal facility or decontaminated to a level that permits the site to be released for unrestricted use shortly after it ceases operation (NRC 2013).
d. SAFSTOR is a method of decommissioning in which a nuclear facility is placed and maintained in a safe and stable condition, and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use (NRC 2013).
e. DECON expected to resume in 2016.
PWR= pressurized water reactor
BWR= boiling water reactor
UNF= used nuclear fuel

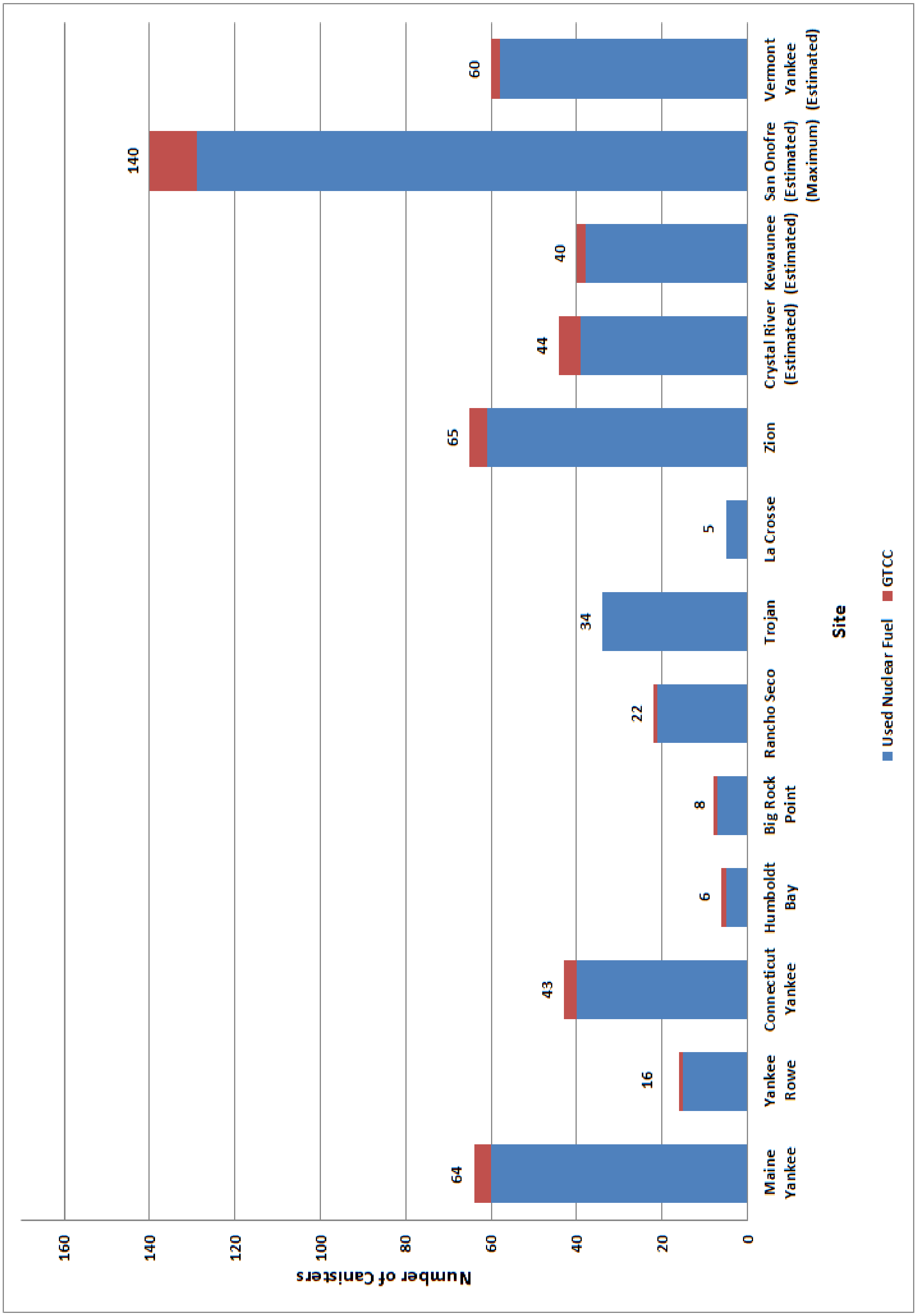

Figure 2-1. Number of Canisters at Shutdown Sites

Figure 2-2 illustrates the number of used nuclear fuel assemblies stored at each site. There are a total of 17,963 used nuclear fuel assemblies present at the shutdown sites. These assemblies are composed of 12,919 pressurized water reactor assemblies and 5044 boiling water reactor assemblies. The number of assemblies ranges from 333 at La Crosse to 3880 at Vermont Yankee. The majority (16,301) of the used nuclear fuel assemblies are zirconium alloy-clad;[5] but Yankee Rowe, Connecticut Yankee, La Crosse, and San Onofre-1 have 1662 stainless steel-clad used nuclear fuel assemblies in storage.

Figure 2-3 illustrates the same information in terms of the metric tons of heavy metal stored at each site. A total of 6227.7 metric tons heavy metal (MTHM) of used nuclear fuel at the shutdown sites consists of 5399.5 MTHM of pressurized water reactor used nuclear fuel and 828.2 MTHM of boiling water reactor used nuclear fuel. The number of assemblies and MHTM of used nuclear fuel at each shutdown site were obtained from the RW-859 database (EIA 2002), from information provided by the shutdown sites, and from projections made using the TSL-CALVIN computer code (Nutt et al. 2012), and may not include material such as fuel debris and failed fuel rods that may also be present in the storage canisters at the shutdown sites.

Table 2-2 lists the storage systems used at the shutdown sites and the corresponding transportation casks that are certified to ship the storage canisters containing used nuclear fuel and GTCC low-level radioactive waste at each of the sites.[6] Out of the nine transportation cask designs listed in Table 2-2, only three types have been fabricated for U.S. use: the HI-STAR HB, the MP187, and the HI-STAR 100.[7] The HI-STAR HB can only be used to ship used nuclear fuel from the Humboldt Bay site. The MP187 can be used to ship used nuclear fuel from the Rancho Seco and San Onofre sites. The HI-STAR 100 casks that have been fabricated are already being used as storage casks at the Dresden and Hatch sites (Ux Consulting 2015a). For these HI-STAR 100 casks to be used to ship used nuclear fuel from the Trojan or Vermont Yankee sites, they would need to be unloaded, their contents placed in other storage overpacks, and the casks transported to the Trojan or Vermont Yankee sites. It would also be necessary to procure impact limiters and spacers for these HI-STAR 100 casks. Two NAC-STC transportation casks have been fabricated for use in China (Washington Nuclear Corporation 2003), but not for use in the United States. In addition, an MP197HB transportation cask is being fabricated in Japan (Vanderniet 2012). Fabrication is expected to be completed in 2015. Currently, there is no transportation cask certified to ship used nuclear fuel stored in NUHOMS 32PTH2 or Holtec MPC-37 canisters.

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[5] The term zirconium alloy clad encompasses Zircaloy-2, Zircaloy-4, ZIRLO, and M5 clad assemblies.

[6] Appendix A lists the docket number, package identification number, revision number, certificate of compliance expiration date, and the U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) accession number for the transportation casks certified to transport used nuclear fuel from the shutdown sites; the docket number, certificate of compliance number issue date, certificate of compliance expiration date, amendment number, amendment effective date, and ADAMS accession number for the general licensed storage systems used at the shutdown sites; and the license number, docket number, license issue date, license expiration date, amendment number, amendment date, and ADAMS accession number for the Humboldt Bay, Rancho Seco, and Trojan site-specific licenses. Appendix B discusses rail infrastructure assessments conducted during site visits to the Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion sites. Appendix C presents a summary of state permitting requirements for oversize and overweight truck shipments in California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Oregon, Vermont, and Wisconsin.

[7] Impact limiters have not been fabricated for these transportation casks.

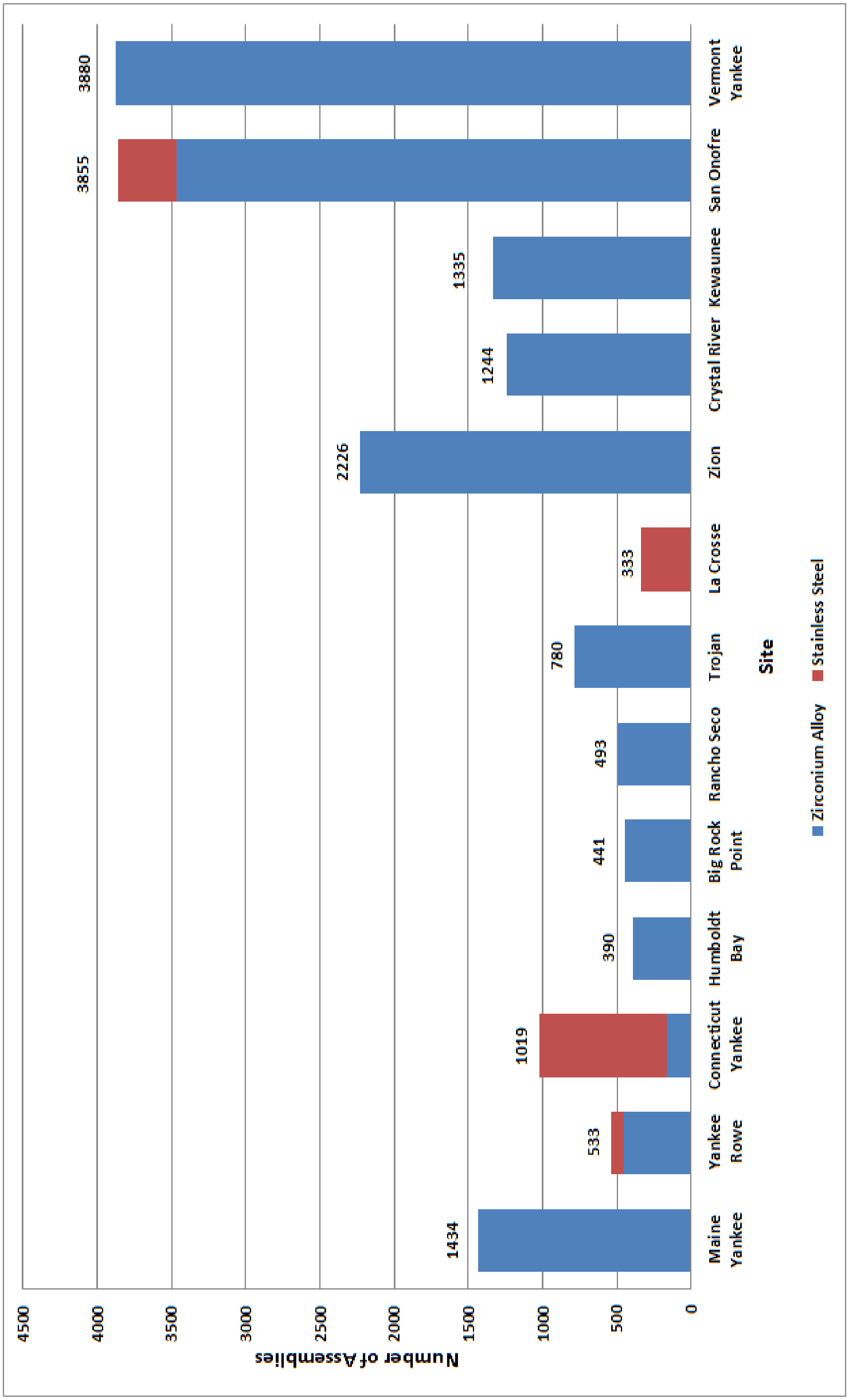

Figure 2-2. Number of Assemblies by Cladding Type at Shutdown Sites

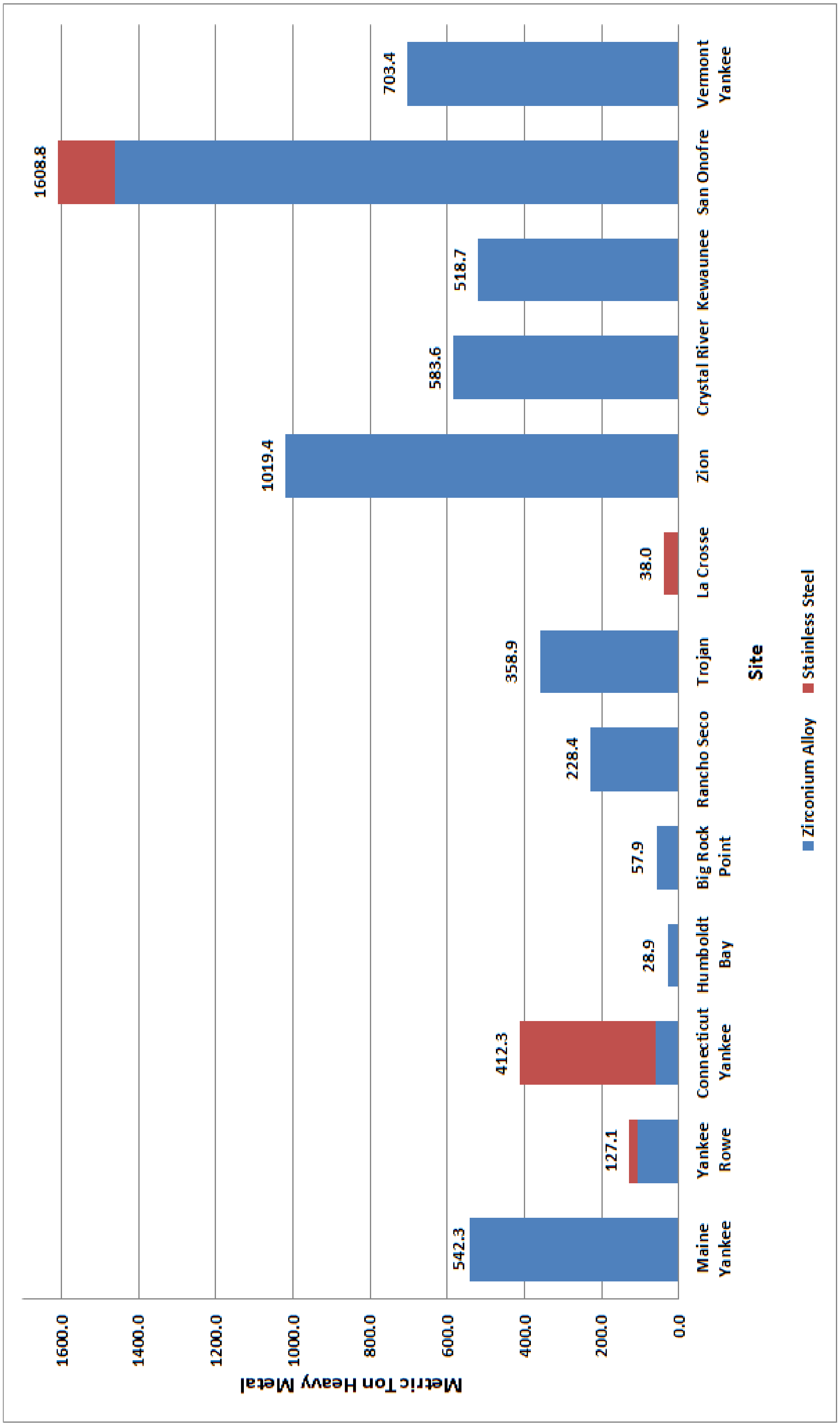

Figure 2-3. Metric Tons Heavy Metal by Cladding Type at Shutdown Sites

Table 2-2. Storage Systems and Transportation Casks Used at Shutdown Sites

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters UNF/GTCC
Maine Yankee	PWR	08/2002-03/2004	NAC-UMS/transportable storage canister	NAC-UMS UTC (Docket No. 71-9270) Certificate expires 10/31/2017. None fabricated	60/4
Yankee Rowe	PWR	06/2002-06/2003	NAC-MPC/Yankee-MPC transportable storage canister	NAC-STC (Docket No. 71-9235) Certificate expires 05/31/2019. Foreign use versions fabricated.	15/1
Connecticut Yankee	PWR	05/2004-03/2005	NAC-MPC/CY-MPC transportable storage canister	NAC-STC (Docket No. 71-9235) Certificate expires 05/31/2019. Foreign use versions fabricated.	40/3
Humboldt Bay	BWR	08/2008-12/2008	Holtec HI-STAR HB/MPC-HB canister	HI-STAR HB (Docket No. 71-9261) Certificate expires 04/30/2019. Fuel in canisters in fabricated casks. No impact limiters.	5/1
Big Rock Point	BWR	12/2002-03/2003	Fuel Solutions W150 Storage Overpack/W74 Canister	TS125 (Docket No. 71-9276) Certificate expires 10/31/2017. None fabricated.	7/1
Rancho Seco	PWR	04/2001-08/2002	TN NUHOMS/FO-DSC, FC-DSC, and FF-DSC canisters	MP187 (Docket No. 71-9255) Certificate expires 11/30/2018. One cask fabricated. No impact limiters.	21/1
Trojan	PWR	12/2002-09/2003	TranStor Storage Overpack/Holtec MPC-24E and MPC-24EF canisters	HI-STAR 100 (Docket No. 71-9261) Certificate expires 04/30/2019. Units fabricated but dedicated to storage at other sites. No impact limiters or spacers.	34/0
La Crosse	BWR	07/2012-09/2012	NAC MPC-LACBWR/MPC-LACBWR transportable storage canister	NAC-STC (Docket No. 71-9235) Certificate expires 05/31/2019. Foreign use versions fabricated.	5/0
Zion 1 and 2	PWR	12/2013-03/2015	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN (Docket No. 71-9356) Application for certificate of compliance under review. None fabricated.	61/4

Table 2-2. (contd.)

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters UNF/GTCC
Crystal River	PWR	Planned 01/2018-08/2019	TN Standardized NUHOMS/32PTH1 canister	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2017. Fabrication of cask expected to be completed in 2015.	39/5[b,c]
Kewaunee	PWR	08/2009-08/2014	TN Standardized NUHOMS/32PT canister	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2017. Fabrication of cask expected to be completed in 2015.	14
Kewaunee	PWR	Planned 2016	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN (Docket No. 71-9356) Application for certificate of compliance under review. None fabricated.	24/2[b,c]
Kewaunee Total					38/2
San Onofre-1	PWR	09/2003-06/2005	TN Standardized Advanced NUHOMS/24PT1 canisters	MP187(Docket No. 71-9255) Certificate expires 11/30/2018. One cask fabricated. No impact limiters.	17/1
San Onofre-2 and -3	PWR	03/2007-07/2012	TN Standardized Advanced NUHOMS/24PT4 canisters	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2017. Fabrication of cask expected to be completed in 2015.	33
San Onofre-2 and -3	PWR	Not Announced	TN Standardized Advanced NUHOMS/24PT4 canisters	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2017. Fabrication of cask expected to be completed in 2015.	0-12/0-12[b]
San Onofre-2 and -3	PWR	Not Announced	TN Standardized Advanced NUHOMS/32PTH2 canisters	MP197HB (Docket No. 71-9302)[d] Certificate expires 08/31/2017. Fabrication of cask expected to be completed in 2015.	0-6/0-6[b]
San Onofre-2 and -3	PWR	Not Announced	Holtec HI-STORM UMAX/MPC-37 canisters	HI-STAR 190 (Docket No. 71-9373) Application for certificate of compliance submitted in 2015.	≤73/0[b]
San Onofre Total					123-129/11

Table 2-2. (contd.)

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters UNF/GTCC
Vermont Yankee	BWR	05/2008-06/2012	Holtec HI-STORM 100S/MPC-68 canisters	HI-STAR 100 (Docket No. 71-9261) Certificate expires 04/30/2019. Units fabricated but dedicated to storage at other sites. No impact limiters or spacers.	13/0
Vermont Yankee	BWR	Not Announced	Holtec HI-STORM 100S/MPC-68 canisters	HI-STAR 100 (Docket No. 71-9261) Certificate expires 04/30/2019. Units fabricated but dedicated to storage at other sites. No impact limiters or spacers.	45/2[b,c]
Vermont Yankee Total					58/2
Total					506-512/35

a. Dates represent the dates that the used nuclear fuel was transferred to the ISFSI.
b. Estimated.
c. Additional canisters of GTCC low-level radioactive waste could be generated during decommissioning.
d. The list of approved contents in the certificate of compliance for the MP197HB transportation cask would need to be modified to include the 32PTH2 canister.
BWR= boiling water reactor
GTCC= greater-than-Class C
ISFSI= independent spent fuel storage installation
PWR= pressurized water reactor
UNF= used nuclear fuel

2.1 Maine Yankee

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Maine Yankee site. The Maine Yankee site is about 25 miles south of Augusta and about 45 miles north of Portland, Maine (TOPO 1993a).

2.1.1 Site Inventory

Sixty canisters containing 1432 used nuclear fuel assemblies, 2 consolidated fuel rod containers, and 2 failed fuel rod containers (i.e., damaged fuel cans[8]) and 4 canisters of GTCC low-level radioactive waste are stored at the Maine Yankee ISFSI (Docket No. 72-30). Figure 2-4 shows the Maine Yankee ISFSI. The storage system used at Maine Yankee is the NAC-UMS system (Docket No. 72-1015), which consists of a transportable storage canister, a vertical concrete storage cask, and a transfer cask. The transportable storage canister holds 24 pressurized water reactor used nuclear fuel assemblies. The fuel assemblies from Maine Yankee were loaded into transportable storage canisters from August 2002 through March 2004 (Leduc 2012). The fuel assemblies have zirconium alloy-clad fuel rods. The transportation cask that is certified to transport the canisters containing this used nuclear fuel or GTCC low-level radioactive waste is the NAC-UMS Universal Transport Cask (UTC) Package (Docket No. 71-9270). No NAC-UMS UTC transportation casks have been fabricated.

Figure 2-5 illustrates the number of used nuclear fuel assemblies at Maine Yankee based on their discharge year. The oldest fuel was discharged in 1974 and the last fuel was discharged in 1996. The median discharge year of the fuel is 1984.

Figure 2-6 illustrates the number of used nuclear fuel assemblies at Maine Yankee based on their burnup. The lowest burnup is 2.8 gigawatt-day per metric ton heavy metal (GWd/MTHM) and the highest burnup is 49.2 GWd/MTHM. The median burnup is 32.1 GWd/MTHM. Used nuclear fuel with a burnup greater than 45 GWd/MTHM is termed as high burnup used nuclear fuel by the NRC. There are 90 of these high burnup used nuclear fuel assemblies at Maine Yankee. These high burnup used nuclear fuel assemblies were packaged in Maine Yankee Fuel Cans (i.e., damaged fuel cans, see Figure 2-7 through Figure 2-9) and were loaded in the four basket corner positions in the transportable storage canisters. Twenty-three transportable storage canisters containing high burnup used nuclear fuel are stored at Maine Yankee. There are also 12 transportable storage canisters containing 43 damaged fuel assemblies in damaged fuel cans stored at Maine Yankee.

[8] A damaged fuel can is a stainless steel container that confines damaged used nuclear fuel. A damaged fuel can is closed on its end by screened openings. These screened openings allow gaseous and liquid media to escape but minimize the dispersal of gross particulate material.

Photo courtesy of Maine Yankee

Figure 2-4. Maine Yankee Independent Spent Fuel Storage Installation (2014)

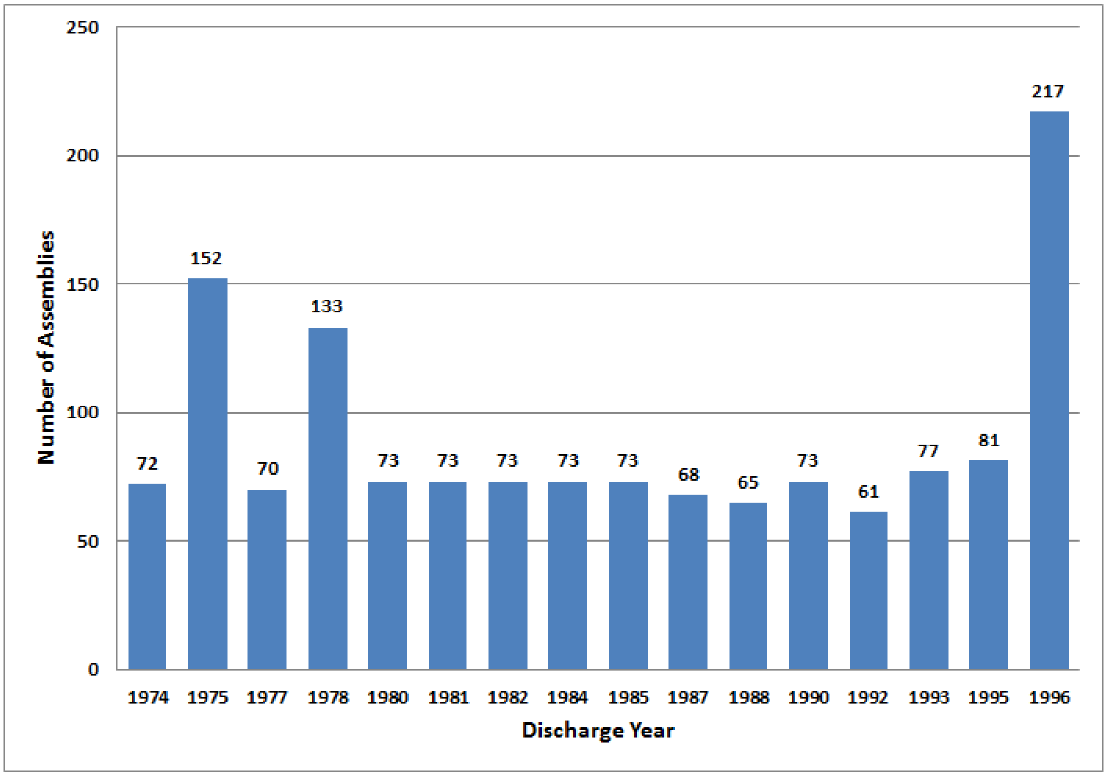

Figure 2-5. Maine Yankee Number of Assemblies versus Discharge Year (EIA 2002)

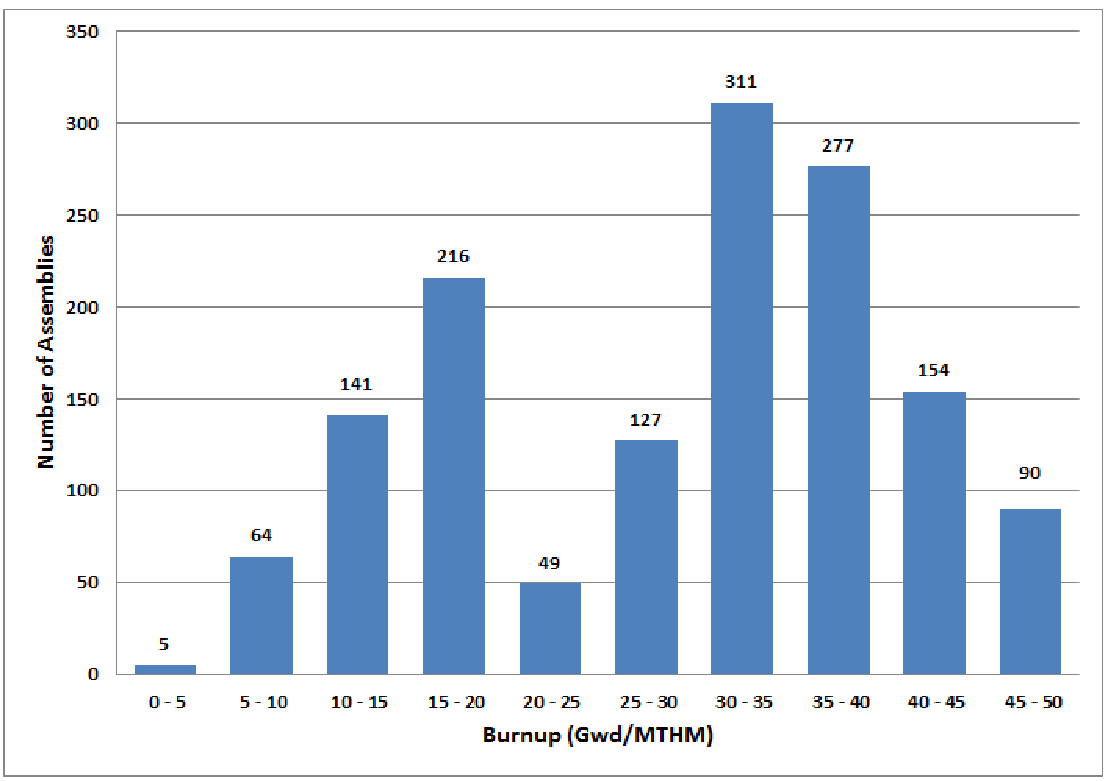

Figure 2-6. Maine Yankee Number of Assemblies versus Burnup (EIA 2002)

Photo courtesy of NAC International

Figure 2-7. Damaged Fuel Cans

Photo courtesy of NAC International

Figure 2-8. Ends of Damaged Fuel Cans with Screened Openings

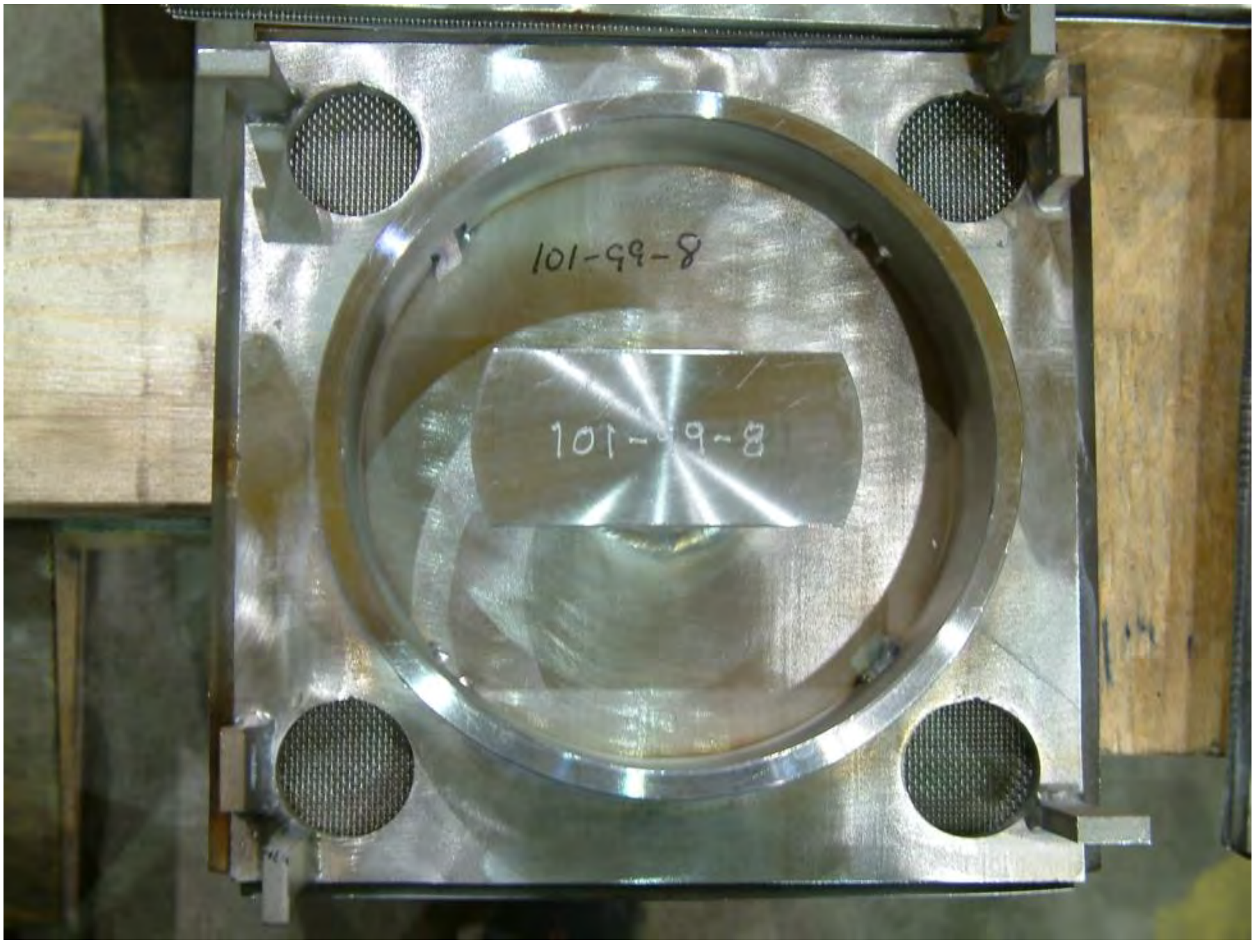

Photo courtesy of NAC International

Figure 2-9. Damaged Fuel Can Lid with Screened Openings

2.1.2 Site Conditions

Figure 2-10 provides an aerial view of the Maine Yankee site, where the Maine Yankee reactor and associated structures have been removed. Electrical power is available at the Maine Yankee ISFSI. However, mobile equipment such as cranes to unload the NAC-UMS vertical concrete storage casks used at Maine Yankee and to load the NAC-UMS UTC transportation cask that is certified to transport the Maine Yankee used nuclear fuel and GTCC low-level radioactive waste, is not present at the site. In addition, a transfer cask, which is used to transfer the transportable storage canister from a NAC-UMS vertical concrete storage cask to a NAC-UMS UTC transportation cask, is not present at the site.

An on-site rail spur exists at Maine Yankee (Figure 2-11). This spur connects to the Rockland branch[9] of the Maine Eastern Railroad at milepost 46.66, which is designated as track class 2.[10]

[9] In September 2015, the Bangor Daily News and Portland Press Herald reported that the Maine Department of Transportation had awarded the contract to operate freight service on the Rockland branch to the Central Maine and Quebec Railway. The lease is expected to take effect on January 1, 2016.

[10] Track class is a measure of track quality. In 49 CFR Part 213, the Federal Railroad Administration has categorized all track into nine classes (1-9), segregated by maximum allowable operating speed.

The distance from the Maine Yankee ISFSI to the Rockland branch is about 2.2 miles. The Rockland branch connects to the Pan Am Railways in Brunswick, Maine. The distance from the Rockland branch to the Pan Am Railways in Brunswick, Maine is about 25 miles. Pan Am Railways is a Class II regional railroad.[11] During decommissioning, 238 radioactive and nonradioactive waste shipments were made over the period 2000 to 2005 using this rail spur (EPRI 2005). There appears to be sufficient room within the Owner Controlled Area to permit staging of railcars. However, the rail spur has been paved over in spots (see Figure 2-12) and is not being maintained.

A barge dock that exists at Maine Yankee (Figure 2-13) would provide access to the Atlantic Ocean. The distance from the Maine Yankee ISFSI to the barge dock is about 0.5 mile. The Maine Yankee steam generators, pressurizer, and reactor pressure vessel were shipped off-site using this barge dock (Wheeler 2002, Feigenbaum 2005). The three steam generators weighed 356 tons each (491 tons each when the shielding and carriage assembly are included) and the pressurizer weighed 100 tons (Radwaste Solutions 2000). These components were transported to Memphis, Tennessee for decontamination (Radwaste Solutions 2000). The reactor pressure vessel package weighed 1175 tons and was transported to the Barnwell, South Carolina low-level radioactive waste disposal facility (Feigenbaum 2005). In addition, EPRI (2005) states that the site’s main power transformers were shipped off-site by barge. The barge dock is approximately 10 feet above the water and the depth of the water is about 6 feet at high tide (TOPO 1993a). The barge dock and access road were last used in 2003 (TriVis Incorporated 2005) and are not being maintained.

[11] Railroads are classified by the Surface Transportation Board based on their annual operating revenues. The class to which a carrier belongs is determined by comparing its adjusted operating revenues for three consecutive years to the following scale: Class I - $250 million or more, Class II - $20 million or more, and Class III - $0 to $20 million. The following formula is used to adjust a railroad's operating revenues to eliminate the effects of inflation: Current Year's Revenues × (1991 Average Index ÷ Current Year's Average Index). The average index (deflator factor) is based on the annual average Railroad Freight Price Index for all commodities (STB 2012). The U.S. Class I railroads in 2013 are the BNSF Railway, CSX Transportation, Grand Trunk Corporation, Kansas City Southern Railway, Norfolk Southern Combined Railroad Subsidiaries, Soo Line Corporation, and Union Pacific Railroad.

Figure 2-10. Aerial View of the Maine Yankee Site (Google 2015)

Figure 2-11. On-site Rail Spur at the Maine Yankee Site (Google 2015)

Figure 2-12. Paved-over Railroad Tracks at the Maine Yankee Site (2012)

Figure 2-13. Barge Dock at the Maine Yankee Site (2012)

2.1.3 Near-site Transportation Infrastructure and Experience

As discussed in Section 2.1.2, Maine Yankee has direct rail access to the Maine Eastern Railroad via an on-site rail spur (see Figure 2-14). This rail spur was used for radioactive and nonradioactive waste shipments during decommissioning. There is sufficient room at Maine Yankee for a long on-site rail spur that should be able to accommodate trains having eight or more railcars (two buffer cars, a security escort car, and five or more cask cars).

The Maine Yankee site is located on Bailey Point on the Back River and has access to the Atlantic Ocean through the Sheepscot River. The Back River and Sheepscot River are navigable waterways and Maine Yankee has an on-site barge dock (see Figure 2-13) and therefore could be accessible by barges that would transport used nuclear fuel transportation casks to nearby ports served by railroads or to barge-accessible rail sidings or spurs. The nearest port with rail access is in Portland, Maine (DSI 2004).

As discussed in Section 2.1.2, during decommissioning at Maine Yankee, three steam generators, the pressurizer, and reactor pressure vessel were transported off-site using barges. Figure 2-15 and Figure 2-16 show the Maine Yankee reactor pressure vessel being loaded onto a barge and being transported by barge, respectively.

For a site such as Maine Yankee that is directly accessible by barge, transportation casks could be loaded, prepared for off-site transportation, and placed onto transport skids/cradles. Because the location of the Maine Yankee ISFSI is not immediately adjacent to the barge dock, heavy-lift equipment could be used to place the casks and transport skids/cradles onto heavy haul vehicles for transport from the ISFSI to the on-site barge dock. Heavy-lift equipment could then transfer the casks from the heavy haul vehicles onto the deck of the transporting barges. Alternatively, the heavy haul transport vehicles with their transport casks could roll onto the barge, thereby not requiring heavy-lift capability at the barge dock to move the casks from the heavy haul truck to the barge.

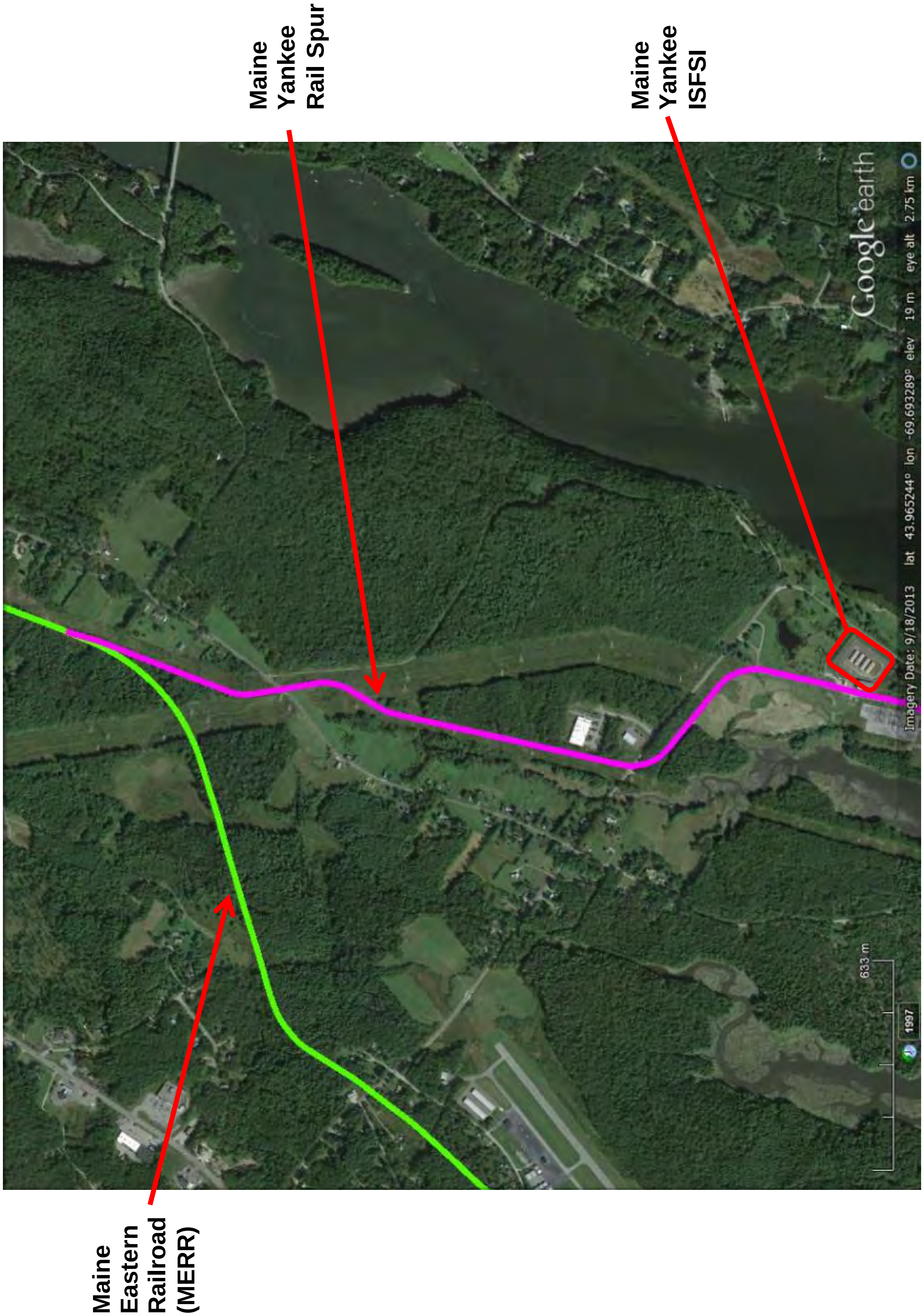

Figure 2-14. Rail Interface at Maine Yankee (Google 2015)

Photo courtesy of Maine Yankee

Figure 2-15. Maine Yankee Reactor Pressure Vessel Being Loaded onto Barge (2003)

Photo courtesy of Maine Yankee

Figure 2-16. Maine Yankee Reactor Pressure Vessel Being Transported on Barge (2003)

2.1.4 Gaps in Information

The principal question for the Maine Yankee site regarding the capability of the off-site transportation infrastructure to accommodate shipments of large transportation casks is whether the Maine Eastern Railroad is capable of accepting and moving used nuclear fuel railcars. An assessment by the Federal Railroad Administration's track safety engineers and of the Maine Eastern Railroad's maintenance-of-way staff would be necessary. If the railroad's infrastructure cannot accommodate the shipments, it would be necessary to ship casks on barges from the site to a port where they would be transferred to railcars. Because the Maine Yankee reactor pressure vessel was shipped from the site by barge, there is substantial confidence that barges could be used to move used nuclear fuel casks from the site. Nonetheless, it would be necessary to obtain a marine engineer's assessment of the condition of the channel leading to the Maine Yankee barge siding and to do any dredging and restoration of navigation aids in the channel that may be necessary.

2.2 Yankee Rowe

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Yankee Rowe site. The Yankee Rowe site is in the northwest corner of Massachusetts, about 0.5 mile south of the Vermont border, 3.5 miles northwest of the town of Rowe, and 48 miles north of Pittsfield, Massachusetts (TOPO 1993b).

2.2.1 Site Inventory

There are 15 canisters containing 533 used nuclear fuel assemblies and 1 reconfigured fuel assembly,[12] and 1 canister of GTCC low-level radioactive waste stored at the Yankee Rowe ISFSI (Docket No. 72-31). The 15 canisters contain 7 damaged used nuclear fuel assemblies, which have been placed in damaged fuel cans.

Figure 2-17 shows the Yankee Rowe ISFSI. The storage system used at Yankee Rowe is the NAC Multi-Purpose Canister system (NAC-MPC) (Docket No. 72-1025), which consists of a transportable storage canister, a vertical concrete storage cask, and a transfer cask. The transportable storage canister used for the Yankee Rowe used nuclear fuel is the Yankee-MPC, which holds 36 Yankee Rowe pressurized water reactor used nuclear fuel assemblies. The Yankee Rowe fuel assemblies were loaded into NAC-MPC canisters from June 2002 through June 2003 (Leduc 2012). The fuel rods in the fuel assemblies at Yankee Rowe are either zirconium alloy-clad (457 assemblies) or stainless steel-clad (76 assemblies). The NAC-STC transportation cask (Docket No. 71-9235) is certified to transport the Yankee-MPC canisters,

[12] A Yankee Rowe reconfigured fuel assembly is a stainless steel container having approximately the same external dimensions as a used nuclear fuel assembly that ensures criticality control geometry and permits gaseous and liquid media to escape while preventing the dispersal of gross particulates. A Yankee Rowe reconfigured fuel assembly may contain intact fuel rods, damaged fuel rods, and fuel debris. The Yankee Rowe reconfigured fuel assembly consists of a shell (square tube with end fittings) and a basket assembly that supports 64 tubes in an 8×8 array, which hold the intact fuel rods, damaged fuel rods, or fuel debris. The shell, basket assembly and tubes are stainless steel. The spent fuel rods are confined in the fuel tubes, which are closed with end plugs. The shell is closed with top and bottom end fittings. The tube end plugs and the shell end fittings have drilled holes to permit draining, drying, and helium backfilling (NAC 2006).

including canisters containing GTCC low-level radioactive waste. Figure 2-18 illustrates the NAC-STC transportation cask. No NAC-STC transportation casks have been fabricated for use in the United States. Two NAC-STC transportation casks have been fabricated for use in China (Washington Nuclear Corporation 2003).

Figure 2-19 illustrates the number of used nuclear fuel assemblies at Yankee Rowe, based on their discharge year. The oldest fuel was discharged in 1972 and the last fuel was discharged in 1991. The median discharge year of the fuel is 1984.

Figure 2-20 illustrates the number of used nuclear fuel assemblies at Yankee Rowe based on their burnup. The lowest burnup is 4.2 GWd/MTHM and the highest burnup is 36.0 GWd/MTHM. The median burnup is 28.0 GWd/MTHM. There are no high burnup used nuclear fuel assemblies (burnup greater than 45 GWd/MTHM) stored at Yankee Rowe.

Photo courtesy of Yankee Rowe

Figure 2-17. Yankee Rowe Independent Spent Fuel Storage Installation

Photo courtesy of NAC International

Figure 2-18. NAC-STC Transportation Cask

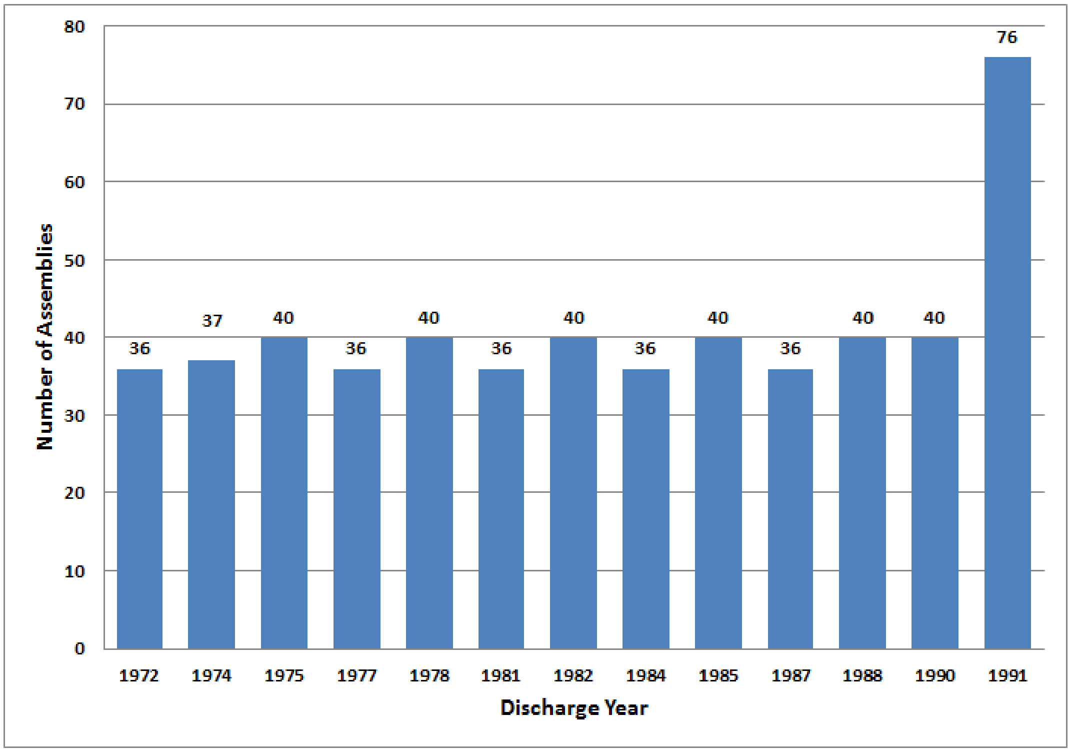

Figure 2-19. Yankee Rowe Number of Assemblies versus Discharge Year (EIA 2002)

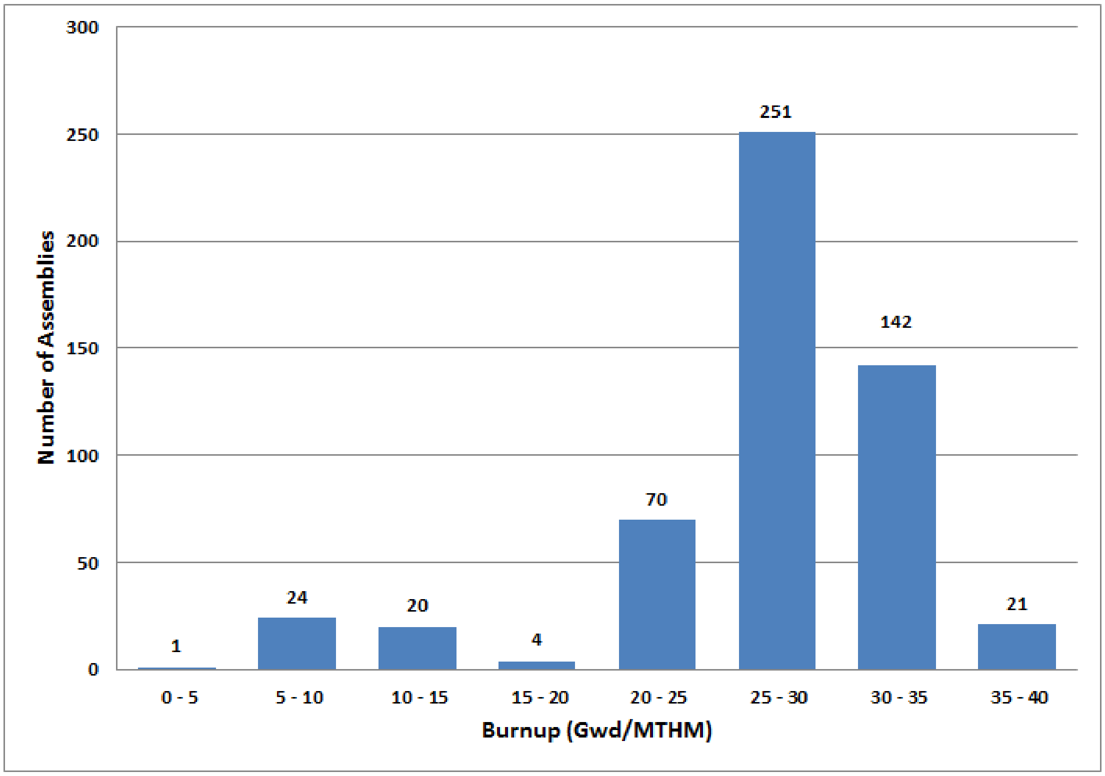

Figure 2-20. Yankee Rowe Number of Assemblies versus Burnup (EIA 2002)

2.2.2 Site Conditions

Figure 2-21 provides an aerial view of the Yankee Rowe site, where the reactor and associated structures have been removed. Electrical power is available at the Yankee Rowe ISFSI. However, mobile equipment such as cranes to unload the NAC-MPC vertical concrete storage casks used at Yankee Rowe and to load the NAC-STC transportation cask that is certified to transport the Yankee Rowe used nuclear fuel and GTCC low-level radioactive waste is not currently present at the site. In addition, a transfer cask, which is used to transfer the Yankee-MPC transportable storage canister from a NAC-MPC vertical concrete storage cask to a NAC-STC transportation cask, is not currently present at the site. There are two compatible transfer casks without doors or hydraulic components stored at the Connecticut Yankee site and one compatible transfer cask at the La Crosse site.

There is no barge access or direct rail access at the Yankee Rowe site. The nearest off-site barge facility is located in Albany, New York, a distance of 50 miles from Yankee Rowe (TriVis Incorporated 2005). Yankee Rowe had direct rail service, but the rail spur to the site was removed in the early 1970s and cannot be reinstalled because the construction of the Cockwell (formerly Bear Swamp) Pumped Storage Plant resulted in submersion of the rail line to Yankee Rowe (TOPO 1993b). The nearest rail access is at the east end of the Hoosac Tunnel, a distance of about 7.5 miles from the Yankee Rowe site. Heavy haul truck transport would be required to move NAC-STC transportation casks containing used nuclear fuel or GTCC low-level radioactive waste to this location.

2.2.3 Near-site Transportation Infrastructure and Experience

The Yankee Rowe site does not have an on-site rail spur or a railroad that passes near to the site or along the site boundary. For Yankee Rowe, heavy haul trucks could be used to move transportation casks over public highways to a rail siding or spur that provides access to a railroad that can accommodate the loaded transportation casks.

For shipments of casks containing used nuclear fuel that require the use of heavy haul trucks, the casks would be prepared for shipment at the Yankee Rowe ISFSI site and loaded onto a transport cradle that would be loaded onto the transport trailer of a heavy haul truck. The truck, led and followed by technical and security escorts, would move over an approved, designated highway route to a nearby rail siding or spur. Heavy lift equipment would be used to transload the cask and its cradle as a unit from the truck to a railcar at the rail siding or spur.

Heavy haul trucks were used to move the reactor pressure vessel and steam generators from the Yankee Rowe site. For example, in 1997, the Yankee Rowe reactor pressure vessel was moved 7.5 miles on an improved county road by a heavy haul truck from the Yankee Rowe site to the rail line at the east portal of the Hoosac Tunnel in western Massachusetts (see Figure 2-22 through Figure 2-24). The rail line is operated by the Pan Am Southern Railroad, a partnership of the Norfolk Southern Railroad and the Pan Am Railroad Company, a northeastern U.S. Class II regional railroad. The Pan Am Southern rail line at the Hoosac Tunnel is designated as track class 3. To reach the east portal of the Hoosac Tunnel, the heavy haul truck and reactor pressure vessel had to cross the Sherman Dam. EPRI (1997a, 1998) states that the spillway bridge on the Sherman Dam was replaced prior to shipping the reactor pressure vessel and the slope stability along the roadway, as well as the roadway culverts, were assessed for the loaded transport conditions. The reactor pressure vessel package weighed 365 tons with saddle and tie downs (EPRI 1997a, 1998). At the Hoosac Tunnel rail crossing, the reactor pressure vessel package was transloaded from the roadway transporter to a TransAlta CAPX 1001 railcar. The railcar was equipped with a lateral shift mechanism that enabled handlers to move the cargo left or right up to 12 inches (Lessard 2000). The loaded gross weight of the railcar and reactor pressure vessel package was 1,122,700 lb. (EPRI 1997a, 1998). The reactor pressure vessel was then transported to the Barnwell, South Carolina low-level radioactive waste disposal facility (Lessard 2000). During the trip to Barnwell, South Carolina, the lateral shift mechanism had to be used on six separate occasions to maneuver around structures or other railcars along the route (Lessard 2000). These shifts ranged from 3 to 12 inches (Lessard 2000).

Figure 2-25 shows the rail line at the east portal of the Hoosac Tunnel and Figure 2-26 shows the east portal of the Hoosac Tunnel. Figure 2-27 shows the Yankee Rowe reactor pressure vessel on the railcar used to transport it to the Barnwell, South Carolina low-level radioactive waste disposal facility. Figure 2-28 shows the route taken from the Yankee Rowe site to the east portal of the Hoosac Tunnel.

2.2.4 Gaps in Information

The Yankee Rowe site is located inland in the western part of Massachusetts and thus does not have access to a navigable waterway. In addition, the Yankee Rowe site does not have direct rail access.

Figure 2-21. Aerial View of the Yankee Rowe Site (Google 2015)

Photo courtesy of AREVA

Figure 2-22. Yankee Rowe Reactor Pressure Vessel Crossing the Sherman Dam (1997)

Photo courtesy of Yankee Rowe

Figure 2-23. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck Moving Under Power Lines (1997)

Photo courtesy of AREVA

Figure 2-24. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck (1997)

Figure 2-25. Rail Line at East Portal of the Hoosac Tunnel (2012)

Figure 2-26. East Portal of the Hoosac Tunnel (2012)

Photo courtesy of Yankee Rowe

Figure 2-27. Yankee Rowe Reactor Pressure Vessel on Railcar (1997)

Consequently, it would be necessary to use heavy haul trucks to transport casks containing used nuclear fuel from the site for a distance of about 7.5 miles over a local, improved road to the nearest location for a rail siding at the eastern portal of the Hoosac Tunnel. This would require constructing an on-site access road from the Yankee Rowe ISFSI to the Sherman Dam and obtaining authorization for the heavy haul vehicles to cross the dam. The Sherman Dam is owned and operated by TransCanada Hydro Northeast, Inc. Based on the experience during decommissioning, TransCanada would need to be notified of the intent to use the roadway and bridge to move heavy loads across the dam; the load evaluation used for the removal of the reactor pressure vessel and steam generators would have to be verified and modified if necessary, and an engineering walk down of the roadway and bridge would be needed to confirm that there had been no changes or deterioration that would invalidate the previous load evaluation.

The heavy haul truck route from Yankee Rowe to the Hoosac Tunnel can be ice covered at times during the winter and could need treatment to prepare it for shipments. A route survey and load evaluation for the heavy haul truck route would also be required. The siding that was installed at the tunnel for the purpose of loading the reactor pressure vessel onto a railcar has been removed and would need to be reinstalled before shipments of casks to this location could take place. Alternative routing for heavy haul trucks that would lead to North Adams, Massachusetts, where casks could be loaded onto railcars, would require travel north over mountainous local roads into Vermont then south to the North Adams area, a distance of about 20 miles.

There is sufficient land in the Hoosac Tunnel area to stage handling equipment. This is based on the use of this area to load the reactor pressure vessel from the transporter to the railcar. However, site preparation work would most likely be required. The available space is limited for a rail siding at the Hoosac Tunnel location, making it likely that only one or two railcars could be placed for loading. It would be necessary to move loaded railcars from the siding to a staging area, possibly in North Adams, where trains with possibly two locomotives, buffer cars, and an escort car could be assembled. A staging location has not been identified.

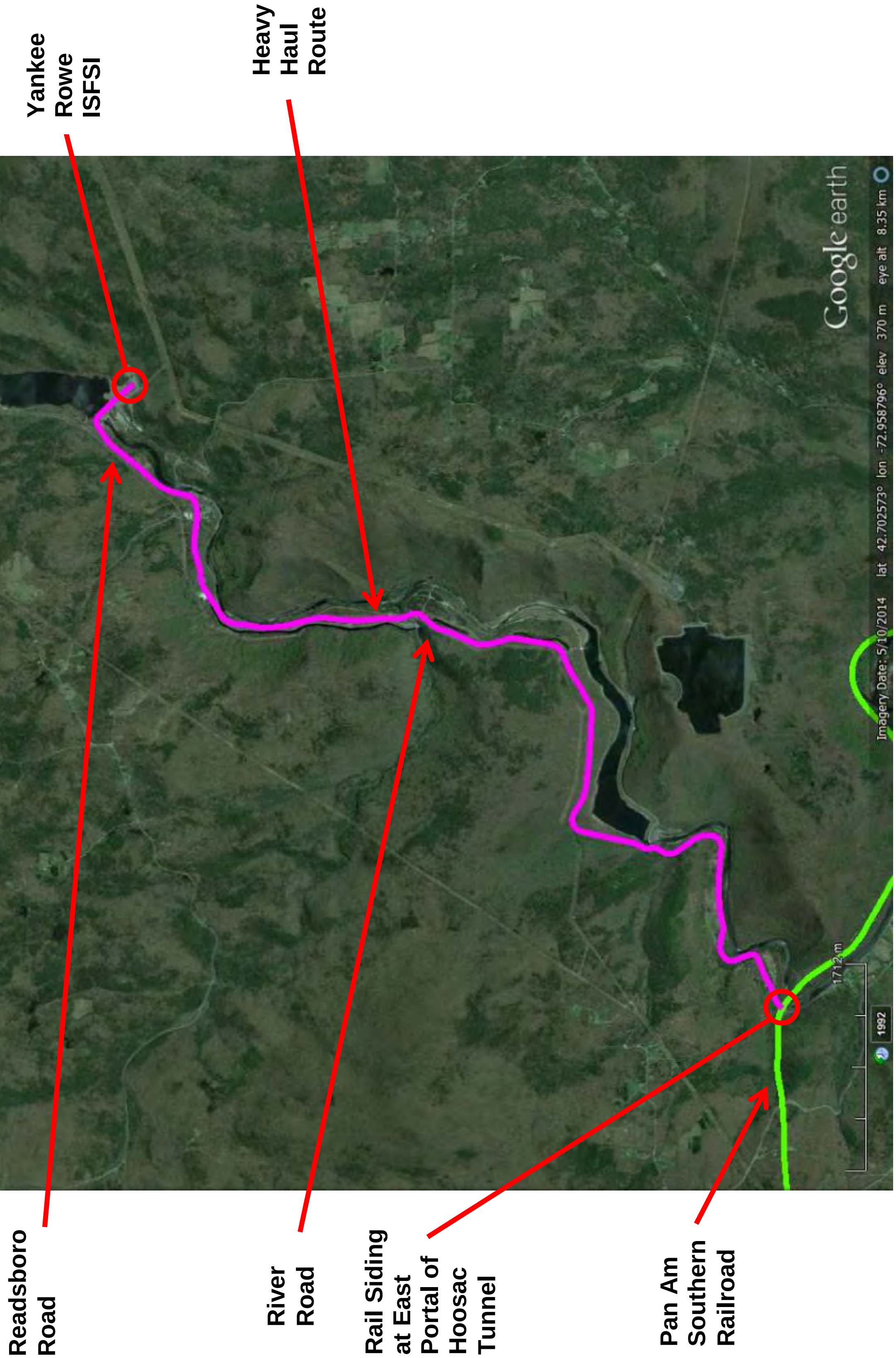

Figure 2-28. Yankee Rowe Reactor Pressure Vessel Heavy Haul Truck Route (Google 2015)

2.3 Connecticut Yankee

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Connecticut Yankee site. The Connecticut Yankee site is located on the eastern shore of the Connecticut River near Haddam Neck, Connecticut, about 13 miles southeast of Middletown and 25 miles southeast of Hartford, Connecticut (TOPO 1993c).

2.3.1 Site Inventory

Forty canisters containing 1019 used nuclear fuel assemblies and 5 fuel rod storage containers, and 3 canisters of GTCC low-level radioactive waste are stored at the Connecticut Yankee ISFSI (Docket No. 72-39). The 40 canisters contain 71 damaged fuel cans, which contain 66 damaged used nuclear fuel assemblies and 5 fuel rod storage containers. There are also an additional 82 stainless steel-clad used nuclear fuel assemblies from Connecticut Yankee that are stored at the Morris, Illinois ISFSI (Docket No. 72-1).

Figure 2-29 shows the Connecticut Yankee ISFSI. The storage system used at Connecticut Yankee is the NAC Multi-Purpose Canister system (NAC-MPC) (Docket No. 72-1025), which consists of a transportable storage canister, a vertical concrete storage cask, and a transfer cask. The transportable storage canister used for the Connecticut Yankee (CY) used nuclear fuel is the CY-MPC. This canister may be configured to hold 24 or 26 pressurized water reactor used nuclear fuel assemblies. The fuel assemblies from Connecticut Yankee were loaded into CY-MPC canisters from May 2004 through March 2005 (Leduc 2012). The fuel rods in the fuel assemblies at Connecticut Yankee are either zirconium alloy-clad (161 assemblies) or stainless steel-clad (858 assemblies). The NAC-STC transportation cask (Docket No. 71-9235) is certified to transport the CY-MPC canisters, including canisters containing GTCC low-level radioactive waste. No NAC-STC transportation casks have been fabricated for use in the United States. Two NAC-STC transportation casks have been fabricated for use in China (Washington Nuclear Corporation 2003).

Photo courtesy of Connecticut Yankee

Figure 2-29. Connecticut Yankee Independent Spent Fuel Storage Installation

In addition to the 43 canisters of used nuclear fuel and GTCC low-level radioactive waste stored at the Connecticut Yankee ISFSI, two transfer casks are stored at the Connecticut Yankee ISFSI. These transfer casks could also be used at the Yankee Rowe site.

Figure 2-30 illustrates the number of used nuclear fuel assemblies at Connecticut Yankee, based on their discharge year. The oldest fuel was discharged in 1971 and the last fuel was discharged in 1996. The median discharge year of the fuel is 1984.

Figure 2-31 illustrates the number of used nuclear fuel assemblies at Connecticut Yankee, based on their burnup. The lowest burnup is 8.2 GWd/MTHM and the highest burnup is 43.0 GWd/MTHM. The median burnup is 33.1 GWd/MTHM. There is no high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) stored at Connecticut Yankee.

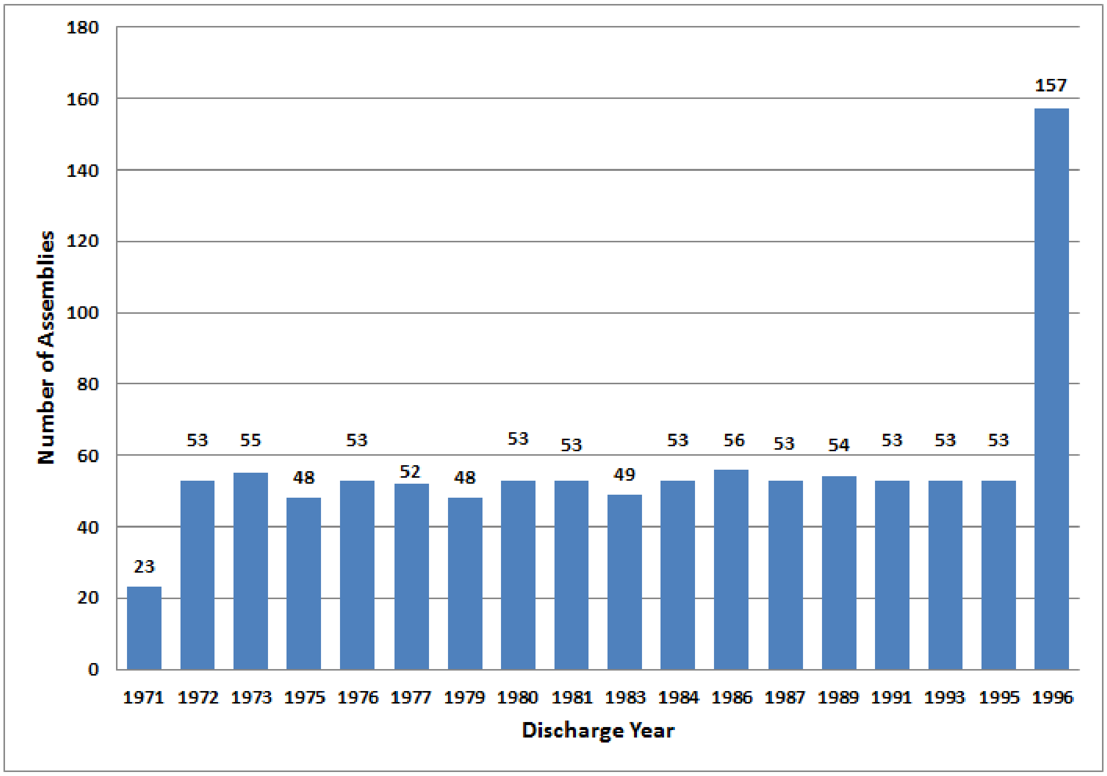

Figure 2-30. Connecticut Yankee Number of Assemblies versus Discharge Year (EIA 2002)

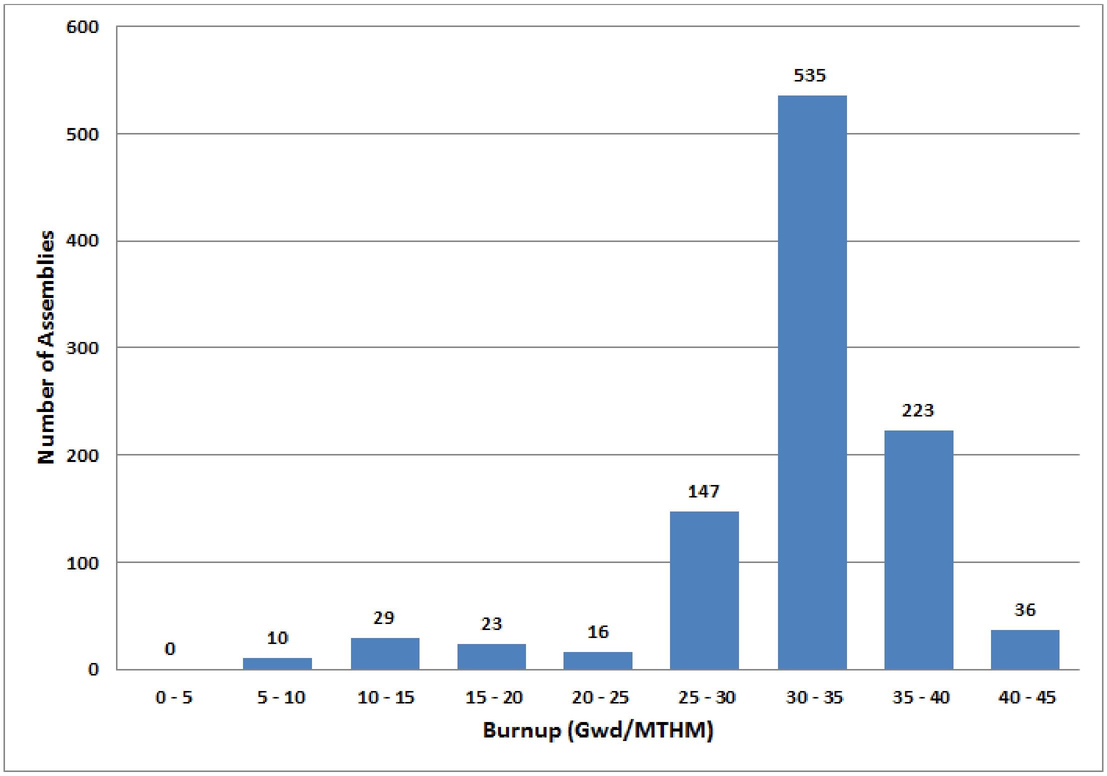

Figure 2-31. Connecticut Yankee Number of Assemblies versus Burnup (EIA 2002)

2.3.2 Site Conditions

Figure 2-32 provides an aerial view of the Connecticut Yankee site, where the reactor and associated structures have been removed. Electrical power is available at the Connecticut Yankee ISFSI. However, mobile equipment such as cranes to unload the NAC-MPC vertical concrete storage casks used at Connecticut Yankee and to load the NAC-STC transportation cask that is certified to transport the Connecticut Yankee used nuclear fuel and GTCC low-level radioactive waste is not currently present at the site. Two transfer casks without doors or hydraulic components are stored at the Connecticut Yankee ISFSI. These transfer casks could also be used at the Yankee Rowe site.

There is no on-site rail access at Connecticut Yankee. The nearest rail access is in Portland, Connecticut near Middletown, Connecticut, about 12 miles from the Connecticut Yankee ISFSI. To reach this location, heavy haul truck transport would be required. The rail line at Portland is designated as track class 1 and connects to the Providence and Worcester Railroad in Middletown, Connecticut after crossing the Connecticut River. The condition of this bridge is unknown. The Providence and Worcester rail line in Middletown, Connecticut is designated as track class 2.

An on-site barge slip at Connecticut Yankee is located in an area of the shoreline along the northwest end of the coolant water discharge canal (see Figure 2-32 and Figure 2-33) and is about 0.9 miles from the Connecticut Yankee ISFSI. This slip provides access to the Connecticut River and Atlantic Ocean (TOPO 1993c). The barge slip and cooling water discharge canal were used to ship the reactor pressure vessel, steam generators, and transformer off-site (EPRI 2006, Connecticut Yankee 2012). At the time that the reactor pressure vessel was shipped, the cooling water discharge canal had silted up, and the canal was dredged before the reactor pressure vessel was shipped (EPRI 2006). The on-site barge slip has not been used since decommissioning but remains intact. It is uncertain at this time whether the cooling water discharge canal is deep enough to accommodate barges without dredging.

2.3.3 Near-site Transportation Infrastructure and Experience

Truck shipments of 82 used nuclear fuel assemblies were made to Morris, Illinois from 1972 through 1987 (SAIC 1991). Eighty assemblies were shipped from Connecticut Yankee to Morris using the IF-200 overweight truck transportation cask (SAIC 1991). Three assemblies were shipped from Connecticut Yankee to Battelle West Jefferson; two of these assemblies were subsequently shipped from Battelle West Jefferson to Morris using the NLI-1/2 truck transportation cask (SAIC 1991).

The Connecticut Yankee site does not have an on-site rail spur or a railroad that passes near to the site or along the site boundary. For Connecticut Yankee, heavy haul trucks could be used to move transportation casks over public highways to a rail siding or spur that provides access to a railroad that can accommodate the loaded transportation casks.

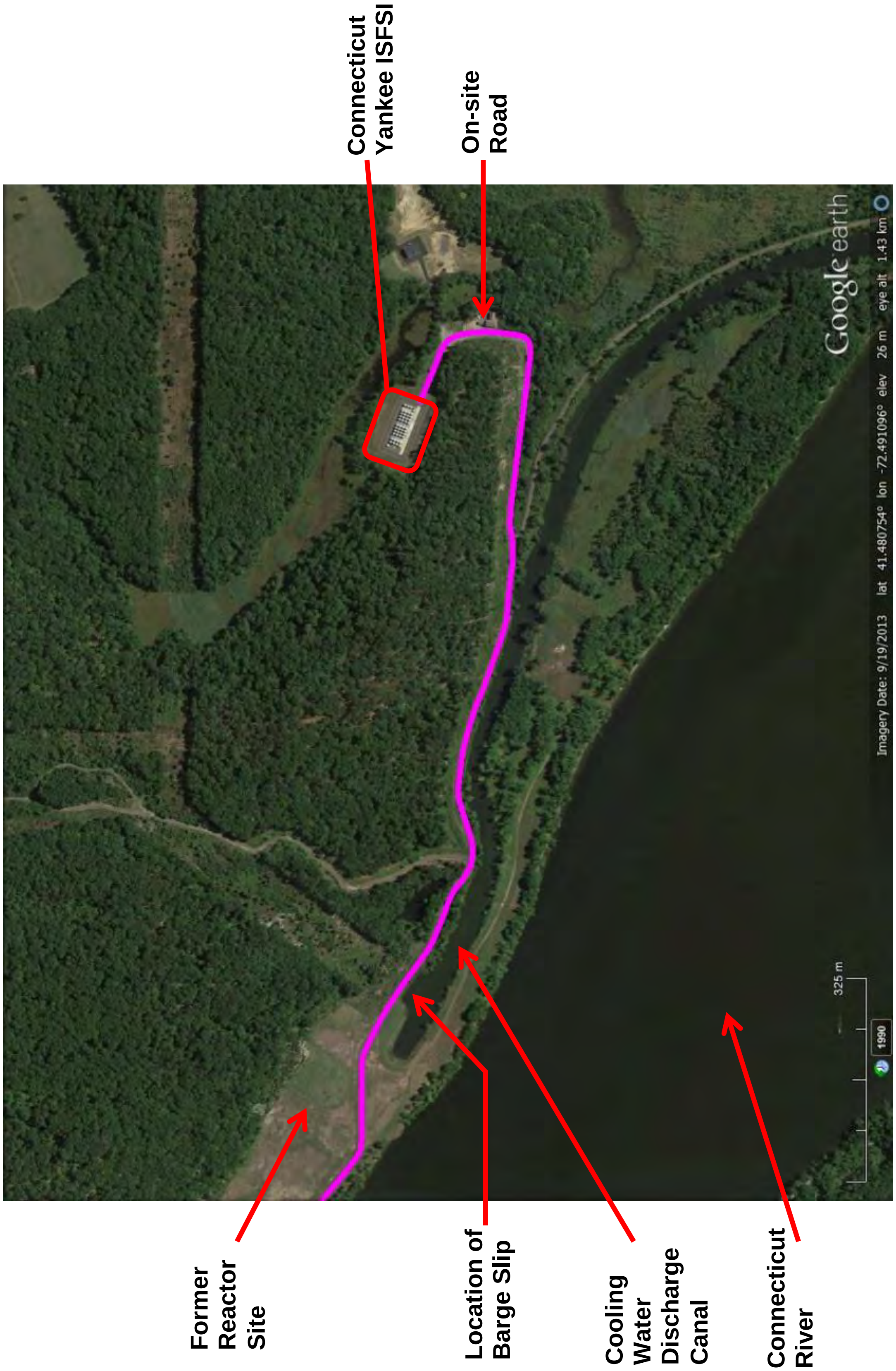

Figure 2-32. Aerial View of the Connecticut Yankee Site (Google 2015)

Figure 2-33. Barge Slip at the Connecticut Yankee Site (2012)

For shipments of casks containing used nuclear fuel that require the use of heavy haul trucks, the casks would be prepared for shipment at the Connecticut Yankee ISFSI site and loaded onto a transport cradle that would then be loaded onto the transport trailer of a heavy haul truck. The truck, led and followed by technical and security escorts, would move over an approved, designated highway route to a nearby rail siding or spur. Heavy lift equipment would be used to transfer the cask and its cradle as a unit from the truck to a railcar at the rail siding or spur.

In 1999 and 2001, the steam domes[13] and pressurizer removed during demolition of the Connecticut Yankee (Haddam Neck) nuclear power plant were moved 12 miles from the plant site over local roads to the Portland rail spur near Middletown, Connecticut, transloaded onto railcars, and transported to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah (EPRI 2006). A total of five heavy haul truck shipments were made. Figure 2-34 shows the pressurizer on its heavy haul truck transporter and Figure 2-35 shows the route taken from the Connecticut Yankee site to the Portland rail spur. Figure 2-36 shows the pressurizer at the end of the Portland rail spur and Figure 2-37 shows the conditions at the end of the Portland rail spur in 2012.

If heavy haul trucks were used to move casks containing used nuclear fuel from the Connecticut Yankee site to the Middletown area rail spur, the P&W Railroad, which is a Class II regional railroad, would then haul the shipments to Hartford, Connecticut. In the Hartford area, the

[13] The steam dome is the upper portion of the steam generator (EPRI 2006).

shipments would be switched to the Pan Am Southern Railroad, the same railroad that operates the rail line that passes near the Yankee Rowe site.

Photo courtesy of Connecticut Yankee

Figure 2-34. Connecticut Yankee Pressurizer on Heavy Haul Truck Transporter

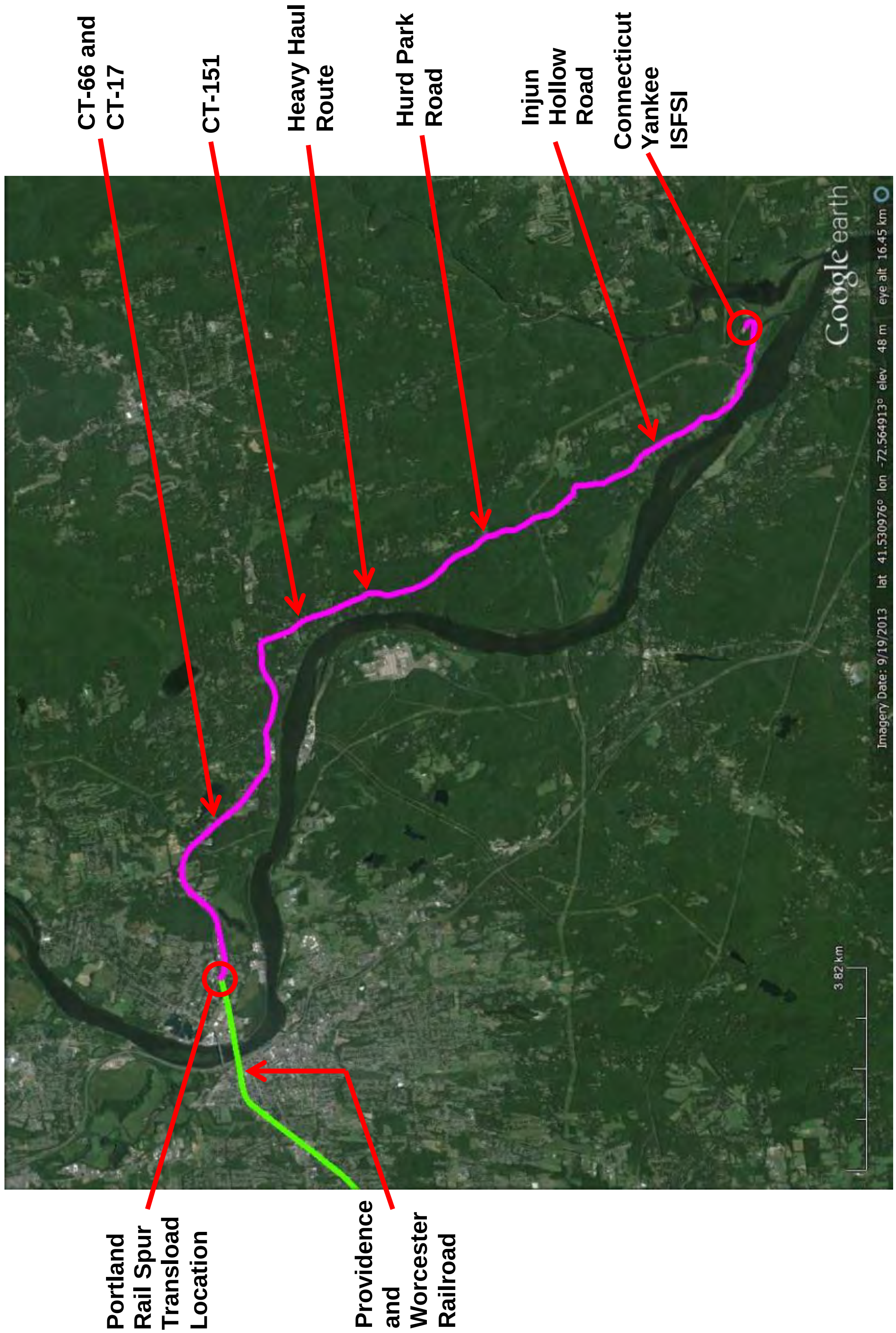

Figure 2-35. Connecticut Yankee Heavy Haul Truck Route (Google 2015)

Photo courtesy of Connecticut Yankee

Figure 2-36. Connecticut Yankee Pressurizer at the End of the Portland Rail Spur

Figure 2-37. Conditions at the End of the Portland Rail Spur (2012)

The Connecticut Yankee site is located on the shores of the Connecticut River and therefore could be accessible by barges that would transport used nuclear fuel transportation casks to nearby ports served by railroads or to barge-accessible rail sidings or spurs. The Connecticut Yankee barge slip is shown in Figure 2-33. The nearest port with rail access is in New Haven, Connecticut (DSI 2004). As discussed in Section 2.3.2, during decommissioning at Connecticut Yankee, the reactor pressure vessel, steam generators, and transformer were transported off-site using barges. Figure 2-38 through Figure 2-40 show the Connecticut Yankee reactor pressure vessel being loaded onto a barge and being transported by barge.

Photo courtesy of Connecticut Yankee

Figure 2-38. Connecticut Yankee Reactor Pressure Vessel Being Loaded onto Barge

Photo courtesy of Connecticut Yankee

Figure 2-39. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge

Photo courtesy of Connecticut Yankee

Figure 2-40. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge in the Connecticut River

2.3.4 Gaps in Information

The Connecticut Yankee site managers suggested that shipments of used nuclear fuel casks from the site should use barges. The on-site barge slip at Connecticut Yankee is an area of the shoreline along the cooling water discharge canal and has not been used since decommissioning but remains intact. It is uncertain whether the depth of the cooling water discharge canal remains deep enough to accommodate barges. In addition, the cooling water discharge canal and the Connecticut River can freeze in the winter.

Should it be necessary to use heavy haul trucks to move casks from the site, it would be necessary to work with local authorities to determine local routing and heavy haul truck operations procedures and schedules that would minimize disruption of traffic flow and other community activities in the moderately populated area. In addition, the heavy haul truck route from the Connecticut Yankee site to Portland, Connecticut can be ice covered at times during the winter and could need treatment to prepare it for shipments. An engineering review of the heavy haul route would also be required. It would also be necessary to work with the owners of the rail spur to improve track structures from their current degraded condition to allow the transfer of casks from heavy haul trucks to railcars. The condition of the rail bridge over the Connecticut River that is located west of the Portland rail spur would also need to be evaluated.

2.4 Humboldt Bay

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Humboldt Bay site. The Humboldt Bay site is located on Humboldt Bay near Eureka, California, about 260 miles north of San Francisco (TOPO 1993d).

2.4.1 Site Inventory

The Humboldt Bay ISFSI has a site-specific 10 CFR Part 72 license (License No. SNM-2514). Five canisters containing 390 used nuclear fuel assemblies and one canister containing GTCC low-level radioactive waste are stored at Humboldt Bay. Figure 2-41 shows the Humboldt Bay ISFSI. In contrast to other ISFSIs, the canisters at Humboldt Bay are stored in HI-STAR HB storage overpacks in a below-grade vault.

The storage system used at Humboldt Bay is the Holtec HI-STAR HB system, which is a variation of the HI-STAR 100 system (Docket No. 72-1008). The system consists of a multipurpose canister inside an overpack designed and certified for both storage and transportation. The MPC-HB canister used at Humboldt Bay can hold up to 80 Humboldt Bay boiling water reactor used nuclear fuel assemblies. The fuel assemblies from Humboldt Bay were loaded from August through December 2008 (Leduc 2012). The fuel rods in the fuel assemblies are zirconium alloy-clad. The HI-STAR HB storage overpacks used at Humboldt Bay are also transportable (Docket No. 71-9261); however, impact limiters are required and would need to be fabricated. The HI-STAR HB casks would also have to be leak tested and closure bolts inspected prior to shipping and seals replaced for any casks that failed the leak test or required replacement of closure bolts. The transportation certificate of compliance for the HI-STAR HB cask would need to be revised to allow transport of 44 used nuclear fuel assemblies at the Humboldt Bay site with initial enrichments of 2.08 weight percent, which is less than the minimum initial enrichment of 2.09 weight percent authorized by the transportation certificate of compliance for the HI-STAR HB cask. In addition, the HI-STAR HB cask is not currently certified for the transport of GTCC low-level radioactive waste.

Photo courtesy of Humboldt Bay

Figure 2-41. Humboldt Bay Independent Spent Fuel Storage Installation

Figure 2-42 illustrates the number of used nuclear fuel assemblies at Humboldt Bay based on their discharge year. The oldest fuel was discharged in 1971. The fuel was last critical in 1976 and was removed from the reactor vessel in 1984. The median discharge year of the fuel is 1975.

Figure 2-43 illustrates the number of used nuclear fuel assemblies at Humboldt Bay based on their burnup. The lowest burnup is 1.3 GWd/MTHM and the highest burnup is 22.9 GWd/MTHM. The median burnup is 16.4 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) is stored at Humboldt Bay.

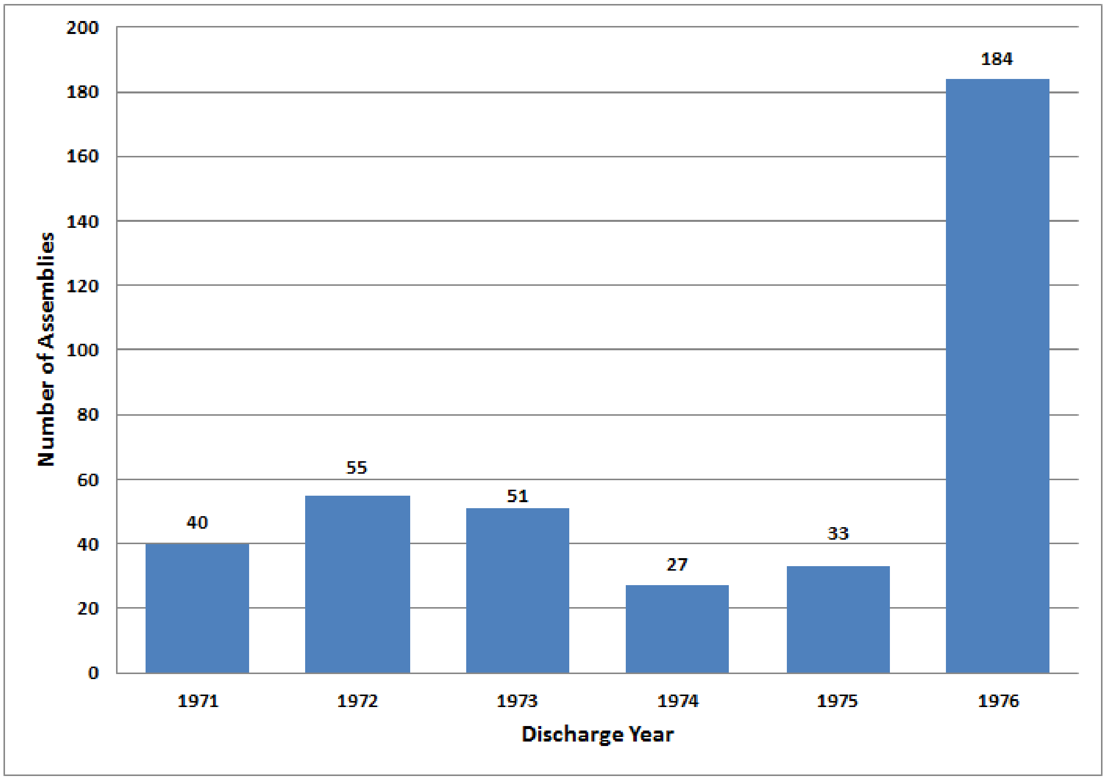

Figure 2-42. Humboldt Bay Number of Assemblies versus Discharge Year (EIA 2002)

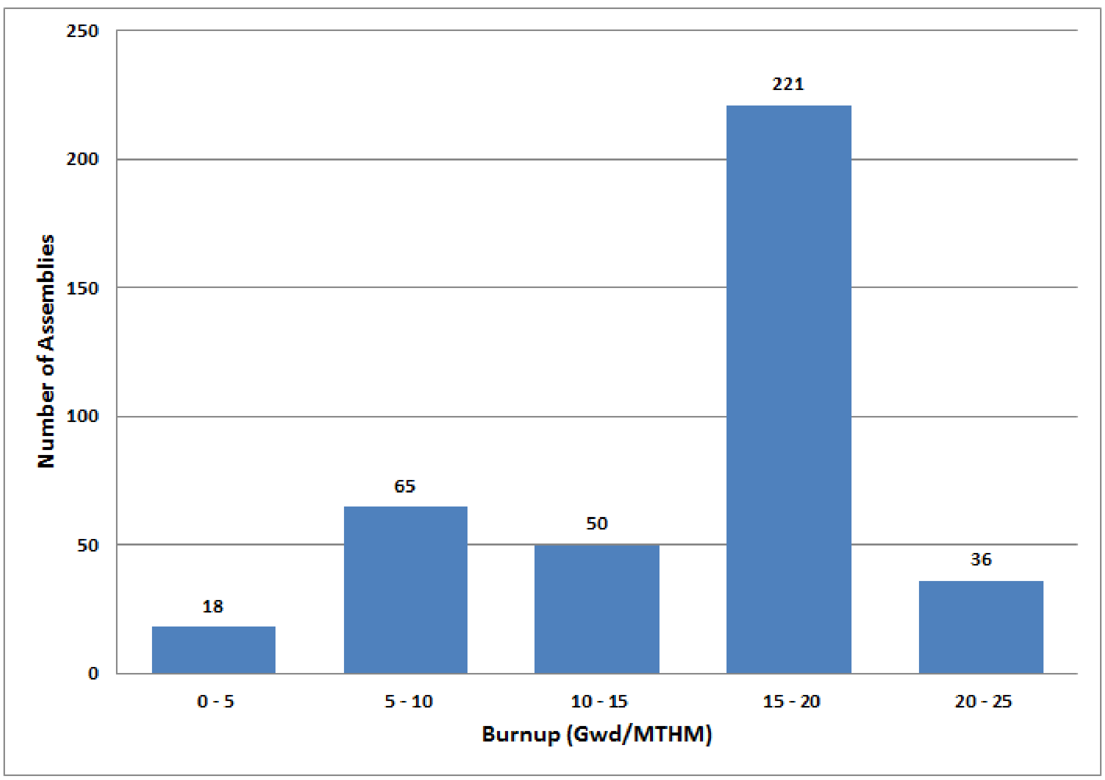

Figure 2-43. Humboldt Bay Number of Assemblies versus Burnup (EIA 2002)

2.4.2 Site Conditions

Figure 2-44 provides an aerial view of the Humboldt Bay site, which is being decommissioned, with completion anticipated in 2019. Electrical power is available at the Humboldt Bay ISFSI. The lifting device shown in Figure 2-41 which is used to remove the HI-STAR HB casks containing the Humboldt Bay used nuclear fuel or GTCC low-level radioactive waste from their below-grade vaults is shared with the Diablo Canyon site; however, mobile equipment such as cranes is not onsite. The HI-STAR HB casks are certified for both the storage and transport of the Humboldt Bay used nuclear fuel. Consequently, a transfer cask is not required at the Humboldt Bay site. The empty HI-STAR HB casks were moved to the Humboldt Bay site using heavy haul trucks (see Figure 2-45).

The Humboldt Bay site has not been served by rail since November 1998, when the Federal Railroad Administration issued Emergency Order 21, which closed the Northwestern Pacific Railroad from Arcata, California (milepost 295.5) to milepost 49.8S (formerly designated milepost 63.4) between Schellville and Napa Junction, California, a distance of 286 miles, for failure to meet federal safety standards (63 FR 67976-67979). In May 2011, the Federal Railroad Administration allowed the Northwestern Pacific Railroad to reopen as far north as milepost 62.9 near Windsor, California (76 FR 27171-27172), about 220 miles south of the Humboldt Bay site. There is also no on-site barge access at the Humboldt Bay site (TriVis Incorporated 2005, TOPO 1993d).

2.4.3 Near-site Transportation Infrastructure and Experience

The Humboldt Bay site does not have an on-site rail spur or an operating railroad that passes near to the site or along the site boundary. For Humboldt Bay, heavy haul trucks could be used to move transportation casks over public highways to a rail siding or spur that provides access to a railroad that can accommodate the loaded transportation casks. Alternatively, heavy haul trucks could be used to move loaded transportation casks from the Humboldt Bay site to a nearby barge facility where the casks would be loaded onto barges.

For shipments of casks containing used nuclear fuel that require the use of heavy haul trucks, the casks would be prepared for shipment at the Humboldt Bay ISFSI site and loaded onto a transport cradle that would then be loaded onto the transport trailer of a heavy haul truck. The heavy haul truck, led and followed by technical and security escorts, would move over an approved, designated highway route to a rail siding or spur or barge facility. Heavy lift equipment would be used to transfer the cask and its cradle as a unit from the heavy haul truck to a railcar at the rail siding or spur, or onto a barge, or the transport trailer carrying the cask could be rolled onto the barge deck.

Photo courtesy of Humboldt Bay

Figure 2-44. Aerial View of Humboldt Bay Site

Photo courtesy of Humboldt Bay

Figure 2-45. Empty HI-STAR HB Cask Being Transported by Heavy Haul Truck

The nearest rail access is located in Redding, California, a distance of about 160 miles from Humboldt Bay. To reach this location, heavy haul truck transport would be required on U.S. Highway 101 and State Route 299. The Union Pacific rail line in the vicinity of Redding is designated as track class 4.

During the decommissioning of Humboldt Bay, several truck routes have been used:[14]

- U.S. Highway 101 south to California State Route 20 to Interstate 5
- U.S. Highway 101 north to U.S. Highway 199 to Interstate 5
- U.S. Highway 101 north to California State Route 299 to Interstate 5.

These routes range in length from about 160 to 240 miles.

[14] Williams JR. 2013. Email message from L Sharp (Pacific Gas and Electric Company) to JR Williams (U.S. Department of Energy), "RE: PG&E Comments to DOE Draft Report," February 25, 2013.

The Humboldt Bay site is located on the Port of Humboldt Bay and therefore could be accessible by barges that would transport used nuclear fuel transportation casks to ports served by railroads or to barge-accessible rail sidings or spurs.

The Port of Humboldt Bay is located on the coast of northern California, approximately 225 nautical miles north of San Francisco, and approximately 156 nautical miles south of Coos Bay, Oregon (USACE 2012). Humboldt Bay is the only harbor between San Francisco and Coos Bay with deep-draft channels large enough to permit the passage of large commercial ocean-going vessels. It is the second largest coastal estuary in California (USACE 2012). Humboldt Bay is reported to have seven shipping terminals: Fairhaven Terminal, Humboldt Bay Forest Products Docks, Fields Landing Terminal, Redwood Marine Terminal, Schneider Dock, Sierra Pacific Eureka Dock, and the Simpson Mill Wharf Port Facility (HBHRCD 2012). The U.S. Army Corps of Engineers dredges shipping channels in and into Humboldt Bay to depths of 35 to 40 feet. DSI (2004) identifies San Francisco Bay and Coos Bay as the closest ports to Humboldt Bay with rail access.

Although there is no on-site barge access at the Humboldt Bay site, in 2010 barges were used to move 10 Wartsila engines weighing 680,000 lb. each and 10 generators weighing 165,000 lb. each to the Fields Landing Terminal (see Figure 2-46 and Figure 2-47), which is about 2 miles from the Humboldt Bay Generating Station[15] (AC&T 2011). The Fields Landing Channel is 12,000 feet long and 300 feet wide, with an 800-foot-long, 600-foot-wide turning basin (USACE 2012). The engines and generators were loaded onto barges at Schneider Dock in Eureka, California, moved by barge to the Fields Landing Terminal, and offloaded. Heavy haul trucks then moved the engines and generators from the Fields Landing Terminal to the Humboldt Bay Generating Station. Figure 2-46 also shows the heavy haul route taken from the Fields Landing Terminal to the Humboldt Bay Generating Station. Figure 2-48 shows the conditions of the Fields Landing Terminal in 2013. Figure 2-49 through Figure 2-53 show a Wartsila engine being loaded on a barge, a barge and Wartsila engine being towed to the Fields Landing Terminal, a barge and Wartsila engine arriving at the Fields Landing Terminal, a Wartsila engine being unloaded from the barge, and a Wartsila engine being transported by heavy haul truck to the Humboldt Bay Generating Station. Figure 2-54 and Figure 2-55 show the location of the Schneider Dock in relation to the Humboldt Bay site.

[15] Maheras SJ. 2012. Email message from A Richards (Senior Project Manager/Special Projects, Bragg Crane & Rigging) to SJ Maheras (Pacific Northwest National Laboratory), "Andy Richards / Bragg Crane & Rigging," October 17, 2012.

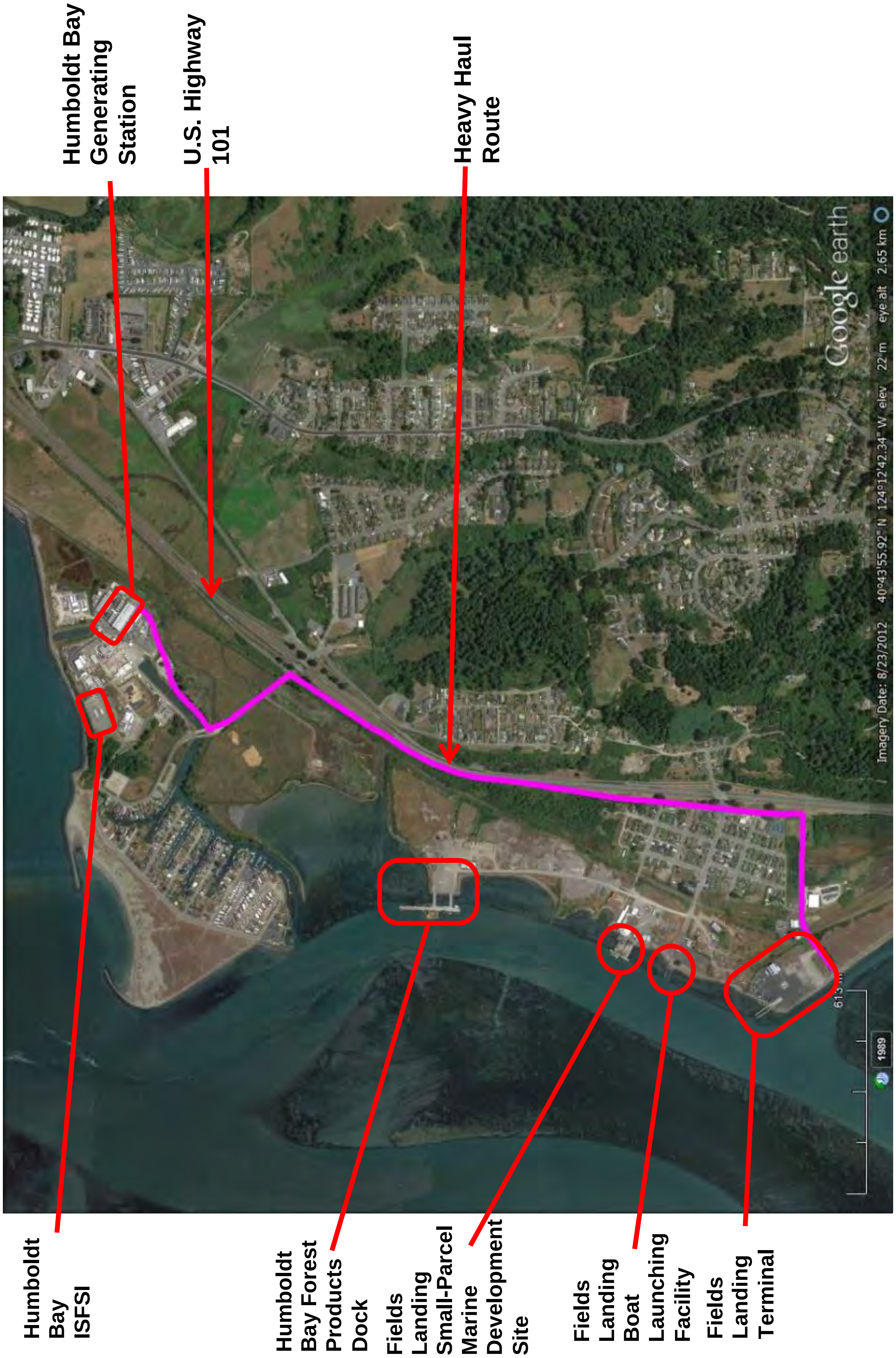

Figure 2-46. Humboldt Bay Independent Spent Fuel Storage Installation and Fields Landing Terminal (Google 2015)

Figure 2-47. Fields Landing Terminal (Google 2015)

Photo courtesy of Federal Railroad Administration

Figure 2-48. Condition of Fields Landing Terminal (2013)

Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-49. Wartsila Engine Being Loaded on a Barge (2010)

Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-50. Wartsila Engine on a Barge Being Towed to Fields Landing Terminal (2010)

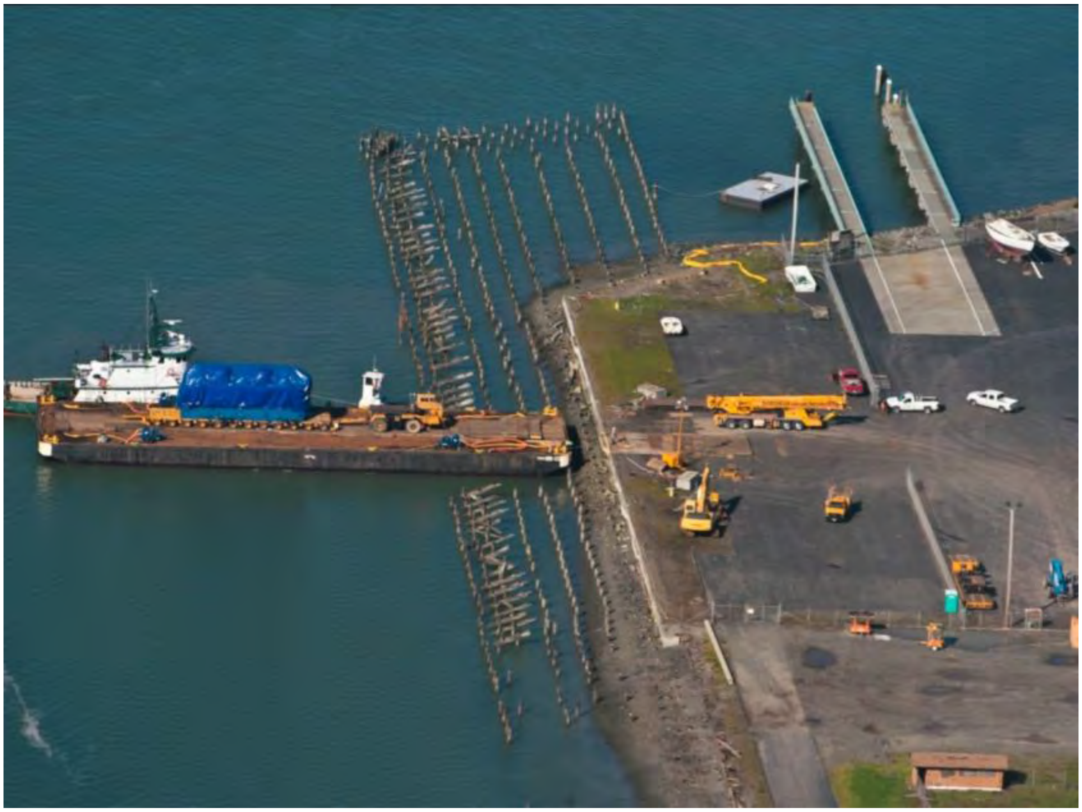

Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-51. Barge with Wartsila Engine Arriving at Fields Landing Terminal (2010)

Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-52. Wartsila Engine Being Unloaded at Fields Landing Terminal (2010)

Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-53. Wartsila Engine Being Transported by Heavy Haul Truck to Humboldt Bay Generating Station (2010)

Figure 2-54. Humboldt Bay Site and Schneider Dock (Google 2015)

Figure 2-55. Schneider Dock (Google 2015)

2.4.4 Gaps in Information

Off-site transportation of HI-STAR HB transportation casks from the Humboldt Bay ISFSI site would require either use of heavy haul trucks for transport over at least 160 miles of mostly two-lane roads that traverse California coastal mountain ranges to a rail siding or spur or use of barges to ship the casks to a port on the western U.S. coast that is served by a railroad.

As discussed in Section 2.4.2, the Humboldt Bay site has not been served by rail since 1998. In 2011, the Northwestern Pacific Railroad reopened as far north as Windsor, California, about 220 miles south of the Humboldt Bay site. The North Coast Railroad Authority hopes to have the rail line open to Willits, California by 2020, which is still about 140 miles south of the Humboldt Bay site. The nearest rail access is located in Redding, California, a distance of about 160 miles from Humboldt Bay (Table 2-3). The 160-mile trip on public highways from the site would entail travel on U.S. Highway 101 through Eureka, connecting to California Highway 299 to travel east across the coastal mountains to Redding, California. This route is illustrated in Figure 2-56. In Redding, heavy-lift equipment would be used to transfer casks from heavy haul trucks onto railcars that would be moved on the Union Pacific mainline that passes through the Redding area. One-way travel time for the heavy haul truck shipments could be greater than one week. It is likely that two of the heavy haul trucks would be moved in convoy in order to limit the overall impact on commuter traffic and business traffic that use the roads. Substantial coordination and planning of the shipments with local and California state officials would be necessary. Prior to the shipments highway engineers would need to survey the roads and road structures (bridges, culverts, and overpasses) to ensure that the shipments could be conducted safely. It is possible that temporary or even permanent improvements, such as adding passing lanes, would need to be made to sections of the roads and structures before the shipments could begin and travel might be limited to late spring through early fall because of weather and frost conditions on roads at higher elevations.

Alternative nearby rail access is located at Grants Pass, Oregon, and Williams, Marysville, and Red Bluff, California. Heavy haul truck routes to these locations are illustrated in Figure 2-56. The distances to these locations range from about 160 to 280 miles (see Table 2-3). Representatives of PG&E have stated that a route using U.S. Highway 101 and State Route 36 would be unacceptable for heavy haul trucks.[16]

Additional heavy haul routes could potentially be used. For example, a heavy haul to Coos Bay, Oregon would be a distance of about 220 miles along U.S. Highway 101, a heavy haul to Windsor, California would be a distance of about 210 miles along U.S. Highway 101, a heavy haul to the San Francisco Bay Area would be a distance of about 240 miles, and a heavy haul to Sacramento, California would be a distance of about 290 miles along U.S. Highway 101, California Highway 20, and Interstate 5. A heavy haul to Willits, California would be a distance of about 130 miles along U.S. Highway 101, but the Northwestern Pacific Railroad is not open to

[16] Williams JR. 2013. Email message from L Sharp (Pacific Gas and Electric Company) to JR Williams (U.S. Department of Energy), "RE: PG&E Comments to DOE Draft Report," February 25, 2013.

Willits. In addition, it is not known if the Northwestern Pacific Railroad will handle hazardous material shipments.[17]

Table 2-3. Alternative Rail Access for Humboldt Bay

Rail Access	Route	Heavy Haul Distance (miles)
Grants Pass, Oregon	U.S. Highway 101 to U.S. Highway 199	180
Redding, California	U.S. Highway 101 to State Route 299	160
Red Bluff, California	U.S. Highway 101 to State Route 36[a]	160
Williams, California	U.S. Highway 101 to State Route 20	240
Marysville, California	U.S. Highway 101 to State Route 20	280

a. Note: Representatives of PG&E have stated that a route using U.S. Highway 101 and State Route 36 would be unacceptable for heavy haul trucks.

Barge transportation of used nuclear fuel casks from the Humboldt Bay site along the Pacific coast to a port facility that is served by a railroad could be an alternative. However, the site does not have a barge siding or dock, and it is uncertain whether barges could be landed at the shoreline of the site to allow roll-on of heavy haul trucks carrying the six HI-STAR HB casks. A marine survey has not been conducted to determine whether the depth of Humboldt Bay waters that approach the site and the bottom conditions near the shore would permit landing and securing a barge to the shoreline, safely loading it, and backing it back into a navigable channel in the bay. In addition, it is possible that approvals would be needed from California state authorities and from the U.S. Army Corps of Engineers before it would be possible to use a landed barge to load transportation casks containing used nuclear fuel.

It may be possible to use heavy haul trucks to transport the casks to a nearby shipping terminal in Humboldt Bay. Humboldt Bay is reported to have seven shipping terminals and it would be necessary to determine which, if any, of the reported shipping terminals in Humboldt Bay could be used for shipments of the casks and what routing would be used by heavy haul trucks. Ten large engines and generators were delivered to Schneider Dock in Eureka, California, transported by barge from Schneider Dock to the Fields Landing Terminal, and transported from Fields Landing Terminal to the Humboldt Bay site using heavy haul trucks (AC&T 2011). Moving casks to the Fields Landing Terminal would involve travel over approximately 2 miles of roadways including about 0.5 mile of U.S. Highway 101 and the remainder on local roadways.

[17] Used nuclear fuel and GTCC low-level radioactive waste would be Class 7 hazardous material.

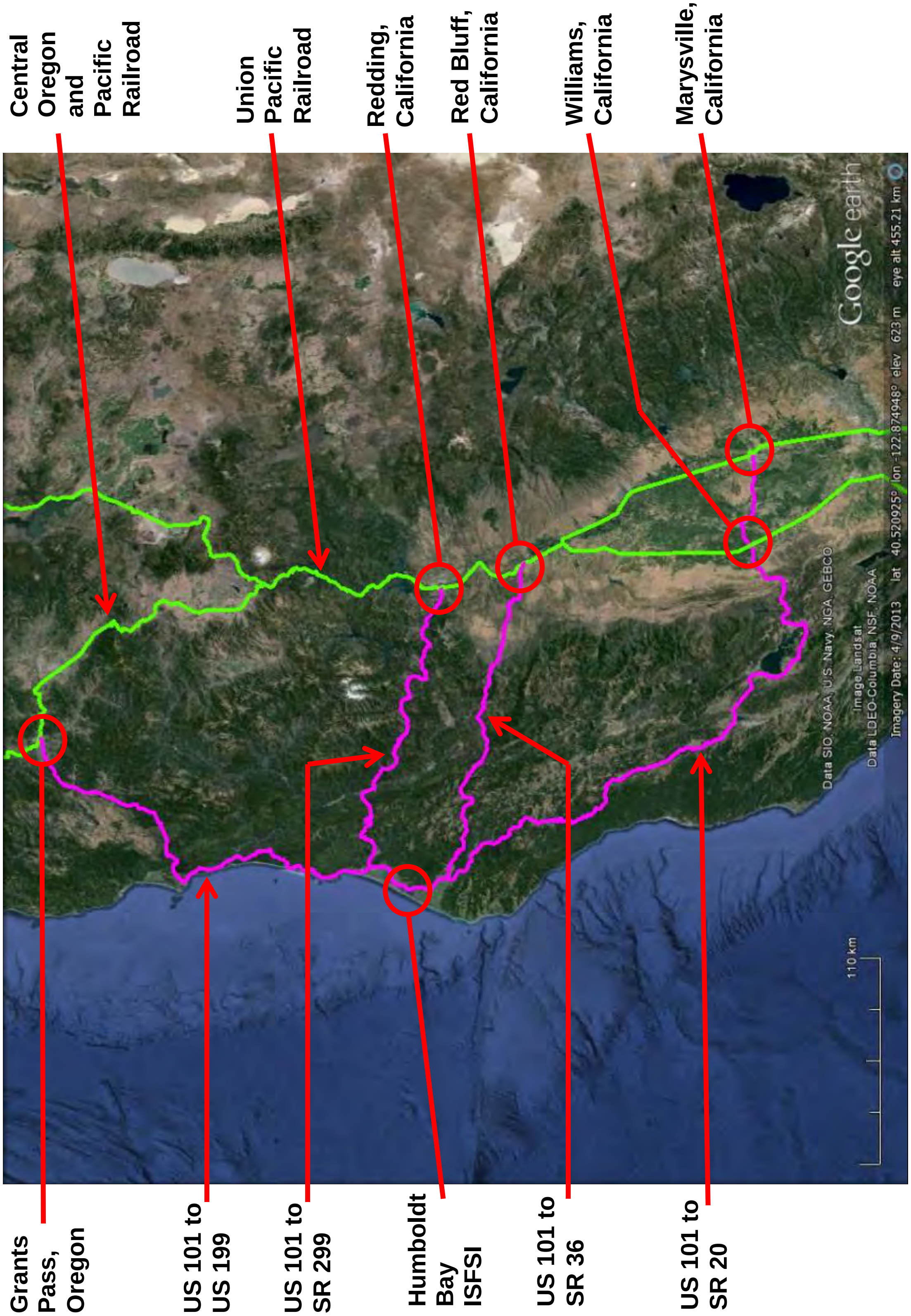

Figure 2-56. Heavy Haul Routes from Humboldt Bay Independent Spent Fuel Storage Installation to Alternative Rail Access Locations (Google 2015)

2.5 Big Rock Point

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Big Rock Point site. The Big Rock Point site is located on the eastern shore of Lake Michigan about 4 miles north of Charlevoix and 10 miles west of Petoskey, Michigan (TOPO 1994a).

2.5.1 Site Inventory

Seven canisters containing 441 used nuclear fuel assemblies and 1 canister of GTCC low-level radioactive waste are stored at the Big Rock Point ISFSI (Docket No. 72-43). The seven canisters contain 50 damaged used nuclear fuel assemblies which have been placed in damaged fuel cans. In addition to uranium dioxide (UO_2) used nuclear fuel assemblies, there are 36 mixed oxide used nuclear fuel assemblies stored at Big Rock Point. Table 2-4 lists the assembly identification numbers for these mixed oxide used nuclear fuel assemblies.

Table 2-4. Assembly Identification Numbers for Mixed Oxide Used Nuclear Fuel Assemblies at Big Rock Point

Fuel Assembly	Fuel Assembly	Fuel Assembly	Fuel Assembly
D72	G04	G13	G204
D73	G05	G14	G205
DA1	G06	G15	G206
DA2	G07	G16	G207
DA3	G08	G17	G208
DA4	G09	G18	G209
G01	G10	G19	G210
G02	G11	G20	E65
G03	G12	G21	E72

a. Source: Maheras SJ. 2014. Email message from LR Potter (Entergy) to SJ Maheras (Pacific Northwest National Laboratory), "RE: mox fuel assemblies at big rock point," April 2, 2014.

Figure 2-57 shows the Big Rock Point ISFSI. The storage system used at Big Rock Point is the FuelSolutions Storage System which consists of the W74 canister, the W150 storage cask, and the W100 transfer cask (Docket No. 72-1026). The W74 canister holds 64 Big Rock Point boiling water reactor used nuclear fuel assemblies. The fuel assemblies from Big Rock Point were loaded into W74 canisters from December 2002 through March 2003 (Leduc 2012). The fuel rods in the fuel assemblies are zirconium alloy-clad. The TS125 transportation cask (Docket No. 71-9276) is certified to transport the W74 canister. No TS125 transportation casks have been fabricated. In addition, the TS125 transportation cask is not certified for the transport of GTCC low-level radioactive waste.

Photo courtesy of Big Rock Point

Figure 2-57. Big Rock Point Independent Spent Fuel Storage Installation

In October 2012, the NRC issued a renewed certificate of compliance to EnergySolutions for the TS125 transportation cask. The renewed certificate of compliance expires on October 31, 2017 (Waters 2012). The Safety Evaluation Report for the renewal of the certificate of compliance observes that no TS125 transportation casks have been fabricated and states that because the TS125 transportation cask has a -85 designation in its identification number (i.e., USA/9276/B(U)F-85), all fabrication of this package must have been completed by December 31, 2006, as required by 10 CFR 71.19(c). In order to fabricate TS125 transportation casks, EnergySolutions would need to apply for a -96 designation by submitting a revised safety analysis report to demonstrate that the TS125 transportation cask meets the current NRC regulations contained in 10 CFR Part 71. The revisions to the TS125 safety analysis report would include:

- **Revised A_1 and A_2 values.** EnergySolutions would need to update the containment analysis in Chapter 4 of the safety analysis report to incorporate revised A2 values in 10 CFR Part 71, Appendix A, Table A-1. An increase in the maximum allowable leakage rates for the TS125 transportation cask would be expected.
- **Criticality Safety Index (CSI).** EnergySolutions would need to revise Chapters 1, 5, and 6 of the TS125 transportation cask safety analysis report to incorporate the CSI nomenclature and the NRC would need to revise the certificate of compliance to delete references to the Transport Index for criticality control.
- **Expansion of Quality Assurance (QA) Requirements.** EnergySolutions would need to revise the safety analysis report for the TS125 transportation cask to demonstrate how its QA program satisfies the specific requirements of 10 CFR 71.101(a), (b), and (c).

A -96 designation must also be obtained before the TS125 transportation cask is certified for the transport of GTCC low-level radioactive waste. The effort to accomplish these changes and to obtain NRC review and approval is estimated to range from one to three years.

Figure 2-58 illustrates the number of used nuclear fuel assemblies at Big Rock Point based on their discharge year. The oldest fuel was discharged in 1974 and the last fuel was discharged in 1997. The median discharge year of the fuel is 1988.

Figure 2-59 illustrates the number of used nuclear fuel assemblies at Big Rock Point based on their burnup. The lowest burnup is 3.5 GWd/MTHM and the highest burnup is 34.2 GWd/MTHM. The median burnup is 23.7 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) is stored at Big Rock Point.

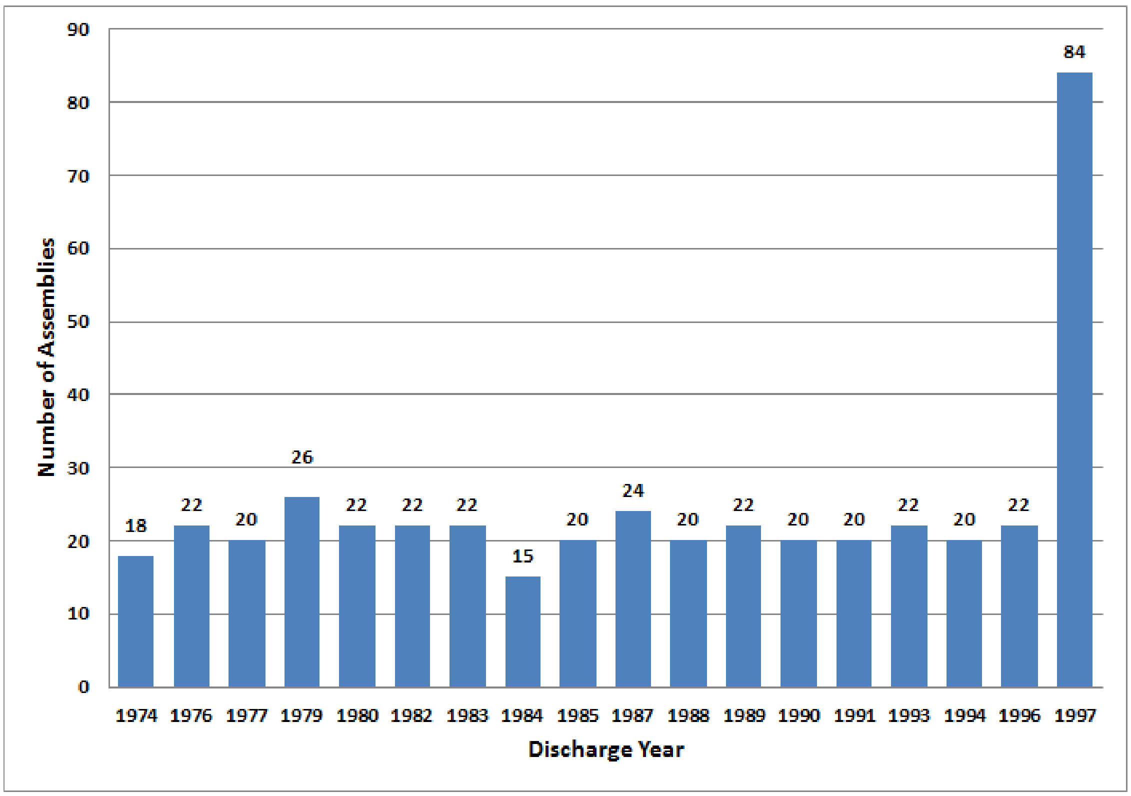

Figure 2-58. Big Rock Point Number of Assemblies versus Discharge Year (EIA 2002)

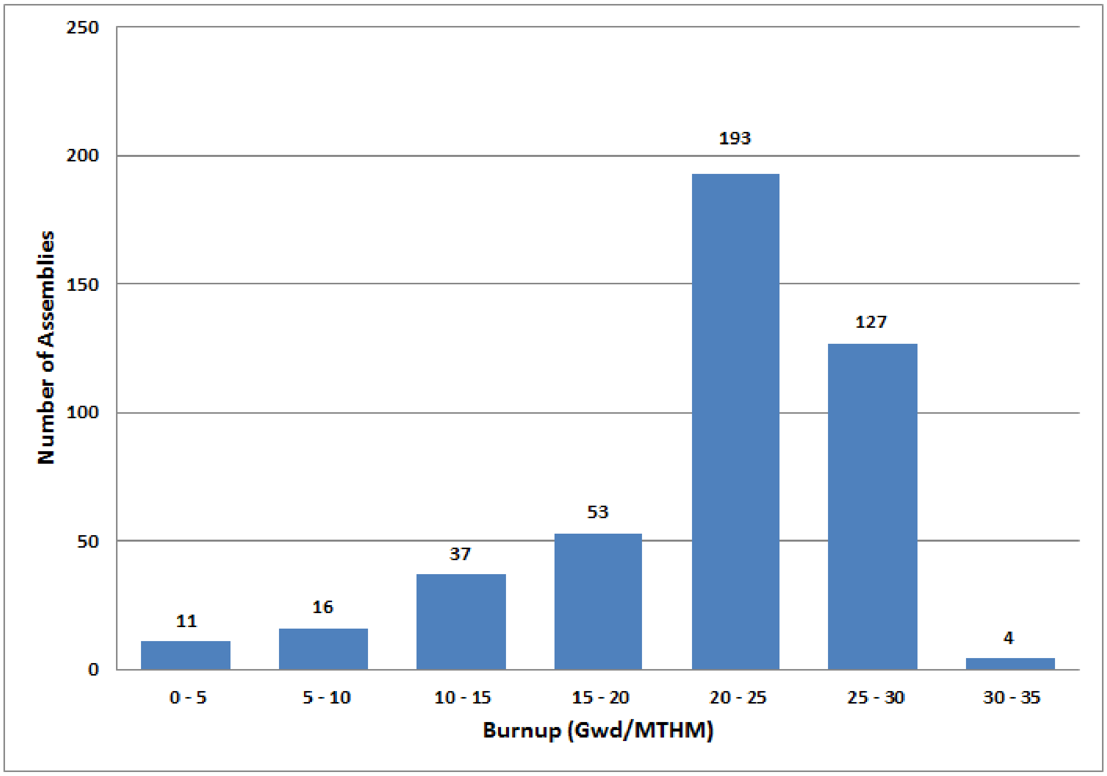

Figure 2-59. Big Rock Point Number of Assemblies versus Burnup (EIA 2002)

2.5.2 Site Conditions

Figure 2-60 provides an aerial view of the Big Rock Point site, where the reactor and associated structures have been removed. Electrical power is available at the Big Rock Point ISFSI; a transfer cask, gantry towers, horizontal transfer system, and J-skid[18] are present at the ISFSI. Herron (2010) stated that the equipment needed to transfer used nuclear fuel and GTCC low-level radioactive waste in W74 canisters from the W150 storage casks to the TS125 transportation cask is in place, is tested on a periodic basis, and preventative maintenance is performed. Figure 2-61 shows the transfer cask and J-skid, Figure 2-62 shows the gantry towers, and Figure 2-63 shows the horizontal transfer system at the Big Rock Point site.

A rail spur that served the Big Rock Point site was removed in 1988 (NAC 1990). This spur was used for nine rail shipments of used nuclear fuel to West Valley, New York between 1970 and 1974 (NAC 1990). There is no on-site rail access at the Big Rock Point site (TriVis Incorporated 2005), and heavy haul truck transport would be necessary to reach nearby rail sidings or spurs. For example, a rail spur in Gaylord, Michigan was used for shipping the reactor pressure vessel from Big Rock Point to the Barnwell, South Carolina low-level radioactive waste disposal facility (Petrosky 2004), and a rail siding in Petoskey, Michigan was used for shipping the steam drum to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah (Tompkins 2006). Herron (2010) states that the heavy haul roadway no longer exists on the site

[18] The J-skid is a built-up welded steel frame of heavy wide flange beams and cross members that is used to capture and engage the W150 storage cask for rotation by the gantry towers. This J-skid is also used to support the W150 storage cask in the horizontal orientation during W74 canister transfer.

and that the current access road from the ISFSI to the highway was not built to support heavy haul transfers, and may need to be rebuilt or enhanced.

TOPO (1994a) states that an on-site barge facility was used during the construction of Big Rock Point, but its use was discontinued in the early 1960s after Big Rock Point was completed. TOPO (1994a) also identifies a potential barge area at the Big Rock Point site (see Figure 2-60). However, NAC (1990) states that Big Rock Point has never had an on-site barge facility.

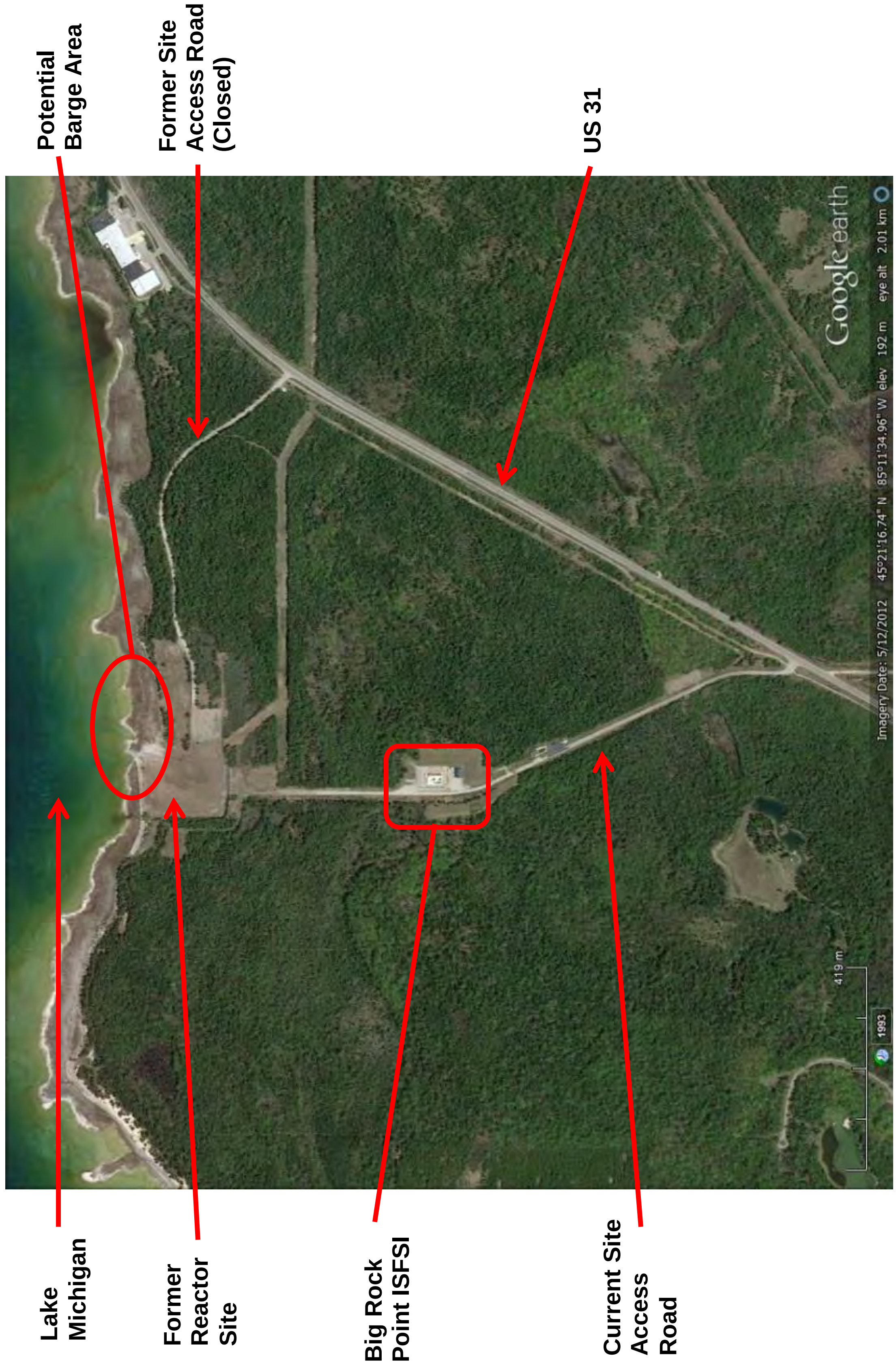

Figure 2-60. Aerial View of Big Rock Point Site (Google 2015)

Photo courtesy of Big Rock Point

Figure 2-61. Transfer Cask and J-Skid at Big Rock Big Rock Point Independent Spent Fuel Storage Installation (2013)

Photo courtesy of Big Rock Point

Figure 2-62. Big Rock Point Gantry Towers (2013)

Photo courtesy of Big Rock Point

Figure 2-63. Big Rock Point Horizontal Transfer System (2013)

2.5.3 Near-site Transportation Infrastructure and Experience

The Big Rock Point site does not have an on-site rail spur or a railroad that passes near to the site or along the site boundary. For Big Rock Point, heavy haul trucks could be used to move transportation casks over public highways to a rail siding or spur that provides access to a railroad that can accommodate the loaded transportation casks. Site representatives from Big Rock Point have also stated that seasonal restrictions would likely exist during January through March because of winter conditions, and during July through September because of the large number of tourists in the Big Rock Point area.

For shipments of casks containing used nuclear fuel that require the use of heavy haul trucks, the casks would be prepared for shipment at the Big Rock Point ISFSI site and loaded onto a transport cradle that would be loaded onto the transport trailer of a heavy haul truck. The truck, led and followed by technical and security escorts, would move over an approved, designated highway route to a rail siding or spur. Heavy lift equipment would be used to transload the cask and its cradle as a unit from the truck to a railcar at the rail siding or spur.

During the decommissioning of the Big Rock Point reactor, heavy haul trucks were used to move the reactor pressure vessel and steam drum from the Big Rock Point site to nearby rail sidings or spurs. In 2003, the reactor pressure vessel from the Big Rock Point reactor was moved on a Goldhofer trailer with 36 independently controlled axles and 144 tires propelled by two 1000-horsepower engines (Figure 2-64) about 52 miles to a rail spur near Gaylord, Michigan, transloaded onto an ETMX1001 railcar (Figure 2-65 through Figure 2-67), and then transported by rail to the Barnwell, South Carolina low-level radioactive waste disposal facility (Petrosky 2004, Slimp et al. 2014) (Figure 2-68). The Big Rock Point pressure vessel and its shipping package weighed more than 565,000 lb. Figure 2-69 shows the route taken from the Big Rock Point site to Gaylord, Michigan. The Lake State Railway in the vicinity of Gaylord is designated as track class 2. In the vicinity of Big Rock Point, a detour off of U.S. 31 was required to bypass an abandoned overhead rail bridge with inadequate vertical clearance. Figure 2-70 shows this detour and Figure 2-71 shows the bridge. Figure 2-72 shows the route taken by the reactor pressure vessel in the vicinity of Gaylord, Michigan and Figure 2-73 and Figure 2-74 show the condition in 2013 of the rail crossing and spur used for the Big Rock Point reactor pressure vessel transload. The track class at this crossing and spur appears to be "Excepted" and would likely require refurbishment prior to use for used nuclear fuel shipments.

In 2003, the Big Rock Point steam drum was also moved by heavy haul truck about 13 miles to a rail siding near Petoskey, Michigan, transloaded onto a railcar, and then transported by rail to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah (Gretzner 2006, Tompkins 2006). The steam drum weighed 200,000 lb. (Figure 2-75 and Figure 2-76). The Great Lakes Central Railroad is designated as track class 1 in the vicinity of Petoskey. The height of the steam drum on its transporter was low enough so that it did not require the same detour as described for the reactor pressure vessel and was able to take U.S. 31 from the Big Rock Point site into Petoskey, Michigan (see Figure 2-69). Figure 2-77 shows the route taken by the reactor pressure vessel in the vicinity of Petoskey, Michigan and Figure 2-78 shows the condition in 2013 of the of rail crossing and siding used for Big Rock Point steam drum transload.

Photo courtesy of Barnhart Crane & Rigging

Figure 2-64. Big Rock Point Reactor Pressure Vessel on Heavy Haul Truck (2003)

Photo courtesy of William J. Trubilowicz

Figure 2-65. ETMX1001 Railcar Staged for Transfer (2003)

Photo courtesy of William J. Trubilowicz

Figure 2-66. Heavy Haul Truck with Reactor Pressure Vessel beside ETMX1001 Railcar (2003)

Photo courtesy of William J. Trubilowicz

Figure 2-67. Transfer of Reactor Pressure Vessel onto ETMX1001 Railcar (2003)

Photo courtesy of Consumers Energy

Figure 2-68. Big Rock Point Reactor Pressure Vessel on ETMX1001 Railcar (2003)

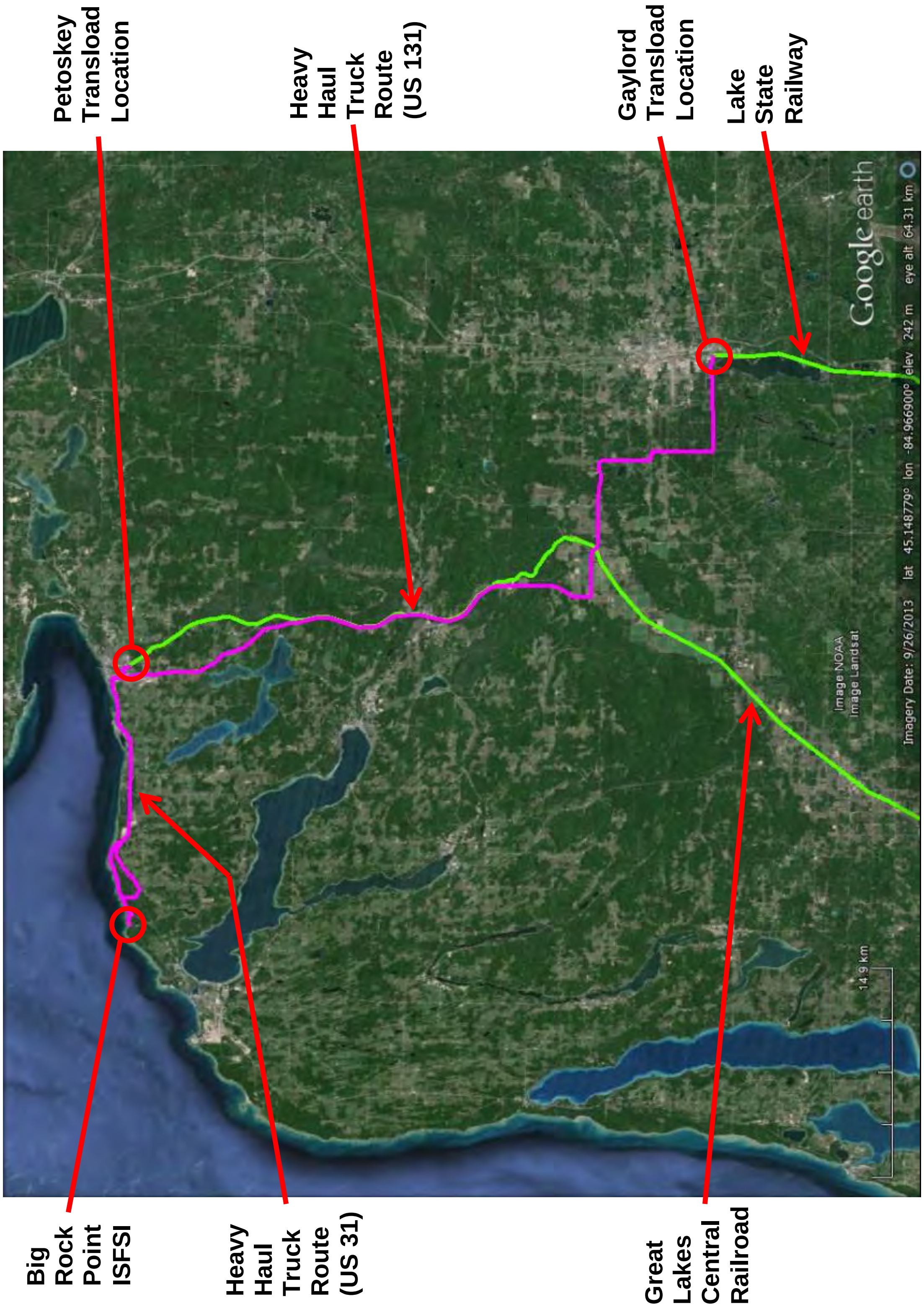

Figure 2-69. Big Rock Point Reactor Pressure Vessel Heavy and Steam Drum Haul Truck Routes (Google 2015)

Figure 2-70. Route Taken By Reactor Pressure Vessel to Bypass Low Overhead Clearance Abandoned Railroad Bridge (Google 2015)

Figure 2-71. Low Overhead Clearance Abandoned Railroad Bridge on U.S. 31 (2013)

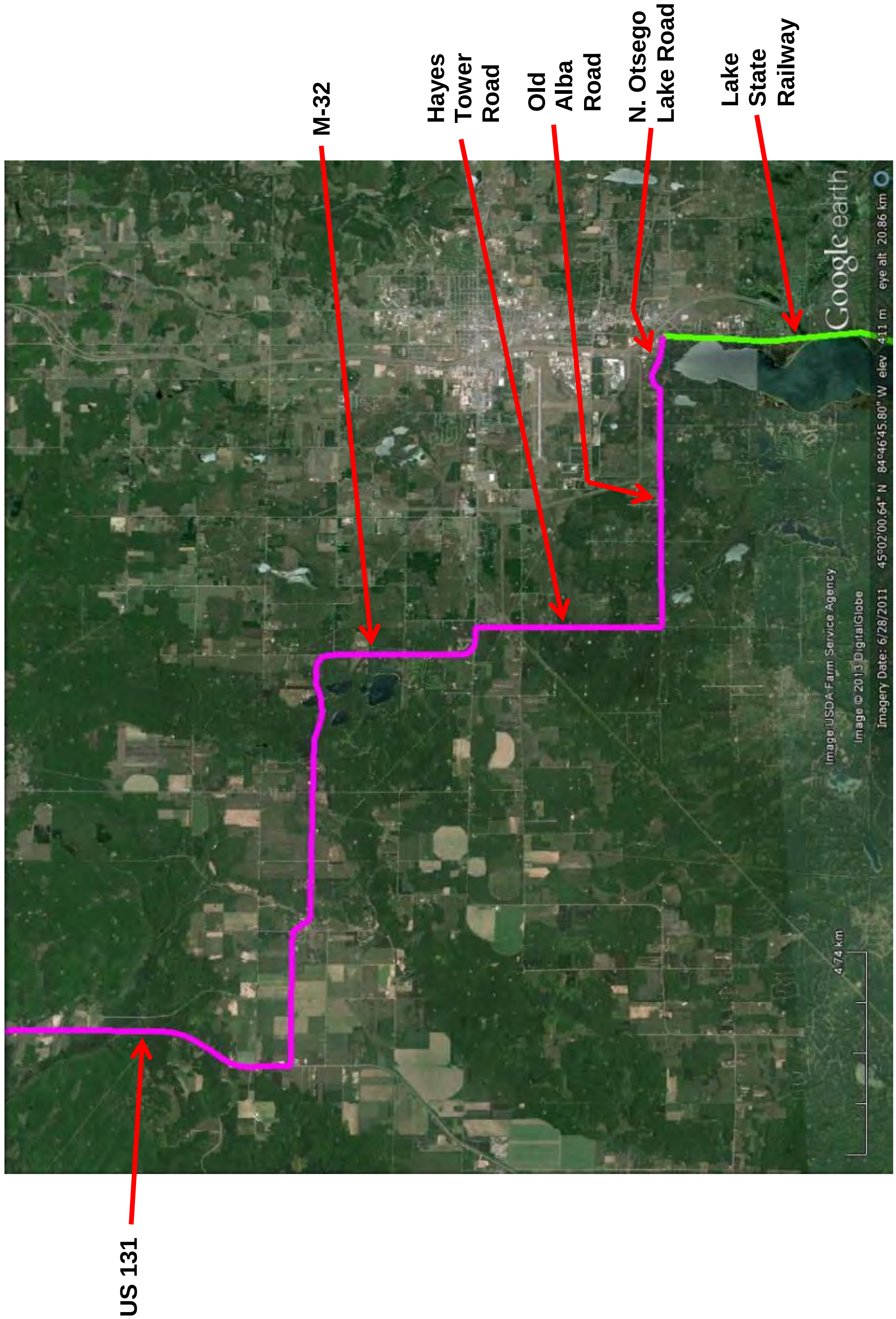

Figure 2-72. Route Taken By Reactor Pressure Vessel in the Vicinity of Gaylord, Michigan (Google 2015)

Figure 2-73. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking North) (2013)

Figure 2-74. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking South) (2013)

Photo courtesy of Consumers Energy

Figure 2-75. Big Rock Point Steam Drum on Heavy Haul Truck (2003)

Photo courtesy of Consumers Energy

Figure 2-76. Big Rock Point Steam Drum on Railcar (2003)

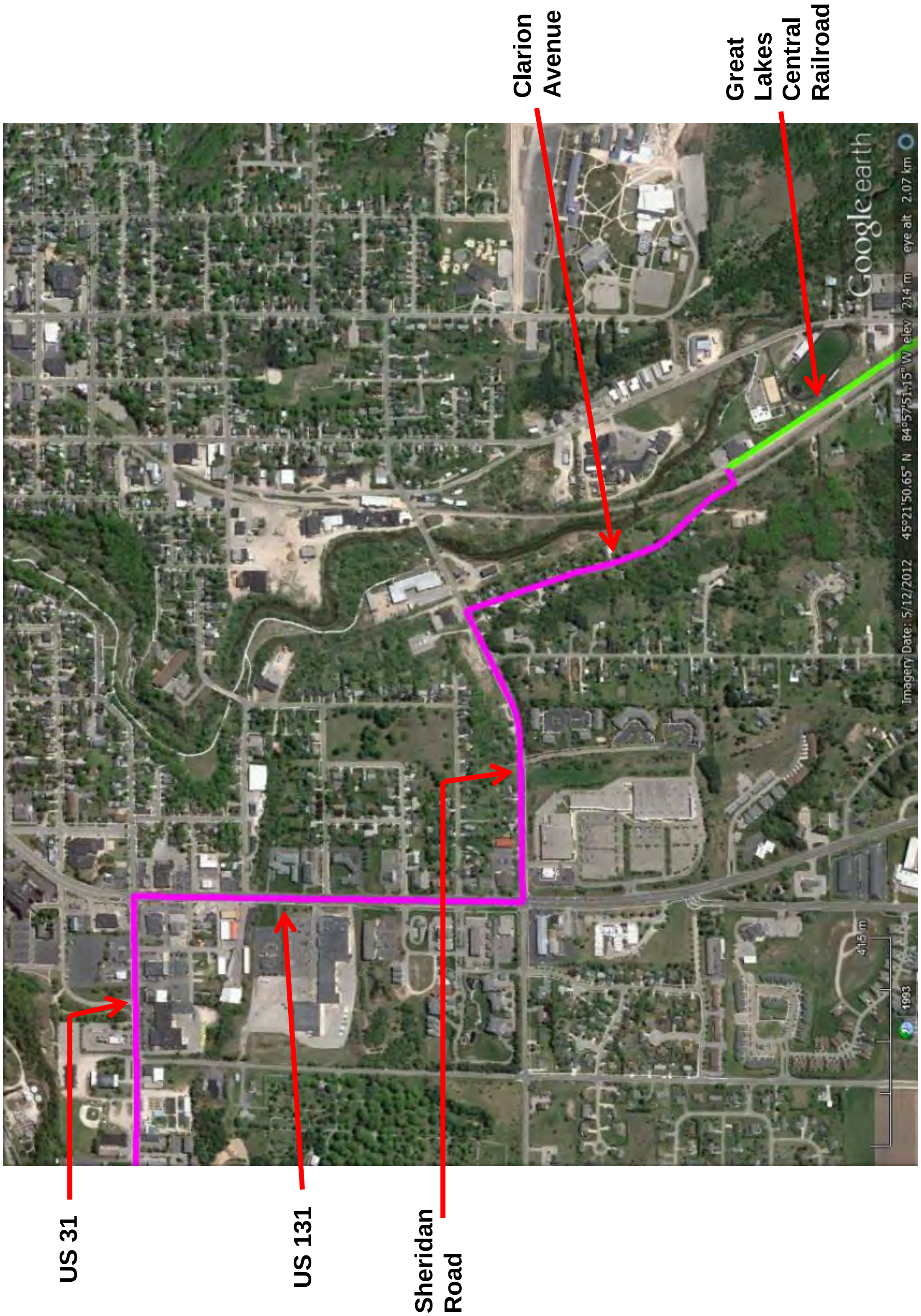

Figure 2-77. Route Taken By Steam Drum in the Vicinity of Petoskey, Michigan (Google 2015)

Photo courtesy of Federal Railroad Administration

Figure 2-78. Condition of Petoskey Rail Siding (2013)

The Big Rock Point site is on the shore of Lake Michigan, and therefore could be accessible by barges that would transport used nuclear fuel transportation casks to nearby ports served by railroads or to barge-accessible rail sidings or spurs. DSI (2004) identifies the following ports with rail access:

- Traverse City, Manistee, Ludington, Muskegon, and Grand Haven as ports with rail access along the eastern shore of Lake Michigan
- Alpena, Bay City, Port Huron, Saint Clair, and Detroit as ports with rail access along the western shore of Lake Huron
- Inland, Escanaba, Green Bay, and Milwaukee as ports with rail access along the western shore of Lake Michigan
- Chicago, Indiana Harbor, Buffington, and Gary as ports with rail access along the southern shore of Lake Michigan.

The capabilities of these ports have not been investigated.

Figure 2-79 shows the condition of the shoreline in 2013 in the vicinity of the potential barge area identified in Figure 2-60.

Photo courtesy of Big Rock Point

Figure 2-79. Condition of Potential Barge Area at Big Rock Point (2013)

2.5.4 Gaps in Information

As discussed in Section 2.5.3, shipments of large reactor components have been made from the Big Rock Point site using heavy haul trucks to carry the components to rail sidings for loading onto railcars. The weight limits associated with the Great Lakes Central Railway and the Lake State Railway track that would be used would need to be evaluated, as well as the current condition of rail sidings or spurs that would be used.

It may also be possible to use barges to transport casks containing used nuclear fuel directly from the Big Rock Point site to a port that is served by a railroad. There is not a barge slip, dock, or landing area on the site's Lake Michigan shoreline. Also, it is unknown whether the depth of water approaching the shore at the site and the bottom conditions near the shore would permit safe operations for barges, and whether extensive grading and spreading of gravel would be required. Barge operations could use either heavy lift equipment to move casks from heavy haul transporters onto barges or the heavy haul transporters might be rolled directly onto barges. Lake Michigan is subject to freezing in the Big Rock Point area (TOPO 1994a), and barge operations would not be conducted on Lake Michigan during winter months.

2.6 Rancho Seco

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Rancho Seco site. The Rancho Seco site is located about 25 miles southeast of Sacramento, California (NAC 1991a).

2.6.1 Site Inventory

The Rancho Seco ISFSI has a site-specific 10 CFR Part 72 license (License No. SNM-2510). Twenty-one canisters containing 493 used nuclear fuel assemblies and 1 canister of GTCC low-level radioactive waste are stored at Rancho Seco. Figure 2-80 shows the Rancho Seco ISFSI. The storage system used at Rancho Seco is a site-specific model of the Standardized NUHOMS-24P system (Docket No. 72-1004), which consists of transportable canisters, reinforced concrete horizontal storage modules, and a transfer cask. The canisters used at Rancho Seco are the fuel-only dry shielded canister (FO-DSC) (2 canisters), fuel with control component dry shielded canister (FC-DSC) (18 canisters), and failed fuel dry shielded canister (FF-DSC) (1 canister). The FO-DSC and FC-DSC hold 24 pressurized water reactor used nuclear fuel assemblies and the FF-DSC holds 13 pressurized water reactor used nuclear fuel assemblies. There are 48 assemblies contained in FO-DSCs, 432 assemblies contained in FC-DSCs, and 13 assemblies contained in FF-DSCs. The fuel assemblies from Rancho Seco were loaded from April 2001 through August 2002 (Leduc 2012). The fuel rods in the fuel assemblies are zirconium alloy-clad. The transfer cask used at Rancho Seco is the MP187 transportation cask (Docket No. 71-9255), which is also certified for off-site transportation of the FO-DSC, FC-DSC, and FF-DSC. The MP187 transportation cask that was used to load the Rancho Seco ISFSI is stored at the Rancho Seco site (see Figure 2-81). The hydraulic ram used to emplace and withdraw canisters from the horizontal storage modules is also stored at the Rancho Seco site (see Figure 2-82). Figure 2-83 shows the MP187 transportation cask and hydraulic ram being used to load a canister into a horizontal storage module. Impact limiters are required for off-site transport of the MP187 transportation cask and would need to be fabricated. The MP187 transportation cask is also not certified for the transport of GTCC low-level radioactive waste.

Photo courtesy of Rancho Seco

Figure 2-80. Rancho Seco Independent Spent Fuel Storage Installation

Figure 2-81. MP187 Transportation Cask at Rancho Seco (2013)

Figure 2-82. Hydraulic Ram Used to Emplace and Withdraw Canisters from Horizontal Storage Modules at Rancho Seco (2013)

Photo courtesy of Rancho Seco

Figure 2-83. MP187 Transportation Cask and Hydraulic Ram Being Used to Load a Canister into a Horizontal Storage Module at Rancho Seco

In August 2013, the NRC issued a renewed certificate of compliance to Transnuclear for the MP187 transportation cask (Sampson 2013).[19] The Safety Evaluation Report for the renewal of the certificate of compliance states that because the MP187 transportation cask has a -85 designation in its identification number (i.e., USA/9255/B(U)F-85), all fabrication of this package must have been completed by December 31, 2006, as required by 10 CFR 71.19(c). To date, one MP187 transportation cask without impact limiters has been fabricated, and before additional MP187 transportation casks are fabricated, Transnuclear/AREVA would need to apply for a -96 designation by submitting a revised safety analysis report to demonstrate that the MP187 transportation cask meets the current NRC regulations contained in 10 CFR Part 71. The revisions to the MP187 safety analysis report would include:

- **Revised A_1 and A_2 values.** Transnuclear would need to update the containment analysis in Chapter 4 of the safety analysis report to incorporate revised A2 values in 10 CFR Part 71, Appendix A, Table A-1. An increase in the maximum allowable leakage rates for the MP187 transportation cask would be expected.

[19] A subsequent update to the MP187 certificate of compliance changed the name of the entity to which the certificate of compliance was issued to from Transnuclear, Inc. to AREVA, Inc. (Sampson 2014).

- **Criticality Safety Index.** Transnuclear would need to revise Chapters 1, 5, and 6 of the MP187 transportation cask safety analysis report to incorporate the CSI nomenclature and the NRC would need to revise the certificate of compliance to delete references to the Transport Index for criticality control.
- **Expansion of QA Requirements.** Transnuclear would need to revise the safety analysis report for the MP187 transportation cask to demonstrate how its QA program satisfies the specific requirements of 10 CFR 71.101(a), (b), and (c).

Representatives of Transnuclear/AREVA have also stated that the -96 designation must be obtained before impact limiters are fabricated for the existing MP187 transportation cask.[20] A -96 designation must also be obtained before the MP187 transportation cask is certified for the transport of GTCC low-level radioactive waste. The effort to accomplish these changes and to obtain NRC review and approval is estimated to range from one to three years.

There are six damaged fuel assemblies stored in five FC-DSCs at Rancho Seco. Table 2-5 lists the details of these damaged fuel assemblies. When this fuel was originally packaged in canisters, the fuel was visually inspected and classified as damaged if cladding failures with breaches greater than 25 percent of the circumference of the fuel pin and at least the length of a fuel pellet were present (Redeker 2006). This equates to a cladding failure that is 0.34 inches across the cladding and 0.7 inches along the cladding. Fuel assemblies not classified as damaged using this definition were classified as intact. The current definition of intact fuel is more restrictive, where fuel assemblies are classified as intact if they contain no cladding breaches (NRC 2007a). Assemblies are classified as undamaged if they have no defects greater than hairline cracks or pinhole leaks (NRC 2007a). This change in the definition of damaged and intact fuel resulted in the six fuel assemblies formerly classified as intact being reclassified as damaged, using the new definition. The Rancho Seco storage license was amended to recognize this situation; however, the certificate of compliance for the MP187 transportation cask requires that damaged fuel assemblies are shipped in FF-DSCs, not in FC-DSCs, so the requirements for transporting the six damaged fuel assemblies in the five FC-DSCs would need to be determined. In addition, the Safety Evaluation Report for the Rancho Seco ISFSI (NRC 2009) noted that visual examination alone is no longer a sufficient method for classifying assemblies as damaged or intact. NRC (2009) also stated that prior to transporting the used nuclear fuel stored at Rancho Seco, fuel classification may need to be revisited, and the damaged fuel assemblies (and potentially some fuel assemblies currently classified as intact) may need to be placed into damaged fuel cans to be transportable.

[20] Best RE. 2013. Email message from P Murray (AREVA) to RE Best (PNNL Consultant), “MP187 Question,” April 2, 2013.

Table 2-5. Details of Damaged Fuel Assemblies at Rancho Seco[a]

Fuel Assembly	Estimated Flaw Size	Canister Number
2G6	0.25 in. × 0.04 in.	FC24P-P16
OEL	0.75 in. long with 0.2 in. hole	FC24P-P10
ODY	0.2 in. hole	FC24P-P10
17G	Unknown	FC24P-P17
1C34	1 in. × 0.1 in.	FC24P-P18
1C04	0.3 in. holes (two)	FC24P-P03

a. Source: Transnuclear (2008)

Figure 2-84 illustrates the number of used nuclear fuel assemblies at Rancho Seco based on their discharge year. The oldest fuel was discharged in 1977 and the last fuel was discharged in 1989. The median discharge year of the fuel is 1983.

Figure 2-85 illustrates the number of used nuclear fuel assemblies at Rancho Seco based on their burnup. The lowest burnup is 10.0 GWd/MTHM and the highest burnup is 38.2 GWd/MTHM. The median burnup is 28.0 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) is stored at Rancho Seco.

2.6.2 Site Conditions

Figure 2-86 provides an aerial view of the Rancho Seco site. The reactor building equipment and spent nuclear fuel pool have been decommissioned and removed, but the cooling towers, reactor containment building, and other associated structures remain on-site. Low-level radioactive waste is also stored on-site. Electrical power is available at the Rancho Seco ISFSI. Also available on-site is the hydraulic ram used to unload the canisters from the NUHOMS reinforced concrete horizontal storage modules and to load the MP187 transportation cask that is certified to transport the Rancho Seco used nuclear fuel. The MP187 transportation cask (without impact limiters) is also stored on-site. The MP187 transportation cask is not certified for the transport of GTCC low-level radioactive waste.

There is no on-site barge access at the Rancho Seco site (TriVis Incorporated 2005). A 1-mile-long on-site rail spur exists at Rancho Seco. A short length of track runs adjacent to the ISFSI and a longer length of track runs into the Rancho Seco reactor site (see Figure 2-86). Figure 2-87 shows the junction of the short track running adjacent to the ISFSI and the longer track running into the Rancho Seco site. Figure 2-88 shows the longer track running into the Rancho Seco site.

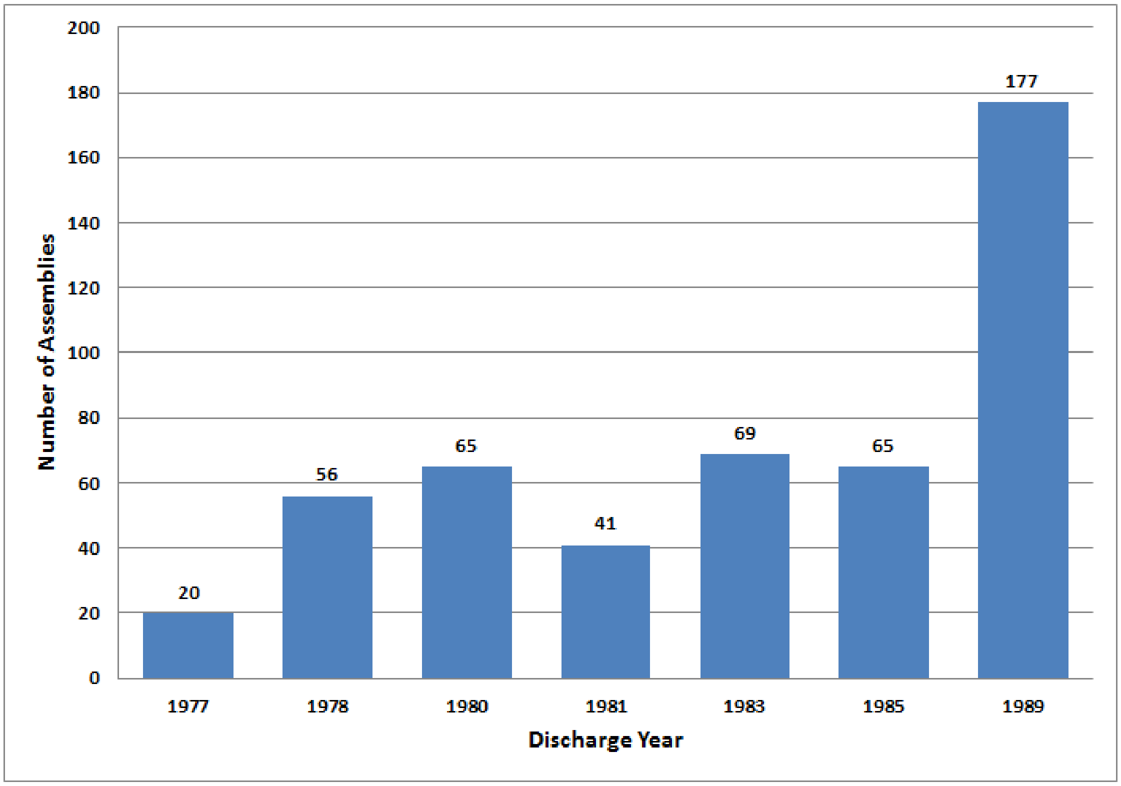

Figure 2-84. Rancho Seco Number of Assemblies versus Discharge Year (EIA 2002)

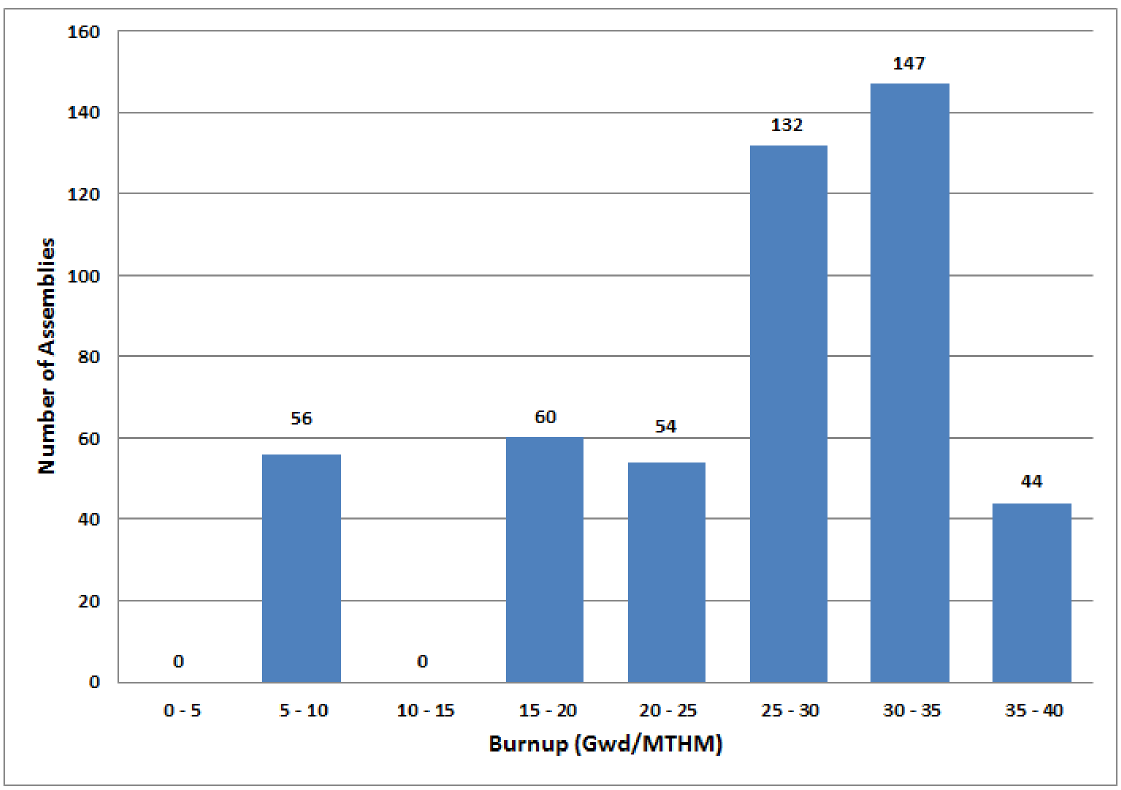

Figure 2-85. Rancho Seco Number of Assemblies versus Burnup (EIA 2002)

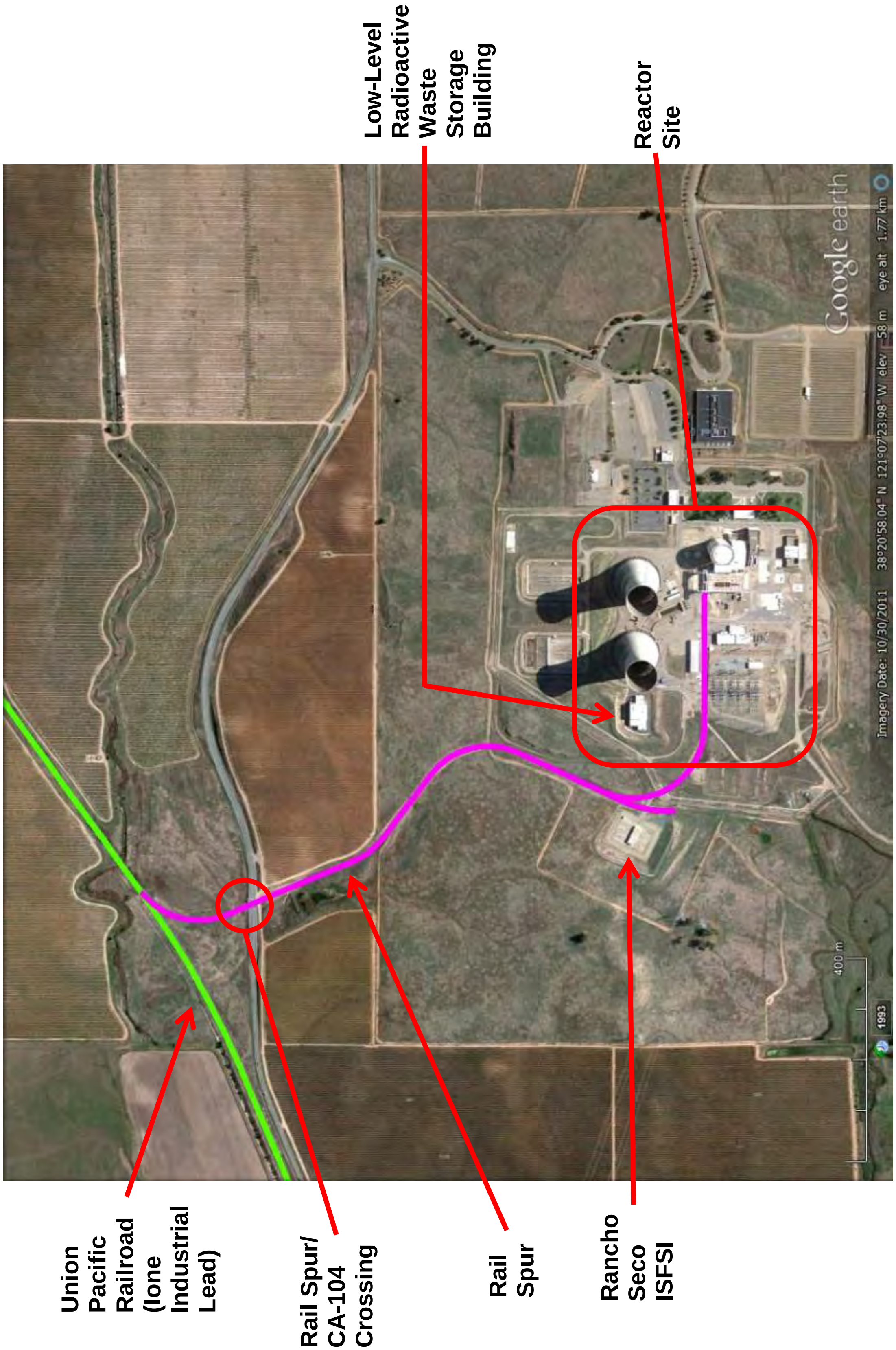

Figure 2-86. Aerial View of Rancho Seco Site (Google 2015)

Figure 2-87. Junction of the On-site Track Spur Running Adjacent to the Independent Spent Fuel Storage Installation (Right) and the Longer Track Running into the Rancho Seco Site (Left) (2013)

Figure 2-88. On-site Rail Spur Running into Rancho Seco Site (2013)

2.6.3 Near-site Transportation Infrastructure and Experience

Rancho Seco owns the rail spur that provides access to the Union Pacific's Ione Industrial Lead, which runs west from the Rancho Seco site to the Union Pacific mainline in Galt, California (see Figure 2-89), a distance of about 15 miles. The distance from Galt to Sacramento, California is about 33 miles and the distance from Galt to Stockton, California is about 28 miles. The Union Pacific mainline is designated as track class 5 and the Ione Industrial Lead is designated as track class 2. The maximum gross weight of railcars on the Ione Industrial Lead between Rancho Seco and Galt is 158 tons, and 6-axle locomotives are prohibited. A loaded MP187 transportation cask would weigh 133 to 136 tons and a cask-carrying railcar would weigh at least 43 tons, so the weight limit of 158 tons is likely to be exceeded, requiring either route clearance or a track upgrade. California State Route 104 crosses the rail spur (see Figure 2-86). The rail spur was not maintained after shutdown in 1989 but was restored to operating condition in the early 2000s to support decommissioning. During decommissioning, this rail spur was used to transport four reactor coolant pumps (50 tons each), the pressurizer (150 tons), and two steam generators (550 tons each) to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah (Johnson 2006). The two steam generators were approximately 80 feet in length and 12 feet in diameter and were too large to ship in their intact state because of the inability to obtain rail route clearances due to their length (Dempsey and Snyder 2005). Therefore, the steam generators were cut latitudinally into four segments (Dempsey and Snyder 2005) and were transported on 12-axle QTTX railcars. Figure 2-90 and Figure 2-91 show the pressurizer and steam generator segments on railcars prior to shipping, respectively. The segmented Rancho Seco reactor pressure vessel was also shipped by rail to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah (EPRI 2007, 2008a).

The rail spur was last maintained and certified in 2008; but is not being maintained. Past restoration of the rail spur to pass inspection was a relatively inexpensive, straightforward project.[21]

Although Rancho Seco is not located on a waterway, commercial inland ports suitable for barge traffic are located at the Port of Sacramento, California, about 40 miles from Rancho Seco, and the Port of Stockton, California, about 45 miles from Rancho Seco (NAC 1991a). During decommissioning, a 520-ton generator was transported by heavy haul truck from Rancho Seco to the Port of Stockton, California (see Figure 2-92). At the Port of Stockton, the generator was transloaded onto an ocean-going barge and transported to the Surry Nuclear Power Plant in Virginia for re-use.

Heavy haul trucks have also been used to ship materials to and from the Rancho Seco site. For example, in 2000, Transnuclear, Inc. contracted with a heavy haul truck operator to ship the 100-ton (empty and without impact limiters) MP187 transportation cask from the eastern United States to the Rancho Seco site (see Figure 2-93).

[21] Ross SB. 2012. E-mail from ET Ronningen (Superintendent, Rancho Seco Assets Power Generation, Sacramento Municipal Utility District) to SB Ross (Pacific Northwest National Laboratory), "Re:Request for Info," September 17, 2012.

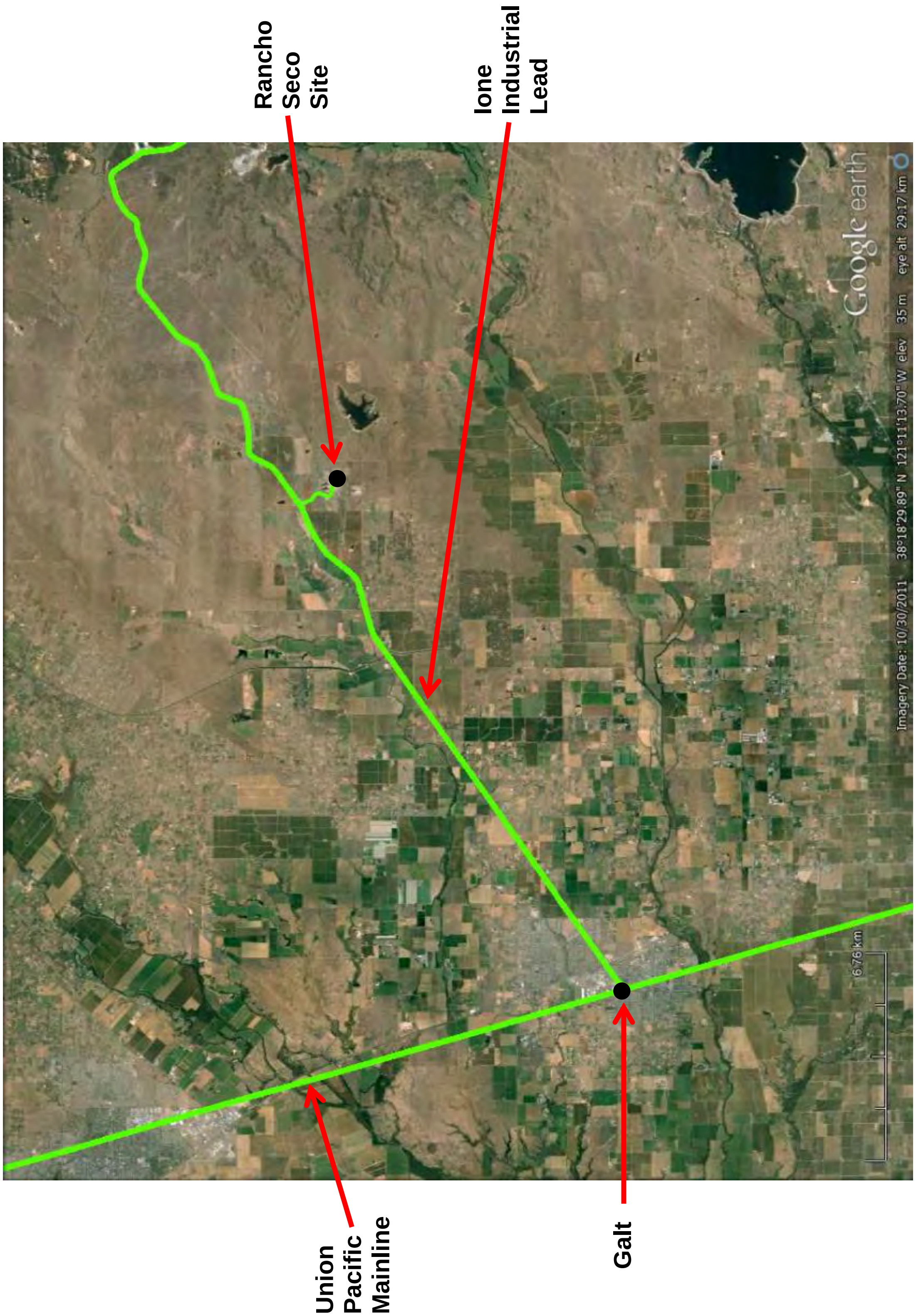

Figure 2-89. Aerial View of Ione Industrial Lead and Union Pacific Mainline (Google 2015)

Photo courtesy of Rancho Seco

Figure 2-90. Rancho Seco Pressurizer on Railcar (2004)

Photo courtesy of Rancho Seco

Figure 2-91. Rancho Seco Steam Generator Segments on Railcars

Photo courtesy of Rancho Seco

Figure 2-92. Rancho Seco Generator on Heavy Haul Truck Being Transported to the Port of Stockton, California (2002)

Photo courtesy of Rancho Seco

Figure 2-93. MP187 Cask Transported by Heavy Haul Truck

2.6.4 Gaps in Information

The principal question for the Rancho Seco site regarding the capability of the off-site transportation infrastructure to accommodate shipments of large transportation casks is the weight limit (158 tons) associated with the Ione Industrial Lead. This weight limit would make it necessary to obtain route clearance from the Union Pacific Railroad or to upgrade the track to allow its use for rail shipments of the MP187 transportation cask. As discussed in Section 2.6.3, during decommissioning loads larger than 158 tons were transported on the Ione Industrial Lead. In addition, it would be necessary to obtain NRC authorization to transport non-failed-fuel canisters containing damaged fuel assemblies in the MP187 transportation cask.

2.7 Trojan

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Trojan site. The Trojan site is located in northwestern Oregon on the Columbia River about 40 miles northwest of Portland, Oregon (NAC 1991b).

2.7.1 Site Inventory

The Trojan ISFSI has a site-specific 10 CFR Part 72 license (License No. SNM-2509). Thirty-four canisters containing used nuclear fuel assemblies and no canisters of GTCC low-level radioactive waste are stored at the Trojan site. The 34 canisters contain 780 intact assemblies, 10 partial assemblies, 8 process can capsules, 1 failed fuel can containing 8 bottom nozzles and 2 process cans, 1 fuel rod storage rack containing 23 ruptured or damaged fuel rods, and 1 assembly skeleton.

Figure 2-94 shows the Trojan ISFSI. The storage system used at Trojan is a hybrid of two storage systems (EPRI 2010), and consists of TranStor concrete storage overpacks and Holtec MPC-24E and MPC-24EF canisters. The MPC-24E and the MPC-24EF canisters hold 24 pressurized water reactor used nuclear fuel assemblies. The fuel assemblies from Trojan were loaded into Holtec canisters from December 2002 through September 2003 (Leduc 2012). The fuel rods in the fuel assemblies are zirconium alloy-clad. The HI-STAR 100 transportation cask (Docket No. 71-9261) is certified to transport the MPC-24E and the MPC-24EF canisters. Although HI-STAR 100 casks have been constructed for use in the United States, these casks are being used as storage casks at the Dresden (4 casks) and Hatch (3 casks) sites (Ux Consulting 2015a). For these HI-STAR 100 casks to be used to ship used nuclear fuel from the Trojan site, they would need to be unloaded, their contents placed in other storage overpacks, and the casks transported to the Trojan site. It would also be necessary to procure impact limiters and spacers for these HI-STAR 100 casks.

Photo courtesy of Trojan

Figure 2-94. Trojan Independent Spent Fuel Storage Installation

Figure 2-95 illustrates the number of used nuclear fuel assemblies at Trojan based on their discharge year. The oldest fuel was discharged in 1978 and the last fuel was discharged in 1992. The median discharge year of the fuel is 1988.

Figure 2-96 illustrates the number of used nuclear fuel assemblies at Trojan based on their burnup. The lowest burnup is 5.0 GWd/MTHM and the highest burnup is 42.1 GWd/MTHM. The median burnup is 33.4 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) is stored at Trojan.

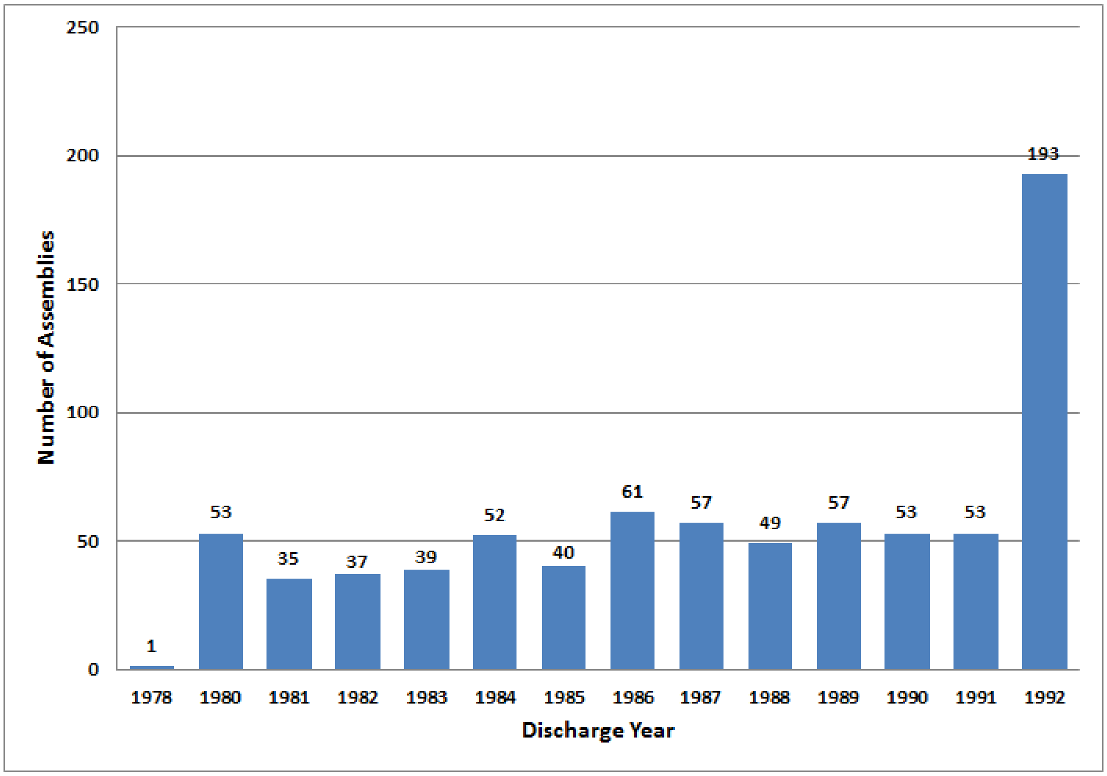

Figure 2-95. Trojan Number of Assemblies versus Discharge Year (EIA 2002)

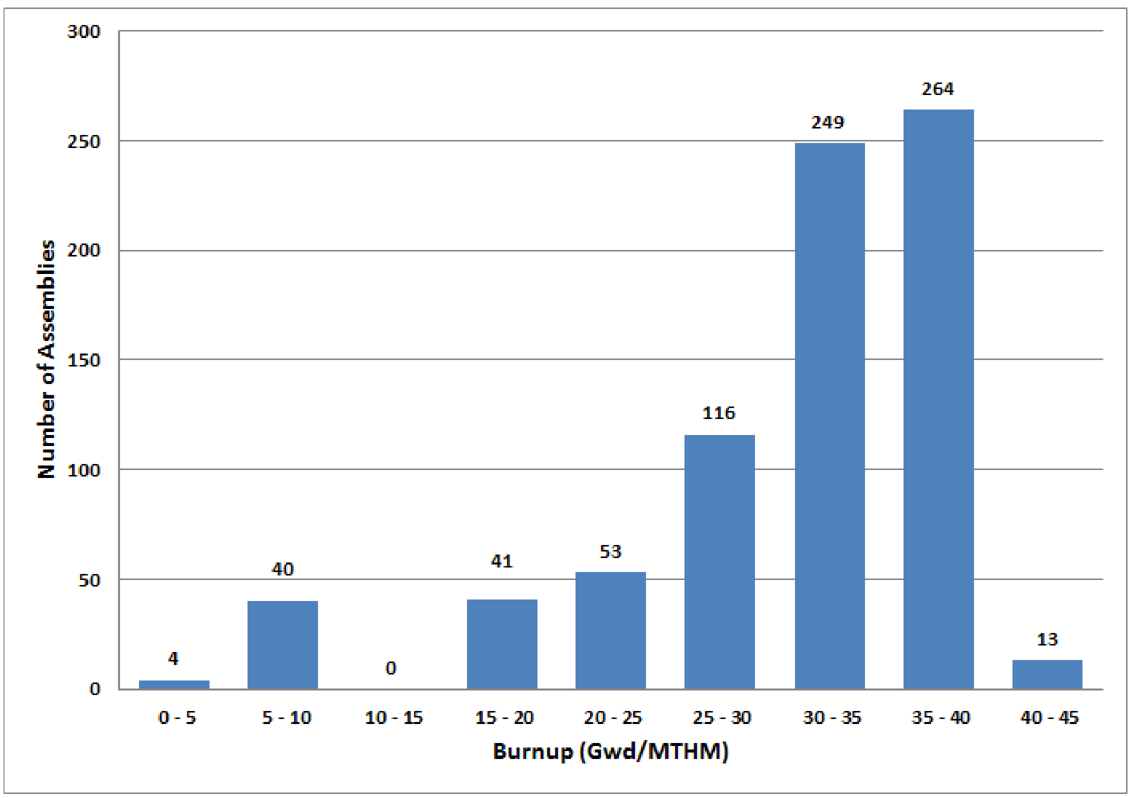

Figure 2-96. Trojan Number of Assemblies versus Burnup (EIA 2002)

2.7.2 Site Conditions

Figure 2-97 provides an aerial view of the Trojan site, where the reactor and associated structures have been removed. Electrical power is available at the Trojan ISFSI. However, mobile equipment such as cranes to unload the TranStor vertical concrete storage overpacks containing the Holtec multipurpose canisters used at Trojan, and to load the HI-STAR 100 transportation casks is not present at the site. The HI-STAR 100 transportation cask is certified to transport the Trojan used nuclear fuel contained in the MPC-24E and the MPC-24EF canisters. A transfer cask, transfer station, and air pad system are also located at the Trojan ISFSI. Figure 2-98 shows the transfer station, Figure 2-99 shows the transfer station with the transfer cask and mobile crane, and Figure 2-100 shows the transfer station with the transfer cask and a TranStor vertical concrete storage overpack.

The Portland and Western Railroad rail line passes through the Trojan site approximately 700 feet from the Trojan ISFSI (TriVis Incorporated 2005). This rail line is designated as track class 2 and connects to the Union Pacific and BNSF Railroads near Portland, Oregon, a distance of about 60 miles. A rail spur formerly entered the protected area (NAC 1991b). This spur has been removed, but could be rebuilt in preparation for shipping used nuclear fuel.[22]

A barge slip is located on the Trojan site about 3000 feet south of the Trojan ISFSI. The barge slip is located at Columbia River Mile 72.5 and provides for roll-on/roll-off capability. The barge slip is not being maintained and dredging is usually required prior to use. There is no crane or other permanently installed handling or lifting equipment at the barge slip.

2.7.3 Near-site Transportation Infrastructure and Experience

At the Trojan site, a rail spur used to run from the Portland and Western Railroad to the site (see Figure 2-101). The rail spur was located at milepost 40.8 on the Astoria District of the Portland and Western Railroad and has been removed. In addition, during decommissioning a short spur was installed for rail shipments of waste from the site. This spur has also been removed.

Figure 2-102 shows the Portland and Western Railroad in the vicinity of the Trojan site, Figure 2-103 shows the location of the former junction of the rail spur with the Portland and Western Railroad, and Figure 2-104 shows the railbed of the former rail spur. Remnants of this spur exist on-site (see Figure 2-105). There appears to be sufficient room at the Trojan site for additional track to accommodate trains having eight or more railcars (two buffer cars, a security escort car, and five or more cask cars).

As discussed in Section 2.7.2, a barge slip is also present at the Trojan site and provides access to the Columbia River. Figure 2-97 shows the location of the barge slip. Figure 2-106 shows the access road to the barge slip, and Figure 2-107 shows the condition of the barge slip in 2013.

[22] Ross SB. 2012. Email message from JP Fischer (Trojan ISFSI Manager, Portland General Electric Company) to SB Ross (Pacific Northwest National Laboratory), "Re: Request for Info," September 17, 2012.

Figure 2-97. Aerial View of Trojan Site (Google 2015)

Photo courtesy of Trojan

Figure 2-98. Trojan Transfer Station

Photo courtesy of Trojan

Figure 2-99. Trojan Transfer Station with Transfer Cask and Mobile Crane

Photo courtesy of Oregon Department of Energy

Figure 2-100. Trojan Transfer Station with Transfer Cask and TranStor Vertical Concrete Storage Overpack

Figure 2-101. Rail Interface at Trojan (Google 2015)

Figure 2-102. Portland and Western Railroad in the Vicinity of the Trojan Site (2013)

Figure 2-103. Location of Former Junction of Portland and Western Railroad and Trojan Rail Spur (2013)

Figure 2-104. Former Trojan Rail Spur Railbed (2013)

Figure 2-105. Remnants of On-site Rail Spur at Trojan (2013)

Photo courtesy of Federal Railroad Administration

Figure 2-106. Trojan Barge Slip Access Road (2013)

Photo courtesy of Federal Railroad Administration

Figure 2-107. Trojan Barge Slip (2013)

During decommissioning, Trojan shipped four steam generators, the pressurizer, and the reactor pressure vessel from this barge slip to the US Ecology low-level radioactive waste disposal facility near Richland, Washington. The steam generator packages weighed 450 tons each and the pressurizer package weighed 125 tons (Lackey and Kelly 1996, 1997). The four steam generators had diameters of 14.5 feet and a length of 68 feet. The pressurizer had a diameter of 8.5 feet and a length of 53 feet. The four steam generators and pressurizer were transported from the Trojan site to the barge slip using a hydraulically-leveled 16-line Goldhofer transporter. The transporter was also used to support the four steam generators and pressurizer while on the barge, and to move the four steam generators and pressurizer from the barge slip at the Port of Benton, Washington (Columbia River Mile 342.8), to the US Ecology low-level radioactive waste disposal facility. A total of five barge shipments were made (EPRI 1997b).

The barge was 180 feet long, 50 feet wide, and 14 feet deep. Prior to transporting the four steam generators and pressurizer, the Trojan barge slip was dredged. The sediments in the barge slip were analyzed to assure that there were no contaminants that would require special handling. Approximately 2750 cubic yards of material were removed from the barge slip. After dredging, the barge slip was graded. Because the barge was grounded for loading and unloading, the barge slip bottoms at the Trojan site and at the Port of Benton were leveled and inspected by divers, who removed any large objects and debris and corrected any out-of-specification unevenness. After the barge was loaded, the barge was deballasted. Inspections were performed prior to ballasting and after deballasting to ensure that no damage was done during loading. The Trojan barge slip is also significantly affected to tides, so departure had to take place during high tide to have sufficient water depth to float the loaded barge (EPRI 1997b).

The reactor pressure vessel package weighed 1000 tons (Radwaste Magazine 1999), had a diameter of 28 feet, and was 42.5 feet long (EPRI 2000). The reactor pressure vessel was transported from the Trojan site to the barge slip using a hydraulically-leveled 4-file, 20-line Scheuerle transport trailer. Each line consisted of 16 tires, which resulted in a total of 320 tires. The transporter was also used to support the reactor pressure vessel package while on the barge, and to move the reactor pressure vessel package from the barge slip at the Port of Benton, Washington (Columbia River Mile 342.8), to the US Ecology low-level radioactive waste disposal facility (EPRI 2000).

The barge was specifically designed and built to transport the reactor pressure vessel package, and was 240 feet long, 55 feet wide, and 15 feet deep. Because the barge was grounded for loading and unloading, the barge slip bottoms at the Trojan site and at the Port of Benton were leveled and inspected by divers, who removed any large objects and debris and corrected any out-of-specification unevenness. After the barge was loaded, the barge was deballasted. Inspections were performed prior to ballasting and after deballasting to ensure that no damage was done during loading. The Trojan barge slip is also significantly affected to tides, so departure had to take place during high tide to have sufficient water depth to float the loaded barge (EPRI 2000).

Figure 2-108 through Figure 2-112 show a steam generator being loaded at the Trojan barge slip, and the Trojan reactor pressure vessel in its transport cradle, the reactor pressure vessel being transported by barge, passing through locks on the Columbia River, and being transported by heavy haul truck to the US Ecology low-level radioactive waste disposal facility.

Photo courtesy of Trojan

Figure 2-108. Trojan Steam Generator Being Loaded at Barge Slip (1995)

Photo courtesy of Oregon Department of Energy

Figure 2-109. Trojan Reactor Pressure Vessel on Transport Cradle (1999)

Photo courtesy of Trojan

Figure 2-110. Trojan Reactor Pressure Vessel Being Transported by Barge (1999)

Photo courtesy of Trojan

Figure 2-111. Trojan Reactor Pressure Vessel Passing Through Locks on the Columbia River (1999)

Photo courtesy of Trojan

Figure 2-112. Trojan Reactor Pressure Vessel Being Transported by Heavy Haul Truck (1999)

2.7.4 Gaps in Information

Both rail and barge modes are feasible for transporting used nuclear fuel from the Trojan site. The Portland and Western Railroad rail line passes through the Trojan site approximately 700 feet from the Trojan ISFSI. In the past, a rail spur entered the protected area. The spur was disconnected, but according to site representatives, could be rebuilt in preparation for shipping used nuclear fuel. The Portland and Western Railroad is a Class II regional railroad whose track is expected to be capable of accommodating shipments of HI-STAR 100 casks from the Trojan site. The Trojan site also has an on-site barge slip, and it is likely the barge slip could be used for shipping used nuclear fuel transportation casks on barges.

2.8 La Crosse

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the La Crosse site. The La Crosse site is located in western Wisconsin on the east bank of the Mississippi River, about 1 mile south of Genoa and 17 miles south of La Crosse, Wisconsin (TOPO 1993e).

2.8.1 Site Inventory

Five canisters containing 333 used nuclear fuel assemblies are stored at the La Crosse ISFSI (Docket No. 72-46). The five canisters contain 176 intact used nuclear fuel assemblies, 157 damaged used nuclear fuel assemblies, and 1 fuel debris can. The 157 damaged assemblies have been placed in damaged fuel cans. La Crosse is undergoing decommissioning; however, because the La Crosse reactor pressure vessel with its internal components has been shipped off-site for disposal (Radwaste Solutions 2007), GTCC low-level radioactive waste would not be generated.

Figure 2-113 shows the La Crosse ISFSI. The storage system used at La Crosse is the NAC Multi-Purpose Canister system (NAC-MPC) (Docket No. 72-1025), which consists of a transportable storage canister, a vertical concrete storage cask, and a transfer cask. The transportable storage canister used for the La Crosse used nuclear fuel is the MPC-LACBWR. This canister holds 68 La Crosse boiling water reactor used nuclear fuel assemblies. The fuel assemblies from La Crosse were loaded into MPC-LACBWR canisters from July through September 2012. The fuel rods in the fuel assemblies are stainless steel-clad. The NAC-STC transportation cask (Docket No. 71-9235) is certified to transport the MPC-LACBWR canister. No NAC-STC transportation casks have been fabricated for use in the United States. Two NAC-STC transportation casks have been fabricated for use in China (Washington Nuclear Corporation 2003).

Figure 2-114 illustrates the number of used nuclear fuel assemblies at La Crosse, based on their discharge year. The oldest fuel was discharged in 1972 and the last fuel was discharged in 1987. The median discharge year of the fuel is 1982.

Figure 2-115 illustrates the number of used nuclear fuel assemblies at La Crosse based on their burnup. The lowest burnup is 4.7 GWd/MTHM and the highest burnup is 21.5 GWd/MTHM. The median burnup is 15.7 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) is stored at La Crosse.

Photo courtesy of La Crosse

Figure 2-113. La Crosse Independent Spent Fuel Storage Installation

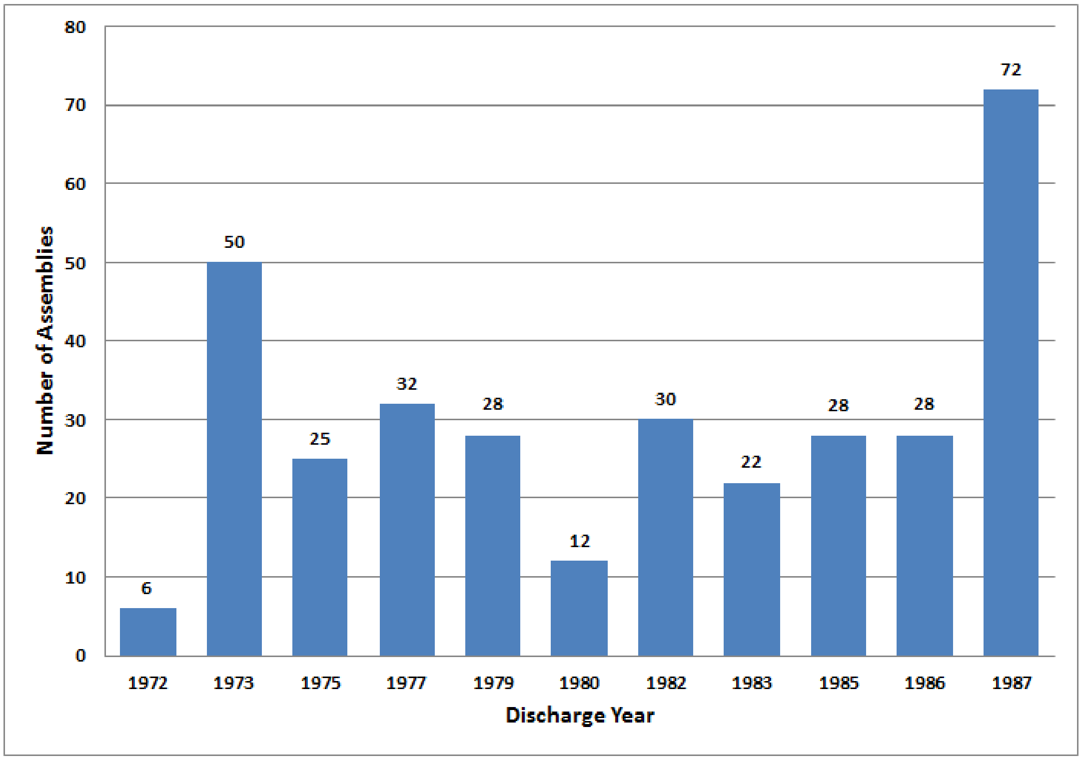

Figure 2-114. La Crosse Number of Assemblies versus Discharge Year (EIA 2002)

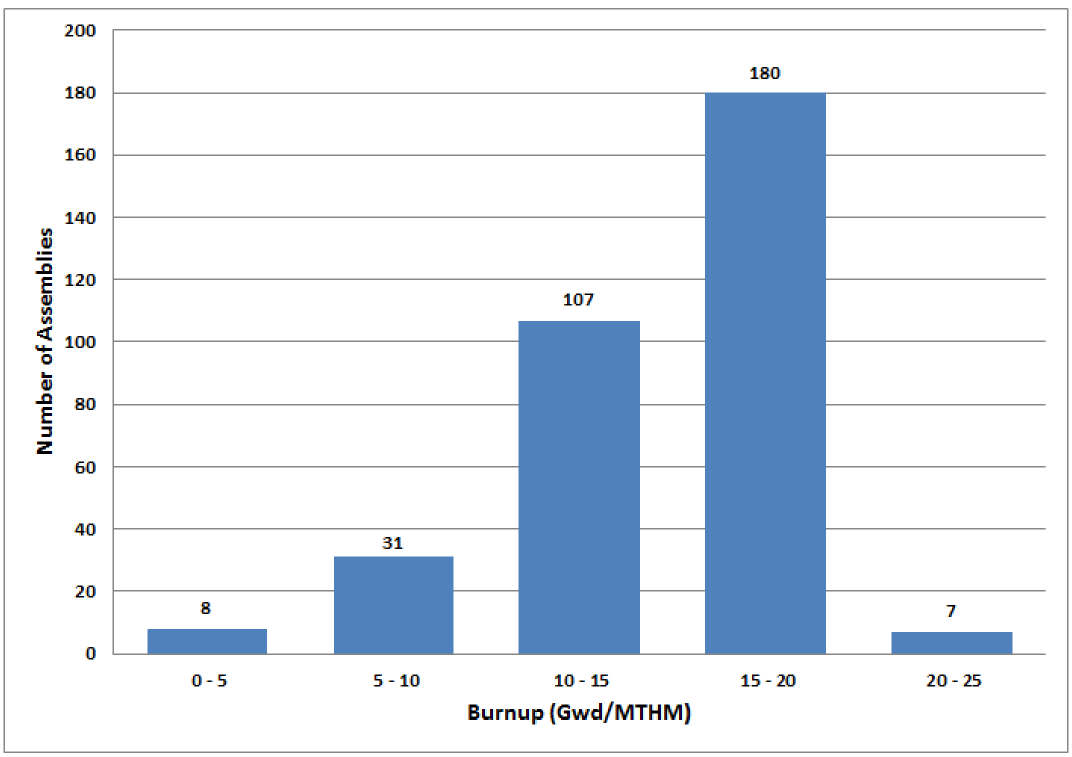

Figure 2-115. La Crosse Number of Assemblies versus Burnup (EIA 2002)

2.8.2 Site Conditions

Figure 2-116 through Figure 2-118 provide aerial views of the La Crosse site, barge facility and on-site rail spur, and ISFSI and boat ramp. As seen in Figure 2-116, the La Crosse ISFSI is located south of the La Crosse reactor site and the Genoa #3 coal-fired power plant. Electrical power is available at the La Crosse ISFSI. However, mobile equipment such as cranes or a gantry system to unload the NAC-MPC vertical concrete storage casks used at La Crosse and to load the NAC-STC transportation cask that is certified to transport the La Crosse used nuclear fuel is not present at the site. A transfer cask is available on-site and is owned by the Dairyland Power Cooperative. This transfer cask could also be used at the Yankee Rowe and Connecticut Yankee sites.

Rail service to the La Crosse site is provided by the BNSF Railroad. The BNSF rail line runs along the eastern boundary of the site about 800 feet from the La Crosse ISFSI. This rail line is designated as track class 4. La Crosse does not have an active on-site rail system;[23] however, remnants of an on-site rail system exist at the site (see Figure 2-119). There is a short on-site spur at the north end of the La Crosse site (see Figure 2-120). Figure 2-121 shows the junction of the on-site rail spur with the BNSF Railroad. In 2007, this on-site rail spur was used during the transport of the La Crosse reactor pressure vessel to the Barnwell, South Carolina low-level radioactive waste disposal facility (Radwaste Solutions 2007). The reactor pressure vessel was transported on a specially designed 20-axle railcar and the shipment weighed 310 tons.

The La Crosse site is located on the Upper Mississippi River at Mississippi River Mile 678.7, 0.5 miles south of Lock and Dam 8 (located at Mississippi River Mile 679.2) and 30.8 miles north of Lock and Dam 9 (located at Mississippi River Mile 647.9). On-site barge access is available about 0.2 miles north of the La Crosse reactor site (see Figure 2-122). The dock area is approximately 500 feet long by 100 feet wide with a minimum 9-foot water depth (TOPO 1993e). The barge facility has direct access to the shipping channel and receives between 450 and 500 barges annually. The barge facility is routinely used for the removal of covers from coal barges using a portable crane and for cleaning out the empty barges after the coal has been unloaded. The coal is unloaded several hundred yards downstream adjacent to the Genoa #3 coal-fired power plant. A large number of barge mooring/securing posts are available. Since the Upper Mississippi River usually freezes in the winter, the typical barge delivery season is from March through October, 30 to 35 weeks. Mobile rental cranes of the required capacity are available (TriVis Incorporated 2005). TOPO (1993e) reports that dredging or other dock area refurbishment is likely to be required.

[23] Ross SB. 2012. Email message from DG Egge (Plant Manager, LACBWR, Dairyland Power Cooperative) to SB Ross (Pacific Northwest National Laboratory), "Re: La Crosse Information," October 17, 2012.

Figure 2-116. Aerial View of La Crosse Site (Google 2015)

Figure 2-117. Aerial View of La Crosse Barge Facility and On-site Rail Spur (Google 2015)

Figure 2-118. Aerial View of La Crosse Independent Spent Fuel Storage Installation and Boat Ramp (Google 2015)

Photo courtesy of La Crosse

Figure 2-119. Remnants of the On-site Rail System at La Crosse Site (2013)

Photo courtesy of La Crosse

Figure 2-120. On-site Rail Spur at Northern End of La Crosse Site (2013)

Photo courtesy of La Crosse

Figure 2-121. Junction of On-site Rail Spur with BNSF Railroad at La Crosse Site (2013)

Figure 2-122. Coal Barge at Barge Dock Area at La Crosse Site (2013)

2.8.3 Near-site Transportation Infrastructure and Experience

At the La Crosse site, a short on-site rail spur exists that provides direct rail access to the BNSF Railroad. There appears to be adequate room at the La Crosse site to extend this spur to accommodate trains having eight or more railcars (two buffer cars, a security escort car, and five or more cask cars). As discussed in Section 2.8.2, in 2007, this on-site rail spur was used to transport the La Crosse reactor pressure vessel to the Barnwell, South Carolina low-level radioactive waste disposal facility. Figure 2-123 and Figure 2-124 show the La Crosse reactor pressure vessel on the on-site spur and on the BNSF Railroad. The La Crosse site is also on the Mississippi River and has on-site barge access. However, barges have not been used for radioactive waste shipments from La Crosse.

2.8.4 Gaps in Information

Rail service to the La Crosse site is provided by the BNSF Railroad that is east of the La Crosse ISFSI using a short on-site rail spur and there appears to be adequate room at the La Crosse site to extend this spur to accommodate trains having eight or more railcars (two buffer cars, a security escort car, and five or more cask cars). The location and method for loading the transportation cask and moving the transportation cask to a rail spur is uncertain.

On-site barge access is available about 0.2 miles north of the La Crosse reactor site. It is uncertain whether the on-site barge facility could accommodate used nuclear fuel transportation casks.

Assuming that the on-site rail spur into the La Crosse site is maintained or refurbished as may be needed, it is unlikely that heavy haul trucks would be used to remove transportation casks containing used nuclear fuel from the site.

Photo courtesy of La Crosse

Figure 2-123. La Crosse Reactor Pressure Vessel on Rail Spur (2007)

Photo courtesy of La Crosse

Figure 2-124. La Crosse Reactor Pressure Vessel on BNSF Railroad (2007)

2.9 Zion

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Zion site. The Zion site is located in the northeastern corner of Illinois on the western shore of Lake Michigan, about 40 miles north of Chicago (TOPO 1994b).

2.9.1 Site Inventory

Sixty-one canisters containing used nuclear fuel assemblies and four canisters of GTCC low-level radioactive waste are stored at the Zion ISFSI (Docket No. 72-1037). The 61 canisters contain 2226 used nuclear fuel assemblies that were discharged from the Zion 1 and Zion 2 reactors. Figure 2-125 shows the Zion ISFSI. The storage system used at Zion is the NAC MAGNASTOR system (Docket No. 72-1031), which consists of a transportable storage canister (see Figure 2-126), a vertical concrete storage cask, and a transfer cask (see Figure 2-127). At Zion, the TSC-37[24] transportable storage canister is being used, which holds 37 pressurized water reactor used nuclear fuel assemblies. Figure 2-128 shows the TSC-37 canister inside the transfer cask and Figure 2-129 shows a damaged fuel can being installed inside a TSC-37 canister. The fuel rods in the fuel assemblies at Zion are all zirconium alloy-clad. The transportation cask that will be certified to transport this used nuclear fuel is the NAC MAGNATRAN (Docket No. 71-9356). The application for a certificate of compliance for the MAGNATRAN is currently under review by the NRC.

[24] The TSC-37 canister is also referred to as the TSC or TSCDF. The TSCDF may contain damaged fuel.

Photo courtesy of ZionSolutions

Figure 2-125. Zion Independent Spent Fuel Storage Installation

Figure 2-130 illustrates the number of used nuclear fuel assemblies at Zion, based on their discharge year. The oldest fuel was discharged in 1976 and the last fuel was discharged in 1997. The median discharge year of the fuel is 1987.

Figure 2-131 illustrates the number of used nuclear fuel assemblies at Zion based on their burnup. The lowest burnup is 14.2 GWd/MTHM and the highest burnup is 55.1 GWd/MTHM. The median burnup is 33.1 GWd/MTHM. There are 36 used nuclear fuel assemblies at Zion with burnups greater than 45 GWd/MTHM. These 36 fuel assemblies are classified by the NRC as high burnup used nuclear fuel. At the Zion site, all fuel with a burnup greater than 45 GWd/MTHM was placed in damaged fuel cans. Each TSCDF canister can accommodate up to four damaged fuel cans. An additional assembly (J47B) with a burnup of 44.945 GWd/MTHM was also treated as high burnup used nuclear fuel and was placed in a damaged fuel can.

In addition to the 37 used nuclear fuel assemblies discussed above, 57 used nuclear fuel assemblies identified as damaged, 2 loose fuel rod storage containers (ZFRSB1 and Y48B) holding 28 fuel rods, and 1 used nuclear fuel assembly (C15R) containing a stainless steel fuel rod of unconfirmed dimensions were placed in damaged fuel cans. Assembly N47B was also canned to meet MAGNATRAN burnup credit requirements. In total, 98 assemblies/fuel rod storage containers are contained in damaged fuel cans. A total of 25 TSCDF canisters contain a combination of high burnup fuel (12 canisters), damaged fuel (20 canisters), or fuel debris (2 canisters).

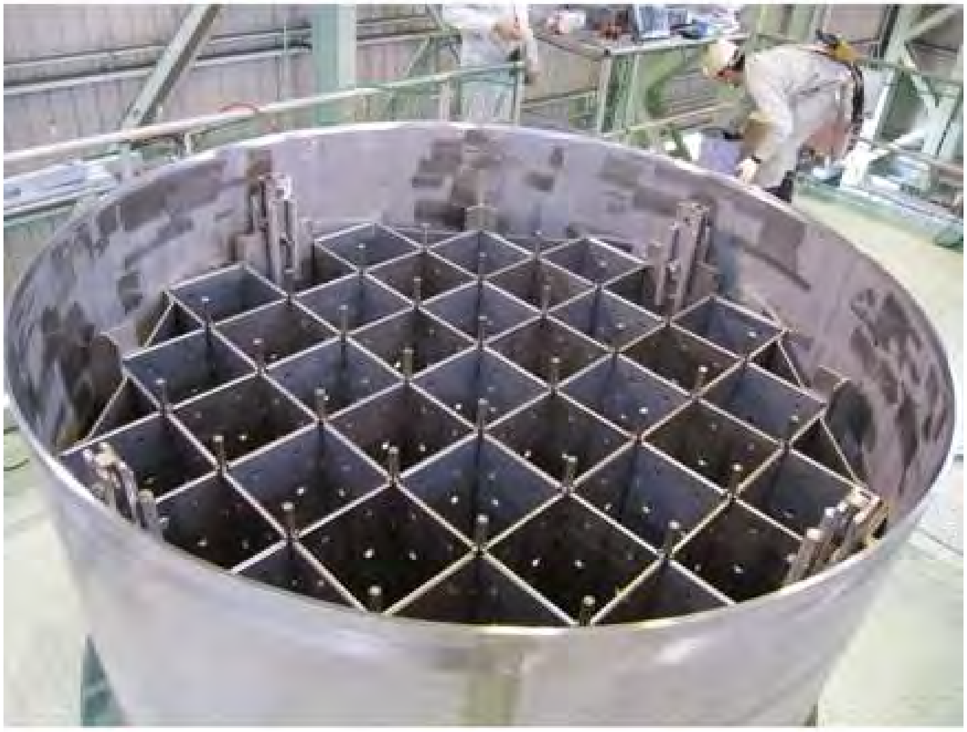

Photo courtesy of NAC International

Figure 2-126. TSC-37 Canister Showing Internal Baskets Which Hold Used Nuclear Fuel Assemblies

Photo courtesy of ZionSolutions

Figure 2-127. Transfer Cask

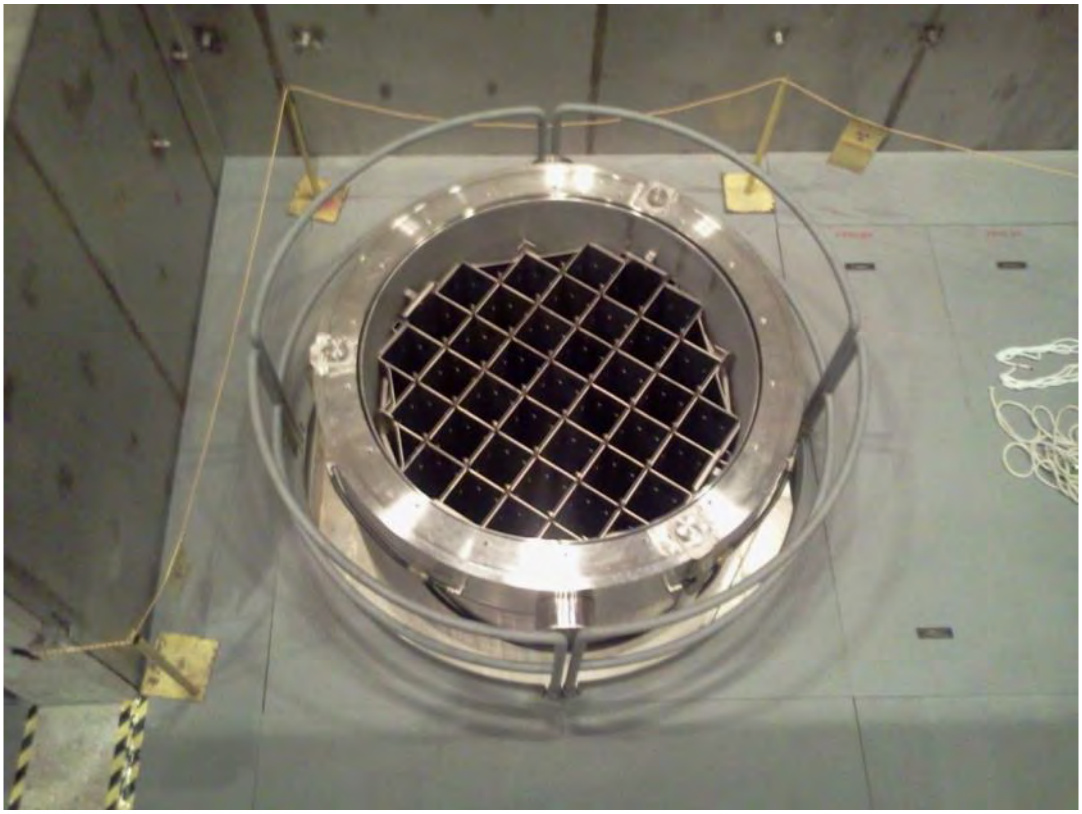

Photo courtesy of ZionSolutions

Figure 2-128. TSC-37 Canister Inside Transfer Cask

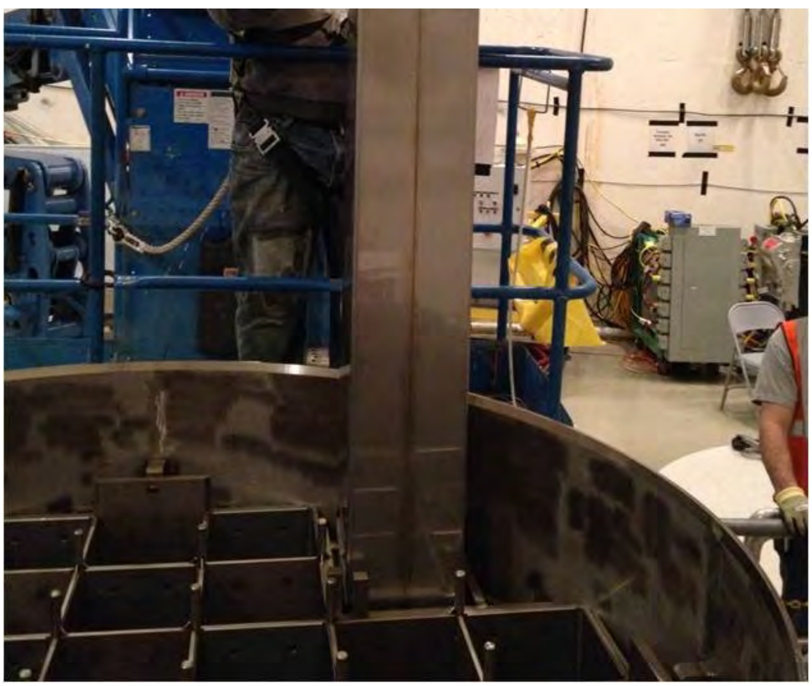

Photo courtesy of ZionSolutions

Figure 2-129. Damaged Fuel Can Being Installed in TSC-37 Canister

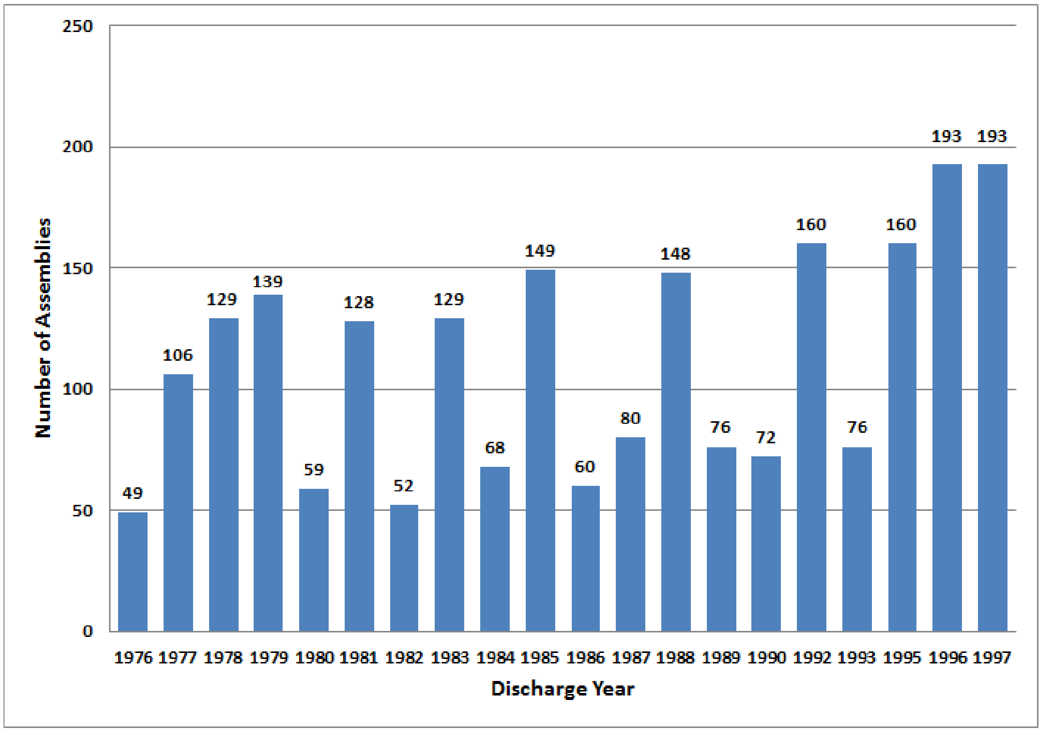

Figure 2-130. Zion Number of Assemblies versus Discharge Year (EIA 2002)

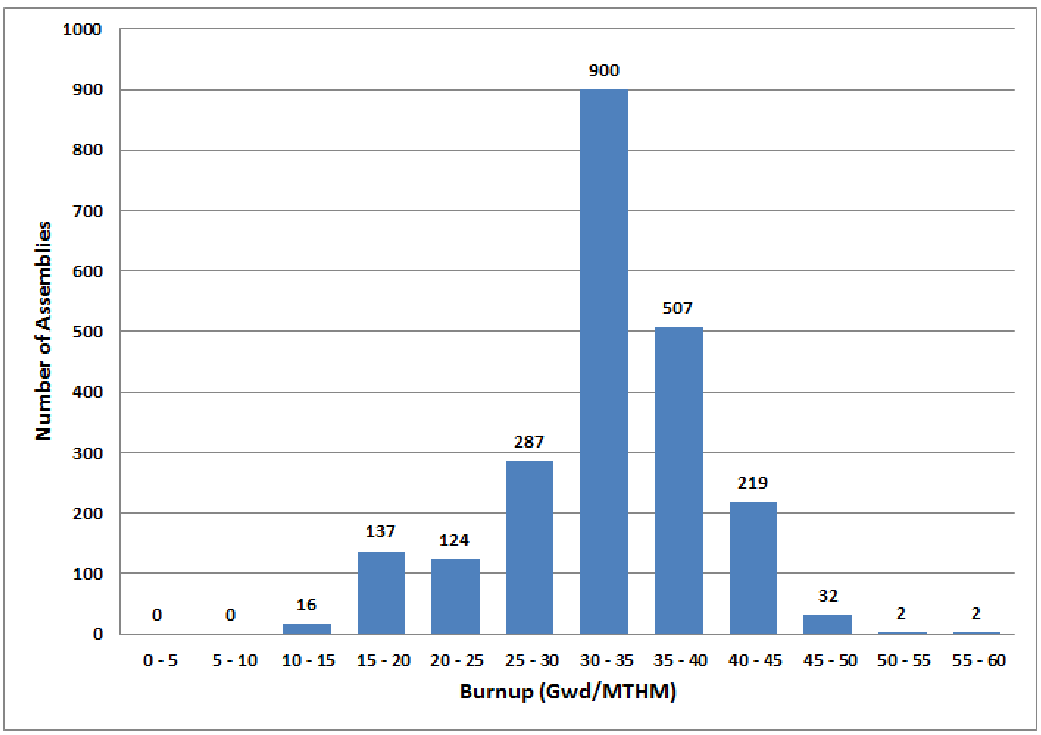

Figure 2-131. Zion Number of Assemblies versus Burnup (EIA 2002)

2.9.2 Site Conditions

Figure 2-132 provides an aerial view of the Zion site, which is being decommissioned. The Zion ISFSI is located at the southern end of the Zion site (see Figure 2-133). At the northern end of the Zion site, 65 vertical concrete storage casks were staged prior to being loaded. Figure 2-134 provides a close-up view of these vertical concrete storage casks. Figure 2-135 shows the TSC-37 transportable storage canisters into which the used nuclear fuel was placed. These canisters were then placed inside vertical concrete storage casks and moved to the Zion ISFSI. Figure 2-136 shows the transporter used to move the loaded vertical concrete storage casks to the ISFSI.

Figure 2-132 also shows the Zion on-site rail spur which was recently refurbished and which is being used for low-level radioactive waste shipments from the site. This refurbishment included installing concrete ties with Pandrol clips on the curves. A 4-inch ballast lift was also performed over the length of the spur and on the east-west portion of the spur every other wooden tie was replaced. This rail spur provides access to the Union Pacific Railroad. The Union Pacific rail line in the vicinity of the Zion site is designated as track class 4.

During construction of the Zion site, barges were used to move materials and components to the site (see Figure 2-137). The barge facility was located at the northern end of the Zion site and has been abandoned, and the land on which it was located was donated to the Illinois Beach State Park (TOPO 1994b). However, the barge pilings (see Figure 2-138) remain and could be reused to refurbish the barge facility.

Figure 2-132. Aerial View of Zion Site (Google 2015)

Figure 2-133. Aerial View of Zion Independent Spent Fuel Storage Installation Under Construction (Google 2015)

Figure 2-134. Vertical Concrete Storage Casks Staged at Zion (2013)

Figure 2-135. Used Nuclear Fuel Transportable Storage Canisters Staged at Zion (2013)

Figure 2-136. Transporter Used to Move Vertical Concrete Storage Casks (2013)

Photo courtesy of ZionSolutions

Figure 2-137. Steam Generators Being Delivered to Zion Site by Barge during Construction

Figure 2-138. Barge Pilings at the North End of the Zion Site (Google 2015)

2.9.3 Near-site Transportation Infrastructure and Experience

At the Zion site, an on-site rail spur provides direct rail access to the Union Pacific Railroad (see Figure 2-139). The Northeast Illinois Regional Commuter Rail Corporation operates commuter service over this same track and there is a commuter rail stop located approximately 4,000 feet from the Zion site entrance.

There is currently enough room on the Zion site to accommodate trains having eight or more railcars (two buffer cars, a security escort car, and five or more cask cars). Figure 2-140 shows the Trackmobile that is being used to move railcars on-site. Figure 2-141 shows the rail spur entering the Zion site and Figure 2-142 shows the junction of the Zion on-site rail spur with the Union Pacific Railroad. Figure 2-142 also shows the concrete rail ties that were used in the reconstructing the curves of the on-site rail spur.

As mentioned in Section 2.9.2, the Zion site was served by barges during construction. The barge facility was abandoned; however, the barge pilings remain and could be reused to refurbish the barge facility.

In addition to rail, Zion has used heavy haul trucks to ship radioactive waste off-site for disposal. For example, in 2011, ZionSolutions, which is decommissioning the Zion reactors, shipped the Zion Unit 2 reactor head from the Zion site to Clive, Utah for disposal. The reactor head was approximately 17 feet in diameter and weighed 225,000 lb. (Troher 2011). A heavy haul truck was used for this shipment because the Zion Unit 2 reactor head was too large for shipment by rail. The heavy haul truck travelled 1,500 miles from the Zion site north of Chicago, Illinois to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah. Figure 2-143 shows the Zion reactor head on its heavy haul truck transporter.

2.9.4 Gaps in Information

At the Zion site, a rail spur connects to the Union Pacific Railroad mainline that runs between Milwaukee, Wisconsin, and Chicago, Illinois. The Union Pacific Railroad is a Class I railroad that is expected to have the capability to move shipments of used nuclear fuel in NAC MAGNATRAN transportation casks. However, the status and maintaining of this rail spur after decommissioning of the Zion site has been completed has not been determined.

The Zion barge facility used during plant construction was abandoned and the land on which it was located was donated to the Illinois Beach State Park. However, the barge pilings remain and could be reused to refurbish the barge facility.

The application for a certificate of compliance for the MAGNATRAN transportation cask is currently under review by the NRC and has not been issued.

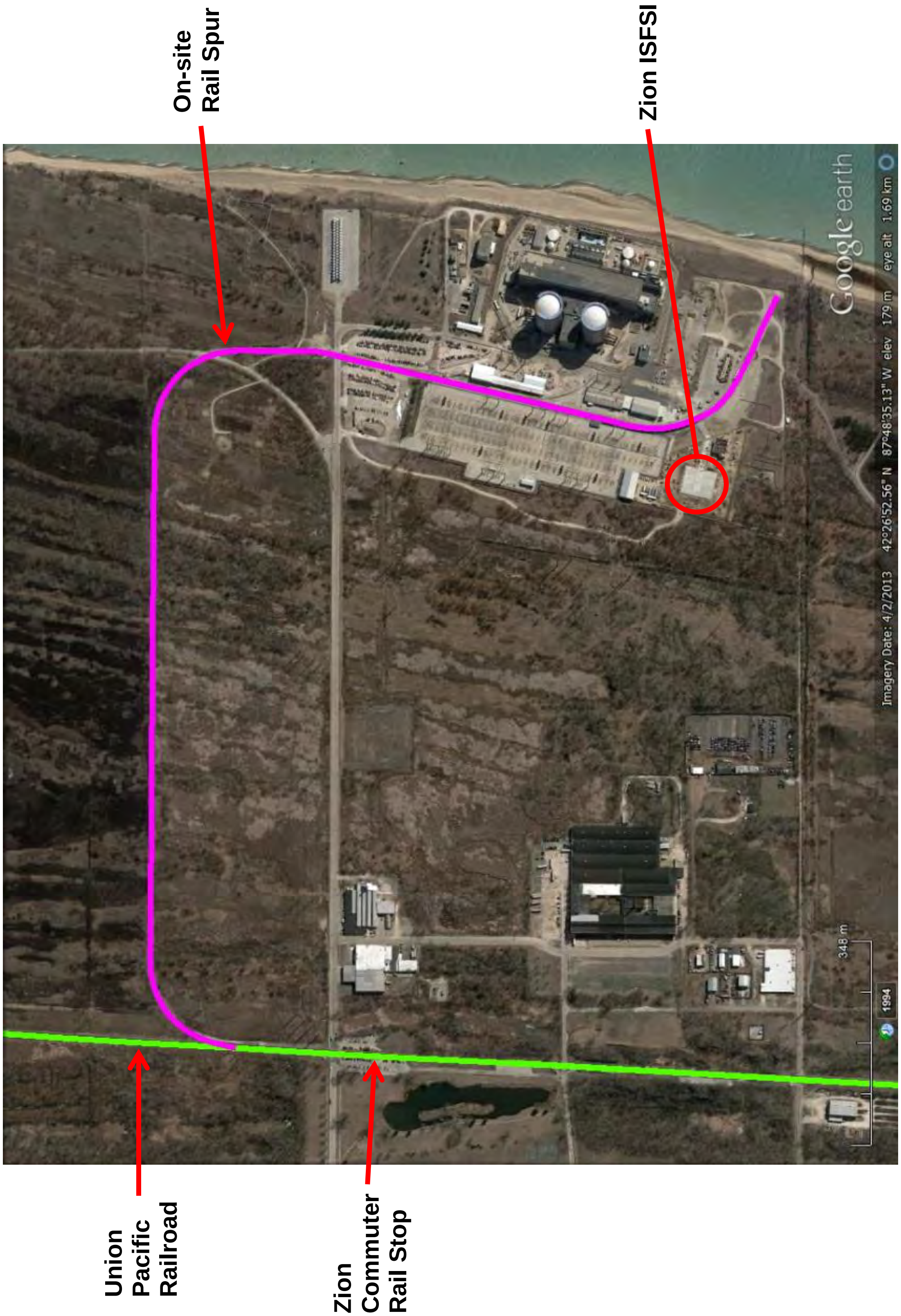

Figure 2-139. Rail Interface at Zion (Google 2015)

Figure 2-140. Trackmobile Used to Move Railcars On-site (2013)

Photo courtesy of Federal Railroad Administration

Figure 2-141. On-site Rail Spur Entering Zion Site (2013)

Figure 2-142. Junction of Zion On-site Rail Spur with Union Pacific Railroad Showing Concrete Rail Ties (2013)

Photo courtesy of ZionSolutions

Figure 2-143. Zion Reactor Head on Heavy Haul Truck Transporter (2011)

2.10 Crystal River

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Crystal River site. The Crystal River site is located in northwestern Florida near the Gulf of Mexico on the Crystal River about 46 miles south-southwest of Gainesville, Florida, and 70 miles north of Tampa, Florida (TOPO 1994c).

2.10.1 Site Inventory

The Crystal River Unit 3 Nuclear Generating Plant (CR-3) has been shut down since September 26, 2009 and the final removal of used nuclear fuel from the reactor vessel was completed on May 28, 2011 (Franke 2013). There are 1244 pressurized water reactor used nuclear fuel assemblies (583.6 MTHM) stored in the spent fuel pool and there is no used nuclear fuel in dry storage at Crystal River.[25] This total includes an assembly that was created by

[25] Fata A. 2014. Email message from A Fata (Duke Energy Corporation) to SJ Maheras (Pacific Northwest National Laboratory), "Re: CR3 input to DOE report," September 30, 2014.

combining failed fuel rods from other assemblies, and does not include 76 assemblies that were loaded into the reactor for restart but not brought to critical. These assemblies are being sold for reuse.

The fuel rods in the fuel assemblies are zirconium alloy-clad. Crystal River is planning on using the Standardized NUHOMS System (Docket No. 72-1004) with the 32PTH1 dry shielded canister for dry storage of used nuclear fuel at an ISFSI. This system consists of transportable 32PTH1 dry shielded canisters, reinforced concrete horizontal storage modules, and a transfer cask. Figure 2-144 shows a transfer cask being used to load a canister into a horizontal storage module.

The 32PTH1 dry shielded canister holds 32 pressurized water reactor used nuclear fuel assemblies. Thirty-nine 32PTH1 canisters would be required to store the 1244 used nuclear fuel assemblies at Crystal River. Elnitsky (2013) estimated that 5 canisters containing GTCC low-level radioactive waste will be generated during decommissioning, and that GTCC low-level radioactive waste would not be packaged until 2068-2070. In addition, Elnitsky (2013) also states that the spent fuel pool will be maintained in a recoverable condition until all fuel has been removed from the Crystal River site unless contingency plans are put in place for offload of the canisters if needed.

The MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 32PTH1 canister and also canisters containing GTCC low-level radioactive waste. In addition, the MP197HB transportation cask is certified to transport high burnup (> 45 GWd/MTHM) used nuclear fuel in the 32PTH1 canister. An MP197HB transportation cask is being fabricated in Japan (Vanderniet 2012). Fabrication is expected to be completed in 2015.

Figure 2-145 illustrates the number of used nuclear fuel assemblies at Crystal River, based on their discharge year.[26] The oldest fuel was discharged in 1978 and the last fuel was discharged in 2009. The median discharge year of the fuel is 1996.

Figure 2-146 illustrates the number of used nuclear fuel assemblies at Crystal River based on their burnup.[27] The lowest burnup is 8.7 GWd/MTHM and the highest burnup is 54.9 GWd/MTHM. The median burnup is 38.2 GWd/MTHM. There are 428 used nuclear fuel assemblies at Crystal River that have burnups greater than 45 GWd/MTHM. These 428 fuel assemblies are classified by the NRC as high burnup used nuclear fuel.

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[26] Fata A. 2014. Email message from A Fata (Duke Energy Corporation) to SJ Maheras (Pacific Northwest National Laboratory), "Re: CR3 input to DOE report," September 30, 2014.

[27] Fata A. 2014. Email message from A Fata (Duke Energy Corporation) to SJ Maheras (Pacific Northwest National Laboratory), "Re: CR3 input to DOE report," September 30, 2014.

Photo courtesy of AREVA TN

Figure 2-144. Transfer Cask Being Used to Load Canister into Horizontal Storage Module

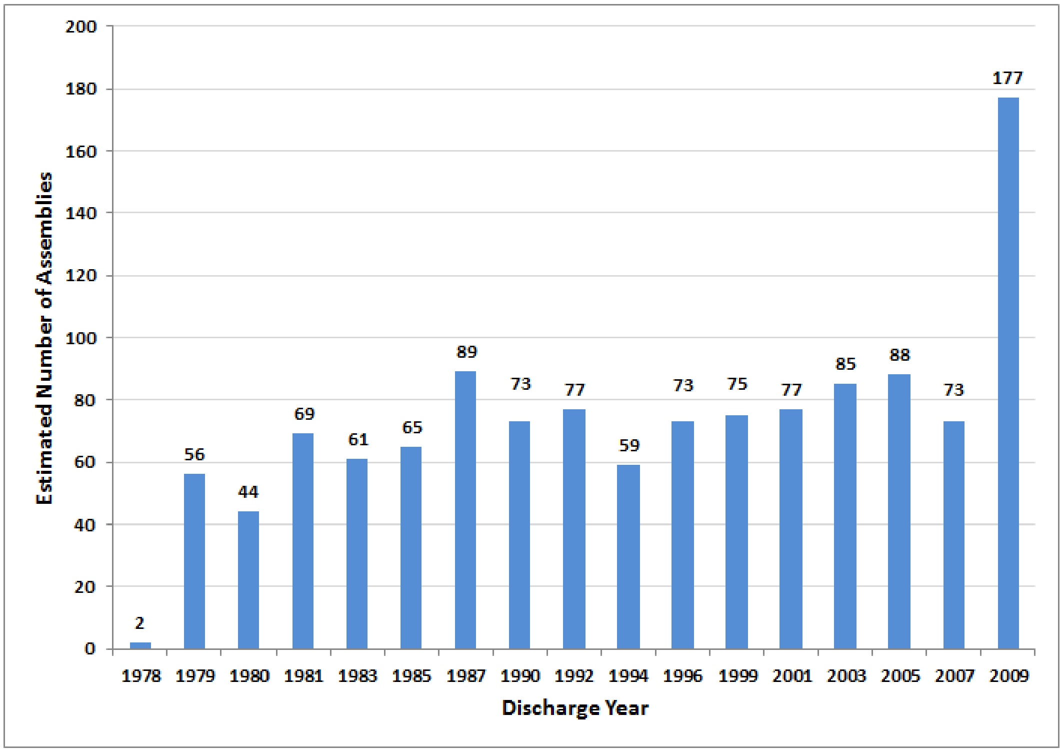


Figure 2-145. Crystal River Number of Assemblies versus Discharge Year

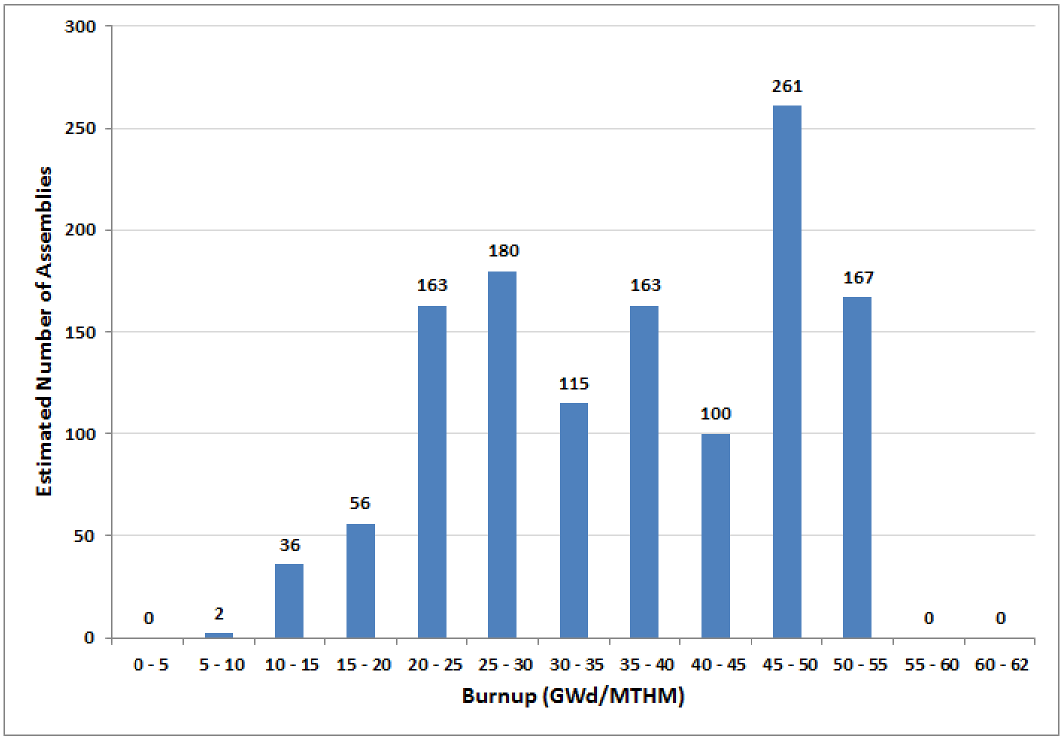


Figure 2-146. Crystal River Number of Assemblies versus Burnup

2.10.2 Site Conditions

The Crystal River Unit 3 Nuclear Generating Plant (CR-3) is part of the larger Crystal River Energy Complex (CREC), which includes the single nuclear unit and four fossil fueled units, Crystal River Units 1, 2, 4, and 5 (CR-1, CR-2, CR-4, and CR-5). Figure 2-147 shows the future site of the Crystal River ISFSI. This area will be built up approximately 20 feet to be above flood level. Figure 2-148 shows an artist's conception of the future Crystal River ISFSI. Figure 2-149 provides an aerial view of the Crystal River Energy Complex showing the location of CR-1 through CR-5, the on-site rail system including the nuclear spur and coal receiving loop, the coal barge unloading area, the barge turning basin, an area used to unload roll-on/roll-off barges, and the intake and discharge canals. Figure 2-150 shows the location of the future ISFSI at the Crystal River site discussed in Section 2.10.1.

Crystal River has an extensive on-site rail system used for coal shipments to the 4 fossil fueled units with service provided by the Florida Northern Railroad. The Crystal River site currently receives 5 coal trains per month but has received 30 to 40 trains per month. The weight of each car is in the range of 100 to 110 tons and coal trains weigh about 11,000 tons. In general, the on-site rail system is built using 132 to 136 lb. rail. A nuclear spur previously extended into the Crystal River reactor cask receiving area; the nuclear spur now terminates about 0.22 miles east of the cask receiving area and does not extend into the ISFSI.

Figure 2-151 and Figure 2-152 show the nuclear spur and the junction of the onsite industrial spur and the nuclear spur. Figure 2-153 and Figure 2-154 show the onsite industrial spur in front of the future ISFSI site. Figure 2-155 and Figure 2-156 show the onsite industrial spur at the junction with the coal receiving loop and approaching U.S. Highway 19 from the west. There is sufficient track outside of the Crystal River protected area to assemble or store more than 20 railcars, but use of the on-site track would not be allowed to interfere with coal shipments for the fossil fueled units.

Intake and discharge canals at the Crystal River site withdraw water from and discharge water to the Gulf of Mexico (see Figure 2-157). The Crystal River site has on-site barge access through the intake canal but loading a transportation cask onto a barge would require a crane to boom out over 30 feet to avoid a coal conveyer. The intake canal, which extends into the Gulf of Mexico, is 14 miles long. It has a minimum depth of 20 feet to accommodate barge traffic used to deliver coal for the fossil fuel units. Southern and northern dikes parallel the intake canal for about 3.4 miles offshore. The southern dike terminates at this point, while the northern dike extends an additional 5.3 miles into the Gulf of Mexico. The dikes are about 50 to 100 feet wide on top and are elevated about 10 feet above the water surface at mean low tide. Starting at the east end, the intake canal is 150 feet wide for 2.8 miles; 225 feet wide for the next 6.3 miles; and 300 feet wide for the last 4.9 miles. Dredging occurs in the intake canal every 5 to 7 years (NRC 2011).

Figure 2-158 shows the coal barge unloading area at the Crystal River site. The Crystal River site currently receives about 20 barges per month and each barge has a capacity of 20,000 tons. Figure 2-159 shows the barge turning basin. This area has been used to unload roll-on/roll-off barges at the Crystal River site.

Photo courtesy of Crystal River

Figure 2-147. Future Site of Crystal River Independent Spent Fuel Storage Installation (2015)

Photo courtesy of Crystal River

Figure 2-148. Artist's Conception of the Future Crystal River Independent Spent Fuel Storage Installation

Figure 2-149. Aerial View of the Crystal River Energy Complex (Google 2015)

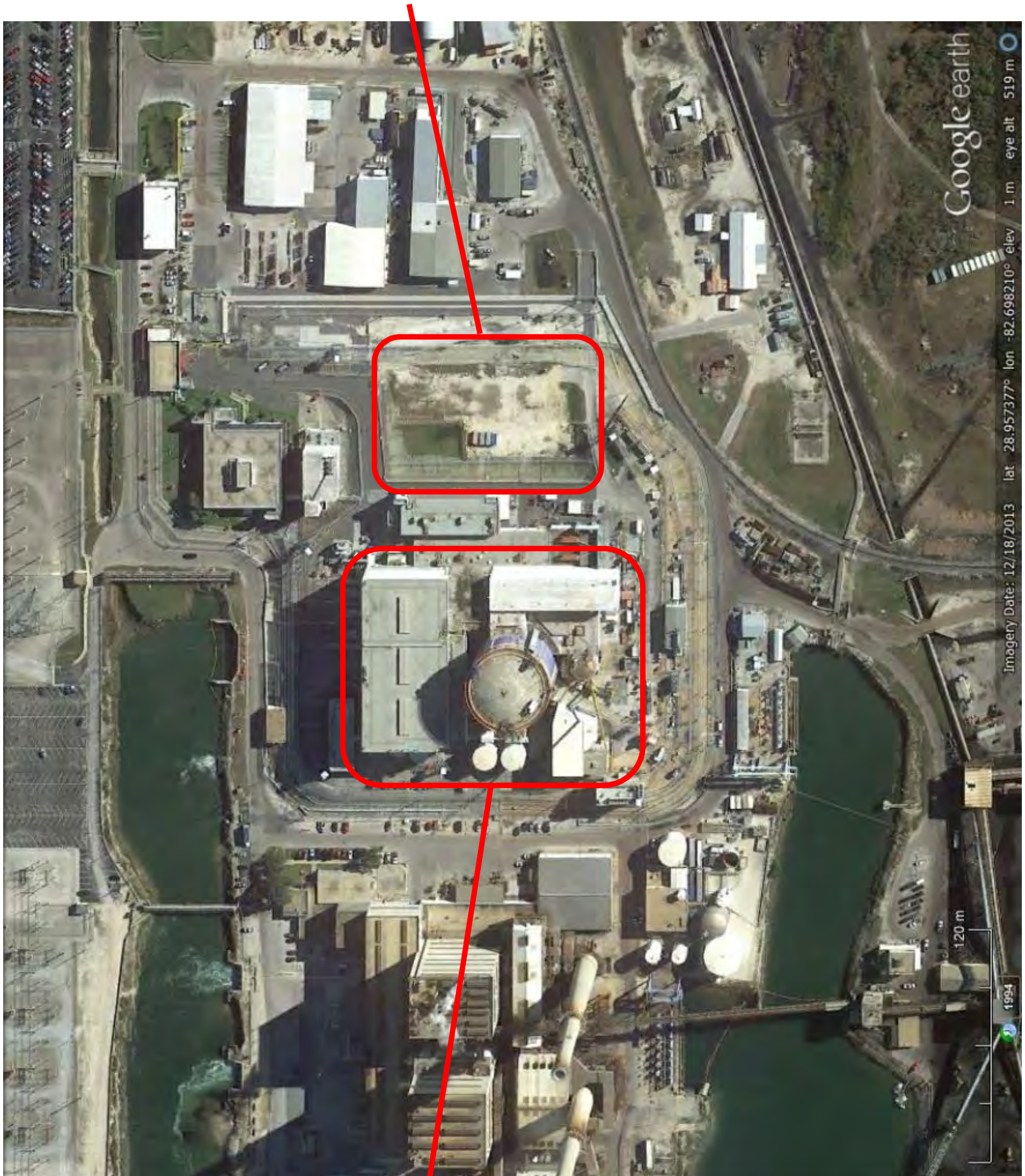


Figure 2-150. Location of Future Crystal River Independent Spent Fuel Storage Installation (Google 2015)

Figure 2-151. Nuclear Spur (2015)

Figure 2-152. Junction of Onsite Industrial Spur (Left) and Nuclear Spur (Right) (2015)

Figure 2-153. Onsite Industrial Rail Spur in Front of the Future Independent Spent Fuel Storage Installation Site (Facing East) (2015)

Figure 2-154. Onsite Industrial Rail Spur in Front of Future Independent Spent Fuel Storage Installation Site (Facing West) (2015)

Figure 2-155. Onsite Industrial Rail Spur at the Coal Loop Junction (2015)

Figure 2-156. Onsite Industrial Rail Spur Approaching U.S. Highway 19 from the West (2015)

Figure 2-157. Aerial View of the Crystal River Intake and Discharge Canals (Google 2015)

Figure 2-158. Current Barge Area Used for Unloading Coal Barges (2015)

Figure 2-159. Barge Turning Basin (2015)

2.10.3 Near-site Transportation Infrastructure and Experience

At the Crystal River site, a 7-mile industrial rail spur provides direct rail access to the Florida Northern Railroad at Red Level Junction (see Figure 2-160). This spur is used to receive coal shipments for CR-1, CR-2, CR-4, and CR-5. The track south of Red Level Junction has been abandoned. In Newberry, Florida, about 60 miles from the Crystal River site, the Florida Northern Railroad interchanges with the CSXT Railroad at the Newberry wye (see Figure 2-161 and Figure 2-162). The Crystal River industrial spur (milepost 793.1 to 785.7) has a speed limit of 10 mph and is designated as track class 1. The Florida Northern Railroad speed limit from milepost 785.7 and 732.0 is 25 mph and is designated as track class 2. At milepost 789.27, the Florida Northern Railroad crosses U.S. Highway 19. At the Newberry wye (milepost 732.0 to 729.9), the speed limit is 10 mph and the track is designated as track class 1. To the northeast of the Newberry wye (milepost 718.7 to 717.0), the speed limit is also 10 mph and the track is designated as track class 1. At milepost 718.34, the Florida Northern Railroad crosses U.S. Highway 41/Main Street. In general, the Florida Northern Railroad is built using 115 lb. rail.

The CSXT track begins at milepost 717.0 and is track class 3. The CSXT also has trackage rights over the Florida Northern Railroad between milepost 718.7 and 717.0, enabling the CSXT to interchange with the Florida Northern Railroad at the Newberry wye, and between milepost 730.0 and 732.0, which is where inbound and outbound trains are staged. Figure 2-163 through Figure 2-166 show the Florida Northern Railroad near Dunnellon, Florida, a highway bridge over the Florida Northern Railroad, a grade crossing on the Florida Northern Railroad, and a bridge on the Florida Northern Railroad, respectively. Figure 2-167 through Figure 2-169 show wheel detectors, a hot bearing detector, and a dragging equipment detector on the Florida Northern Railroad at milepost 759.6. Figure 2-170 shows track maintenance equipment staged at the mine spur, just off the industrial spur, and Figure 2-171 shows a Florida Northern Railroad Hi-Rail vehicle used for track inspections.

In 2009, four moisture separator reheaters and a generator rotor were shipped to the Crystal River site by rail. The moisture separator reheaters weighed 300,000 lb. each, and had a length of 51 feet and a diameter of 14 feet (see Figure 2-172 and Figure 2-173). The generator rotor weighed 395,000 lb., and had a length of 50 feet and a diameter of 8 feet (see Figure 2-174 and Figure 2-175). The moisture separator reheaters and a generator rotor were unloaded at the Crystal River site nuclear spur. The old moisture separator reheaters were also loaded at the nuclear spur and shipped offsite by rail (see Figure 2-176 and Figure 2-177).

In 2015, twelve horizontal storage modules were shipped to the Crystal River site by rail. The horizontal storage modules were transported using 230-ton, 27-foot deck, 8-axle depressed center railcars. Each horizontal storage module weighed 189,000 lb., and had a length of 20.7 feet, a width of 9.7 feet, and a height of 14.8 feet. As with the moisture separator reheaters and the generator rotor, the horizontal storage modules were unloaded at the nuclear spur. Figure 2-178 shows two horizontal storage modules loaded on railcars, Figure 2-179 shows a horizontal storage module staged for unloading, Figure 2-180 shows a horizontal storage module being unloaded from a railcar, and Figure 2-181 shows the twelve horizontal storage modules at the nuclear spur after unloading.

As discussed in Section 2.10.2, Crystal River also has barge access to the Gulf of Mexico through the intake canal at the site. In 2012, the Crystal River site received low pressure turbine components by barge. These components consisted of two low pressure rotors (353,000 lb. each), two low pressure upper casings (117,000 lb. each), and two low pressure lower casings (200,000 lb. each). The components were unloaded at an area adjacent to the coal barge unloading area (see Figure 2-182), which also shows the barge turning basin. A ramp was constructed in the bank of the barge turning basin, the barge grounded, and the components rolled off the barge. Figure 2-183 through Figure 2-190 show the sequence of operations used to offload the components from the barge.

The Crystal River site has also received components by heavy haul truck. For example, in 2011, a high pressure turbine rotor was received by the Crystal River site (see Figure 2-191). The high pressure turbine weighed 150,000 lb., and had a length of 28 feet and a diameter of 7 feet.

2.10.4 Gaps in Information

At the Crystal River site, an on-site rail spur provides direct access to the Florida Northern Railroad which interchanges with the CSXT Railroad and consequently, barge or heavy haul truck transport of used nuclear fuel and GTCC low-level radioactive waste would be unlikely from the Crystal River site.

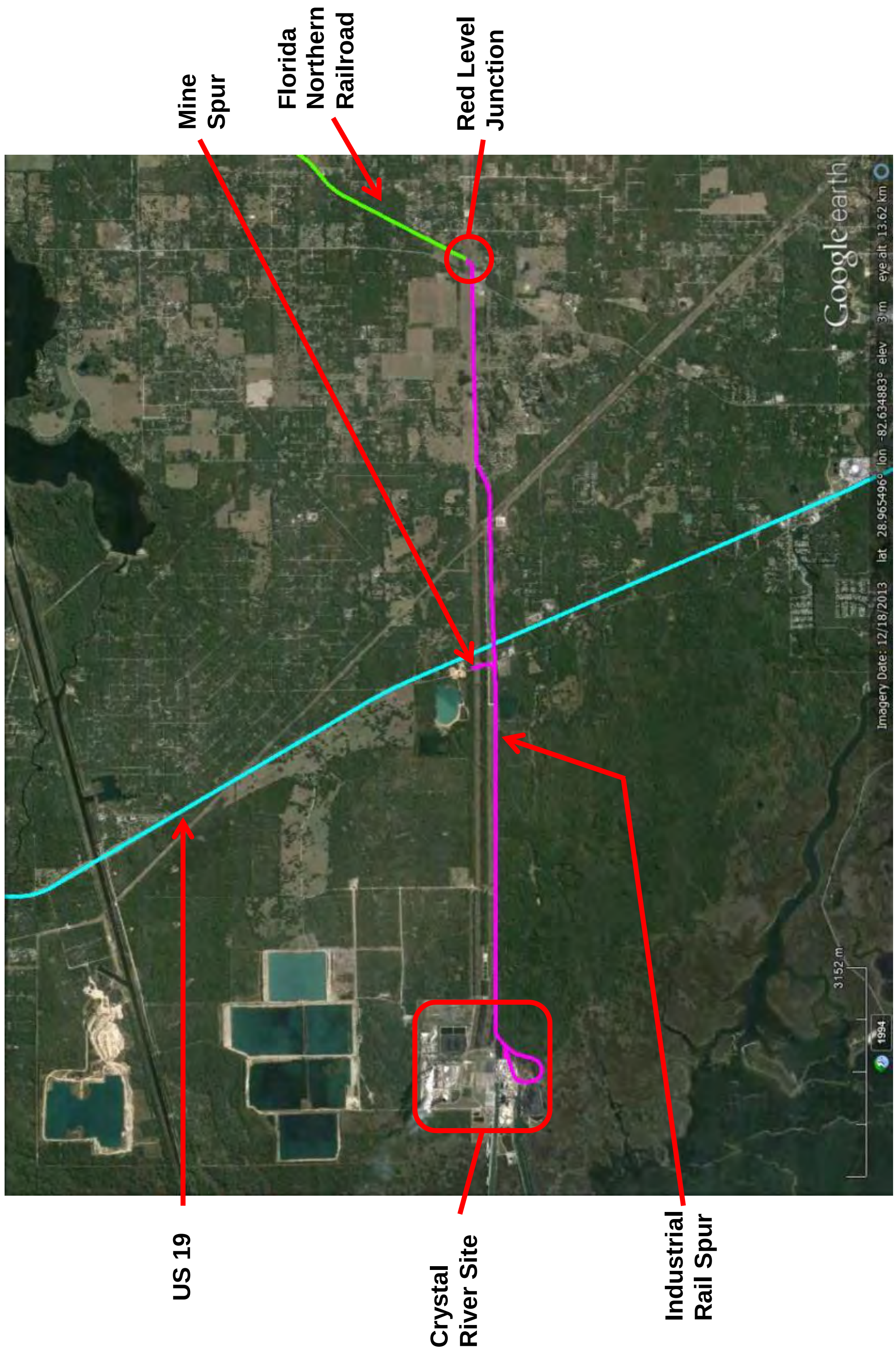


Figure 2-160. Aerial View of the Crystal River Industrial Rail Spur and Florida Northern Railroad (Google 2015)

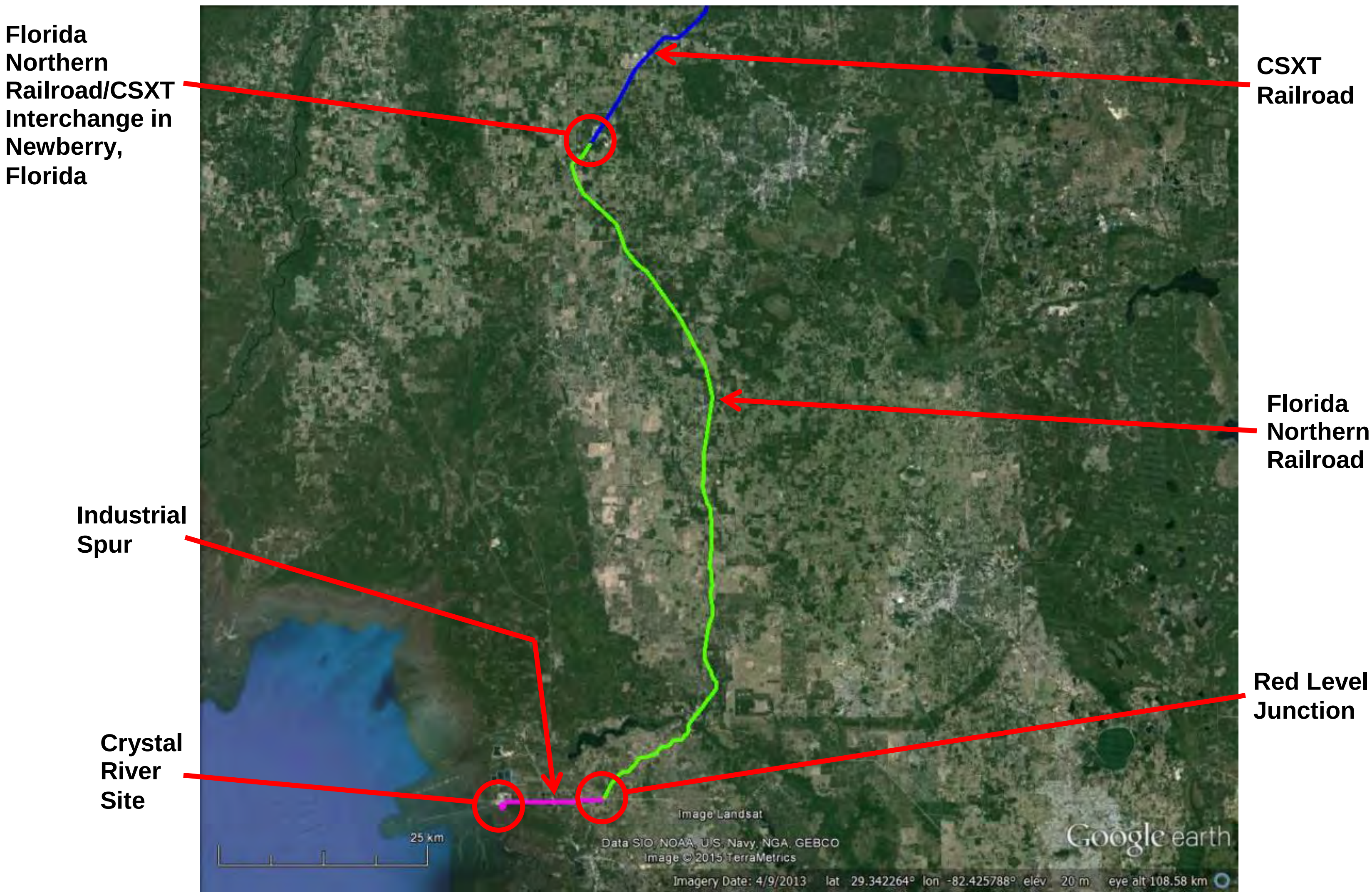


Figure 2-161. Aerial View of the Crystal River Industrial Rail Spur, Florida Northern Railroad, and CSXT Railroad (Google 2015)

Figure 2-162. Newberry Wye (Google 2015)

Figure 2-163. Florida Northern Railroad near Dunnellon, Florida (2015)

Figure 2-164. Highway Bridge over Florida Northern Railroad (2015)

Figure 2-165. Florida Northern Railroad Grade Crossing (2015)

Figure 2-166. Florida Northern Railroad Bridge (2015)

Figure 2-167. Wheel Detectors on Florida Northern Railroad (2015)

Figure 2-168. Hot Bearing Detector on Florida Northern Railroad (2015)

Figure 2-169. Dragging Equipment Detector on Florida Northern Railroad (2015)

Figure 2-170. Track Maintenance Equipment Staged at the Mine Spur (2015)

Figure 2-171. Hi-Rail Vehicle Used for Track Inspections (2015)

Photo courtesy of Crystal River

Figure 2-172. Moisture Separator Reheaters Being Shipped by Rail to the Crystal River Site (2009)

Photo courtesy of Crystal River

Figure 2-173. Moisture Separator Reheaters Being Unloaded at the Crystal River Site (2009)

Photo courtesy of Crystal River

Figure 2-174. Generator Rotor Being Shipped by Rail to the Crystal River Site (2009)

Photo courtesy of Crystal River

Figure 2-175. Generator Rotor Being Unloaded at the Crystal River Site (2009)

Photo courtesy of Crystal River

Figure 2-176. Old Moisture Separator Reheaters Being Shipped Offsite by Rail (2009)

Photo courtesy of Crystal River

Figure 2-177. Locomotive Picking Up Old Moisture Separator Reheaters (2009)

Photo courtesy of Crystal River

Figure 2-178. Two Horizontal Storage Modules Loaded on Railcars (2015)

Photo courtesy of Crystal River

Figure 2-179. Horizontal Storage Module Staged for Unloading (2015)

Photo courtesy of Crystal River

Figure 2-180. Horizontal Storage Module Being Unloaded from Railcar (2015)

Photo courtesy of Crystal River

Figure 2-181. Horizontal Storage Modules at Nuclear Spur after Unloading (2015)

Figure 2-182. Crystal River Site Barge Area (Google 2015)

Photo courtesy of Crystal River

Figure 2-183. Crystal River Turbine Components on Barge (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-184. Barge with Turbine Components Approaching Ramp (2012)

Photo courtesy of Crystal River

Figure 2-185. Barge with Turbine Components Just Before Grounding at Ramp (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-186. Barge with Turbine Components Grounded at Ramp (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-187. Turbine Components Being Unloaded Using Self-Propelled Modular Transporter (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-188. Turbine Components Driving Off of Unloading Ramp (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.
Figure 2-189. Turbine Components Fully Unloaded from Barge (2012)

Photo courtesy of Argonautics Marine Engineering, Inc.
Figure 2-190. Self-Propelled Modular Transporter Turning with Turbine Components (2012)

Photo courtesy of Crystal River

Figure 2-191. High Pressure Turbine Rotor Delivered to Crystal River Site by Heavy Haul Truck (2011)

2.11 Kewaunee

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Kewaunee site. The Kewaunee site is located on the western shore of Lake Michigan between the towns of Manitowoc and Kewaunee about 30 miles southeast of Green Bay and 98 miles north of Milwaukee, Wisconsin (TOPO 1994d).

2.11.1 Site Inventory

Kewaunee has been shut down since May 7, 2013 and final removal of used nuclear fuel from the reactor vessel was completed on May 14, 2013 (Stoddard 2013a, 2013b). A total of 1335 used nuclear fuel assemblies (518.7 MTHM) are stored at Kewaunee (Sartain 2014a), of which 887 pressurized water reactor used nuclear fuel assemblies (348.4 MTHM) are stored in the spent fuel pool and 448 pressurized water reactor used nuclear fuel assemblies (170.3 MTHM) are in dry storage at the Kewaunee ISFSI (Docket No. 72-64). The fuel rods in the fuel assemblies are zirconium alloy-clad. The 448 fuel assemblies are stored in 14 32PT dry shielded canisters. The 32PT dry shielded canister holds 32 pressurized water reactor used nuclear fuel assemblies and is part of the Standardized NUHOMS System (Docket No. 72-1004).

This system consists of transportable dry shielded canisters, reinforced concrete horizontal storage modules, and a transfer cask.

The MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 32PT canister and also canisters containing GTCC low-level radioactive waste. Transport of high burnup (> 45 GWd/MTHM) used nuclear fuel in the 32PT canister is not authorized in Revision 7 of the certificate of compliance for the MP197HB. An MP197HB transportation cask is being fabricated in Japan (Vanderniet 2012). Fabrication is expected to be completed in 2015.

After 2014, Kewaunee plans to load used nuclear fuel into the NAC MAGNASTOR system (Docket No. 72-1031). The MAGNASTOR system consists of transportable storage canisters, vertical concrete storage casks, and a transfer cask. At Kewaunee, the TSC-37 transportable storage canister, which holds 37 pressurized water reactor used nuclear fuel assemblies, will be used. Twenty-four TSC-37 canisters would be required and it is expected that the loading of the canisters and the MAGNASTOR system will start in 2016 (Ux Consulting 2015b). The transportation cask that will be certified to transport the TSC-37 canister is the NAC MAGNATRAN (Docket No. 71-9356). The application for a certificate of compliance for the MAGNATRAN is currently under review by the NRC.

At the Kewaunee site, it is estimated that a total of 38 canisters containing used nuclear fuel and 2 canisters containing GTCC low-level radioactive waste will be stored. Sartain (2014b) states that GTCC low-level radioactive waste would not be packaged until 2070.

Figure 2-192 illustrates the number of used nuclear fuel assemblies at Kewaunee based on their discharge year. The oldest fuel was discharged in 1976 and the last fuel was discharged in 2013. The median discharge year of the fuel is 1994.

Figure 2-193 illustrates the number of used nuclear fuel assemblies at Kewaunee based on their burnup. The lowest burnup is 14.7 GWd/MTHM and the highest burnup is 56.3 GWd/MTHM. The median burnup is 37.2 GWd/MTHM. There are 264 used nuclear fuel assemblies at Kewaunee that have burnups greater than 45 GWd/MTHM. These 264 fuel assemblies are classified by the NRC as high burnup used nuclear fuel.

As mentioned previously, Kewaunee has 448 used nuclear fuel assemblies stored in 14 dry storage canisters. Figure 2-194 and Figure 2-195 illustrate the number of canistered fuel assemblies based on their discharge year and burnup. The oldest canistered fuel was discharged in 1982 and the last fuel was discharged in 2004. The median discharge year of the canistered fuel is 1992. The lowest burnup is 25.0 GWd/MTHM and the highest burnup is 43.1 GWd/MTHM. The median burnup is 36.9 GWd/MTHM. There are no canistered fuel assemblies at Kewaunee that have burnups greater than 45 GWd/MTHM.

Figure 2-196 and Figure 2-197 illustrate the number of fuel assemblies based on their discharge year and burnup for the 887 uncanistered fuel assemblies at Kewaunee. The oldest uncanistered fuel was discharged in 1976 and the last fuel was discharged in 2013. The median discharge year of the uncanistered fuel is 2001. The lowest burnup is 14.7 GWd/MTHM and the highest burnup is 56.3 GWd/MTHM. The median burnup is 37.6 GWd/MTHM. There are 264 uncanistered fuel assemblies at Kewaunee that have burnups greater than 45 GWd/MTHM.

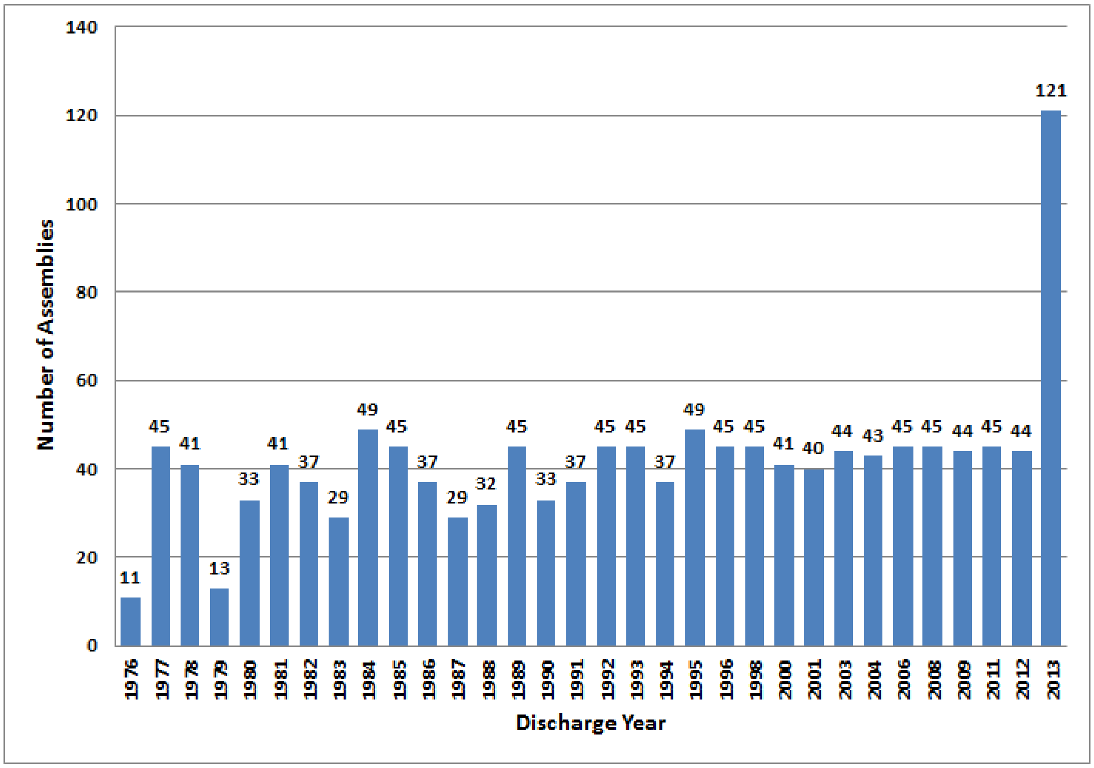


Figure 2-192. Kewaunee Number of Assemblies versus Discharge Year

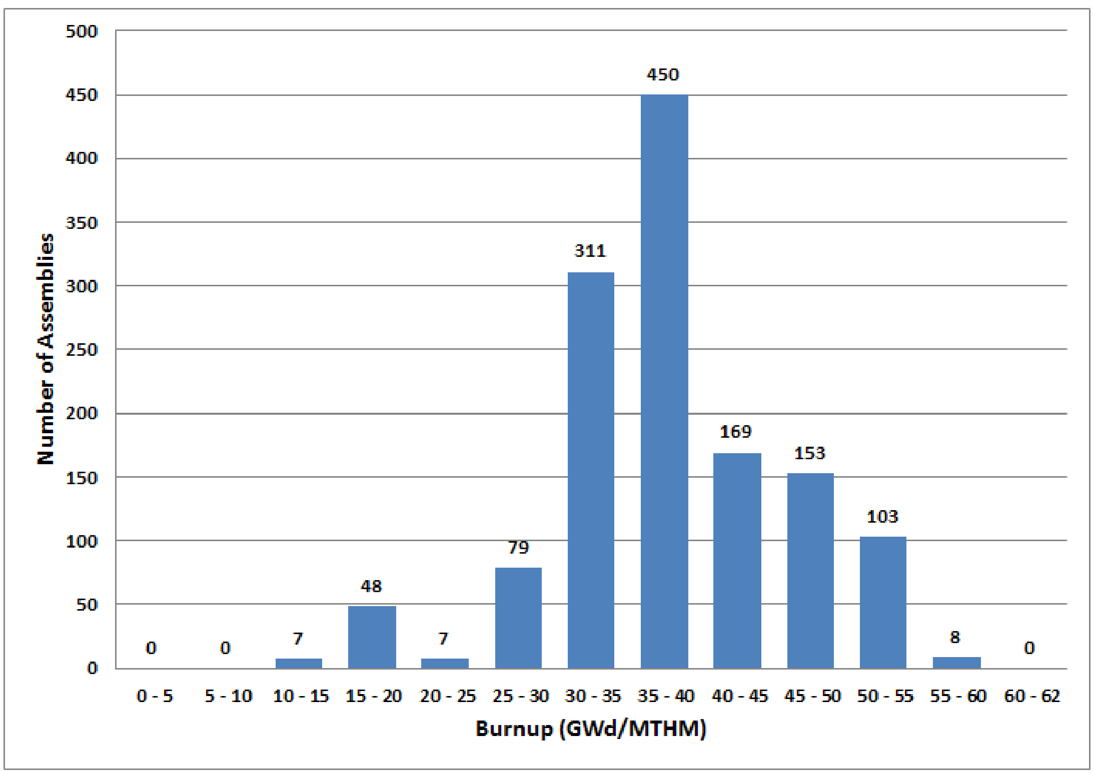


Figure 2-193. Kewaunee Number of Assemblies versus Burnup

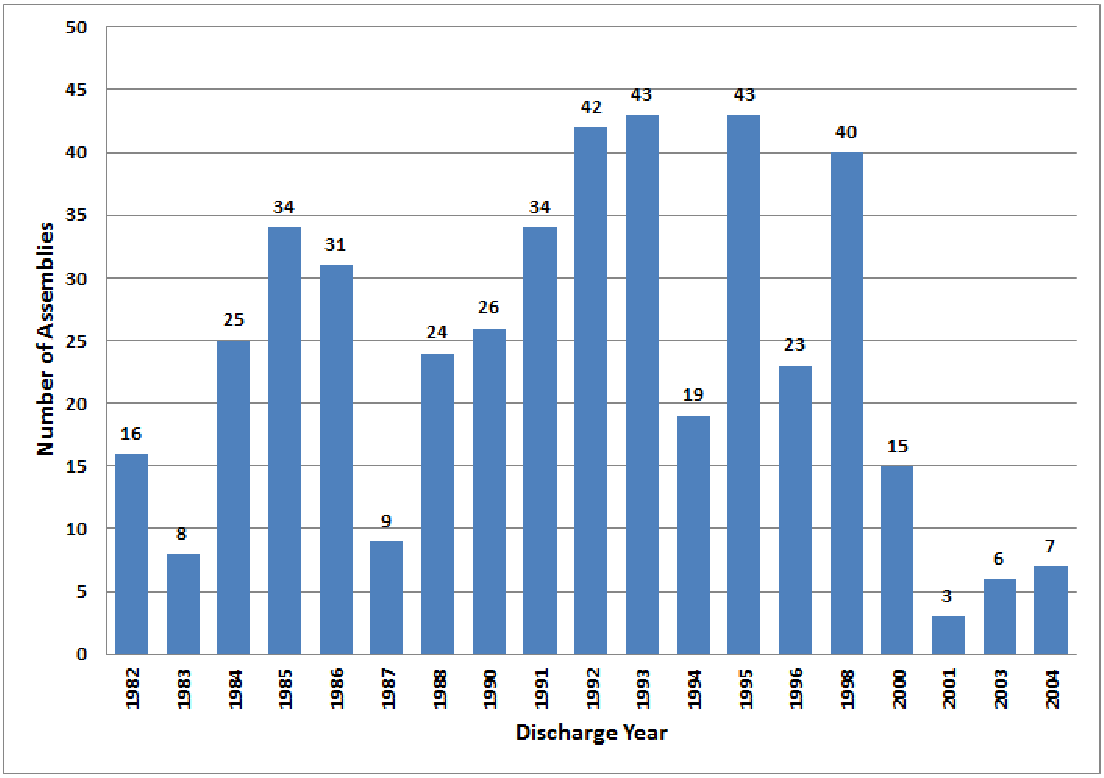


Figure 2-194. Kewaunee Number of Canistered Assemblies versus Discharge Year

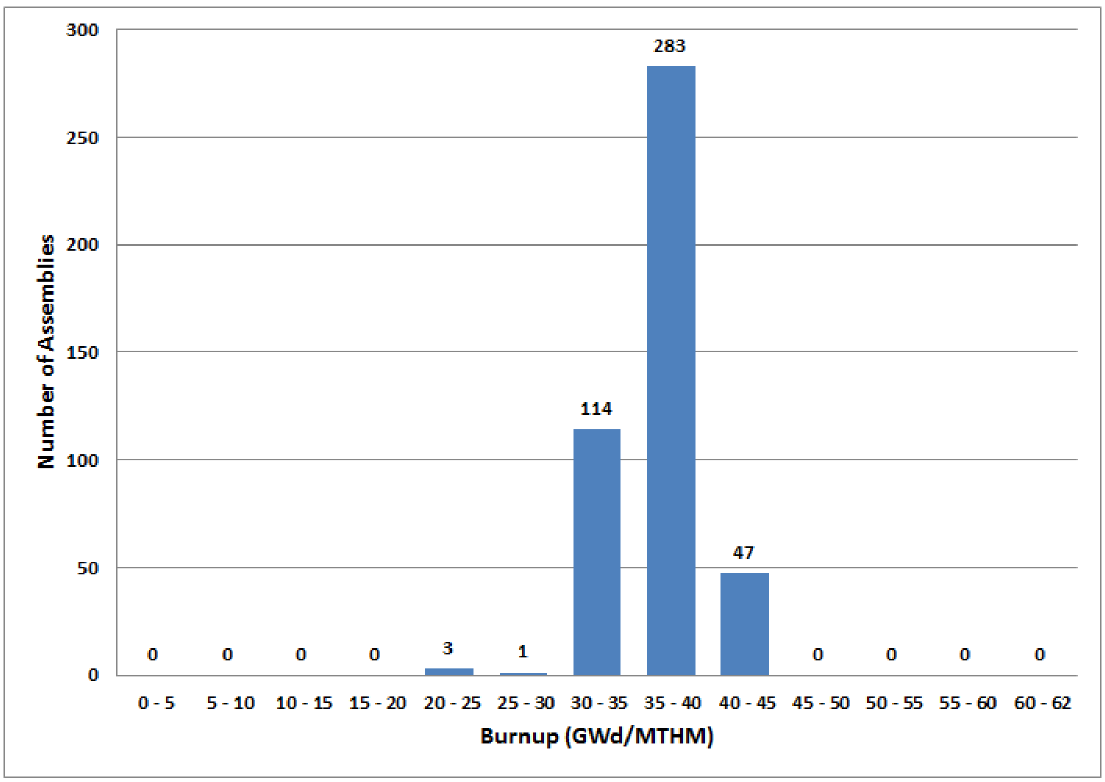


Figure 2-195. Kewaunee Number of Canistered Assemblies versus Burnup

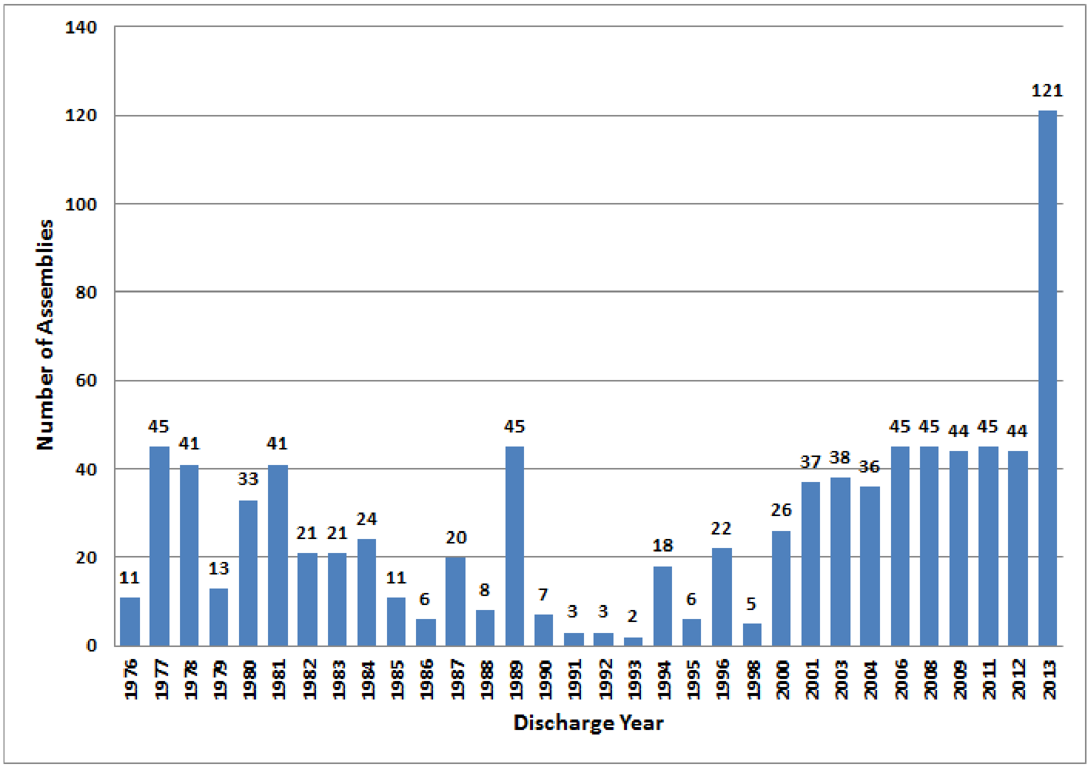


Figure 2-196. Kewaunee Number of Uncanistered Assemblies versus Discharge Year

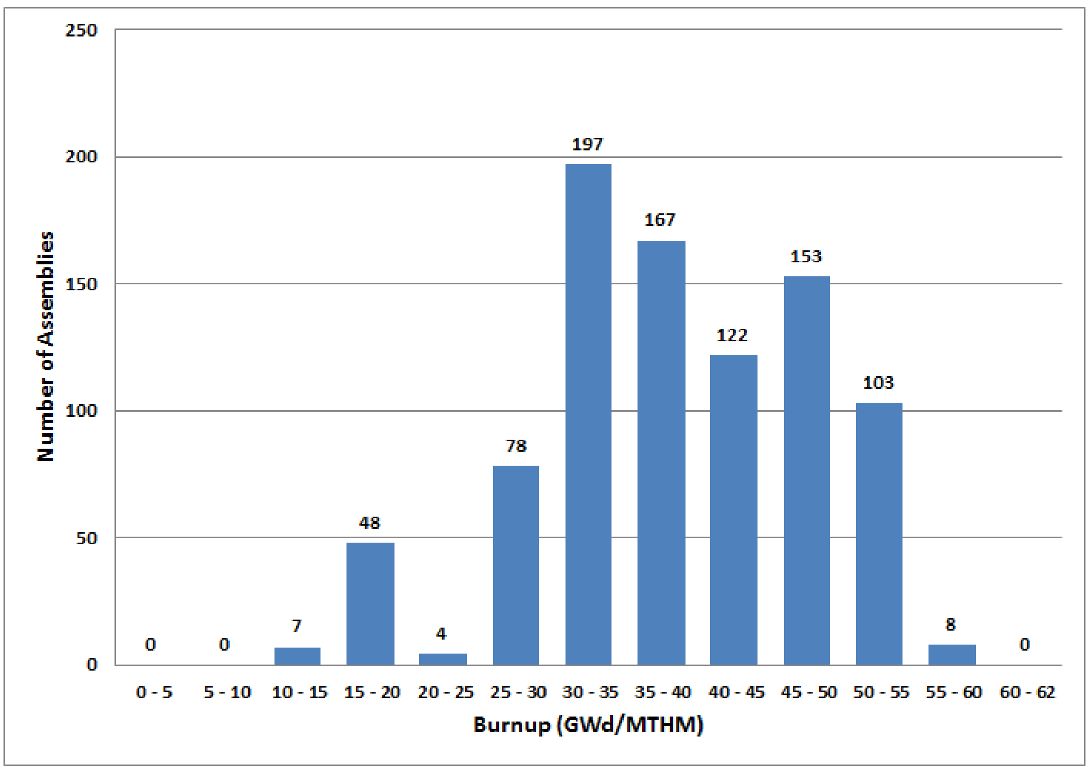


Figure 2-197. Kewaunee Number of Uncanistered Assemblies versus Burnup

2.11.2 Site Conditions

The Kewaunee site is located on the western shore of Lake Michigan and the Kewaunee ISFSI (see Figure 2-198) is located at the northern end of the site (see Figure 2-199). There is no direct rail or barge service to the site (TOPO 1994d). The nearest rail access is in Denmark, Wisconsin, about 16 miles from the site, and the nearest barge terminal is in Kewaunee, Wisconsin, about 10 miles from the site. There was an on-site barge facility during plant construction, but it was disassembled, and reestablishment would require a major restoration (TriVis Incorporated 2005).

Photo courtesy of Kewaunee

Figure 2-198. Kewaunee Independent Spent Fuel Storage Installation

Figure 2-199. Aerial View of Kewaunee Site (Google 2015)

2.11.3 Near-site Transportation Infrastructure and Experience

The Kewaunee site does not have an on-site rail spur or a railroad that passes near to the site or along the site boundary. For Kewaunee, heavy haul trucks could be used to move transportation casks over public highways to a rail siding or spur that provides access to a railroad that can accommodate the loaded transportation casks.

For shipments of casks containing used nuclear fuel that require the use of heavy haul trucks, the casks would be prepared for shipment at the Kewaunee ISFSI site and loaded onto a transport cradle that would be loaded onto the transport trailer of a heavy haul truck. The truck, led and followed by technical and security escorts, would move over an approved, designated highway route to a nearby rail siding or spur. Heavy lift equipment would be used to transload the cask and its cradle as a unit from the truck to a railcar at the rail siding or spur.

Table 2-6 lists distances from the Kewaunee site to potential transload locations at Luxemburg, Bellevue, Denmark, Rockwood, and Manitowoc, Wisconsin (see Figure 2-200). Figure 2-200 also shows the location of the Point Beach Nuclear Plant, which is about 4.5 miles south of the Kewaunee site. The rail lines in the vicinity of Luxemburg, Bellevue, and Denmark are designated as track class 1. These rail lines connect to the Fox River Subdivision of the Canadian National Railroad which is designated as track class 2. The rail line in the vicinity of Rockwood is designated as track class 1. After merging with the mainline at Manitowoc, the rail line is designated as track class 2.

Table 2-6 also provides potential routes that heavy haul trucks might use to get to the rail transload locations. These routes have not been evaluated for attributes such as weight limitations, bridge and tunnel limitations, turning radii, vertical or horizontal clearances, seasonal restrictions, presence of culverts, etc.

Table 2-6. Potential Kewaunee Rail Transload Locations

Rail Transload Location	Distance From Kewaunee Site (mile)	Potential Route
Luxemburg	23.5	WI-42 North to County Road C North to WI-29 West to County Road AB North
Bellevue	27.9	WI-42 North to County Road C North to WI-29 West
Denmark	16.7–17.4	WI-42 South to County Road BB West to County Road R North WI-42 South to County Road BB West to County Road R North to County Road T West
Rockwood Spur at WI-310	21.0–22.7	WI-42 South to WI-310 West WI-42 South to County Road BB West to County Road Q South to WI-310 West
Rockwood Spur at Manitowoc Airport	21.5	WI-42 South to County Road B West
Manitowoc (waterfront area)	21.3	WI-42 South

Figure 2-201 shows an aerial view of a potential transload location at Luxemburg, Wisconsin, and Figure 2-202 shows a potential heavy haul truck route from the Kewaunee site to the Luxemburg transload location. Figure 2-203 through Figure 2-205 show the current condition of the potential Luxemburg transload location. In 2008, the Luxemburg transload location was used to transload four 160-ton transformers from railcars to 15-axle Goldhofer trailers using a gantry system, which were then moved to the Kewaunee site. Figure 2-206 shows the gantry system used to transfer the transformers from the railcars to Goldhofer trailer and Figure 2-207 shows a transformer on a heavy haul truck being moved from Luxemburg to the Kewaunee site.

Figure 2-208 shows an aerial view of a potential transload location at Bellevue, Wisconsin, and Figure 2-209 shows a potential heavy haul truck route from the Kewaunee site to the Bellevue transload location. Figure 2-210 through Figure 2-213 show the current condition of the potential Bellevue transload location. In 2008, the Bellevue transload location was used to transload ten 82-ton NUHOMS horizontal storage modules from railcars to 6-axle Goldhofer trailers using a 550-ton crane. Figure 2-214 shows horizontal storage modules on railcars and Figure 2-215 shows a horizontal storage module on a heavy haul truck being moved from Bellevue to the Kewaunee site.

Figure 2-216 shows an aerial view of a potential transload location at Denmark, Wisconsin, and Figure 2-217 shows a potential heavy haul truck route from the Kewaunee site to the Denmark transload location. Figure 2-218 through Figure 2-221 show the current condition of the potential Denmark transload location.

Figure 2-222 shows an aerial view of a potential transload location at the junction of the Rockwood Spur and WI-310, located near Manitowoc, Wisconsin, and Figure 2-223 shows potential heavy haul truck routes from the Kewaunee site to the Rockwood Spur and WI-310 transload location. Figure 2-224 through Figure 2-227 show the current condition of the potential Rockwood Spur and WI-310 transload location. Figure 2-228 shows a traffic circle on WI-310 that a transportation cask would have to pass through to approach the transload location from the east.

Figure 2-229 shows an aerial view of a potential transload location on the Rockwood Spur near the Manitowoc, Wisconsin airport, and Figure 2-230 shows a potential heavy haul truck route from the Kewaunee site to the Rockwood Spur near the Manitowoc, Wisconsin airport. Figure 2-231 through Figure 2-233 show the current condition of this transload location.

Figure 2-234 shows an aerial view of a potential transload location in Manitowoc, Wisconsin, and Figure 2-235 shows potential heavy haul truck routes from the Kewaunee site to the Manitowoc transload location. Figure 2-236 through Figure 2-238 show the current condition of the Manitowoc transload location.

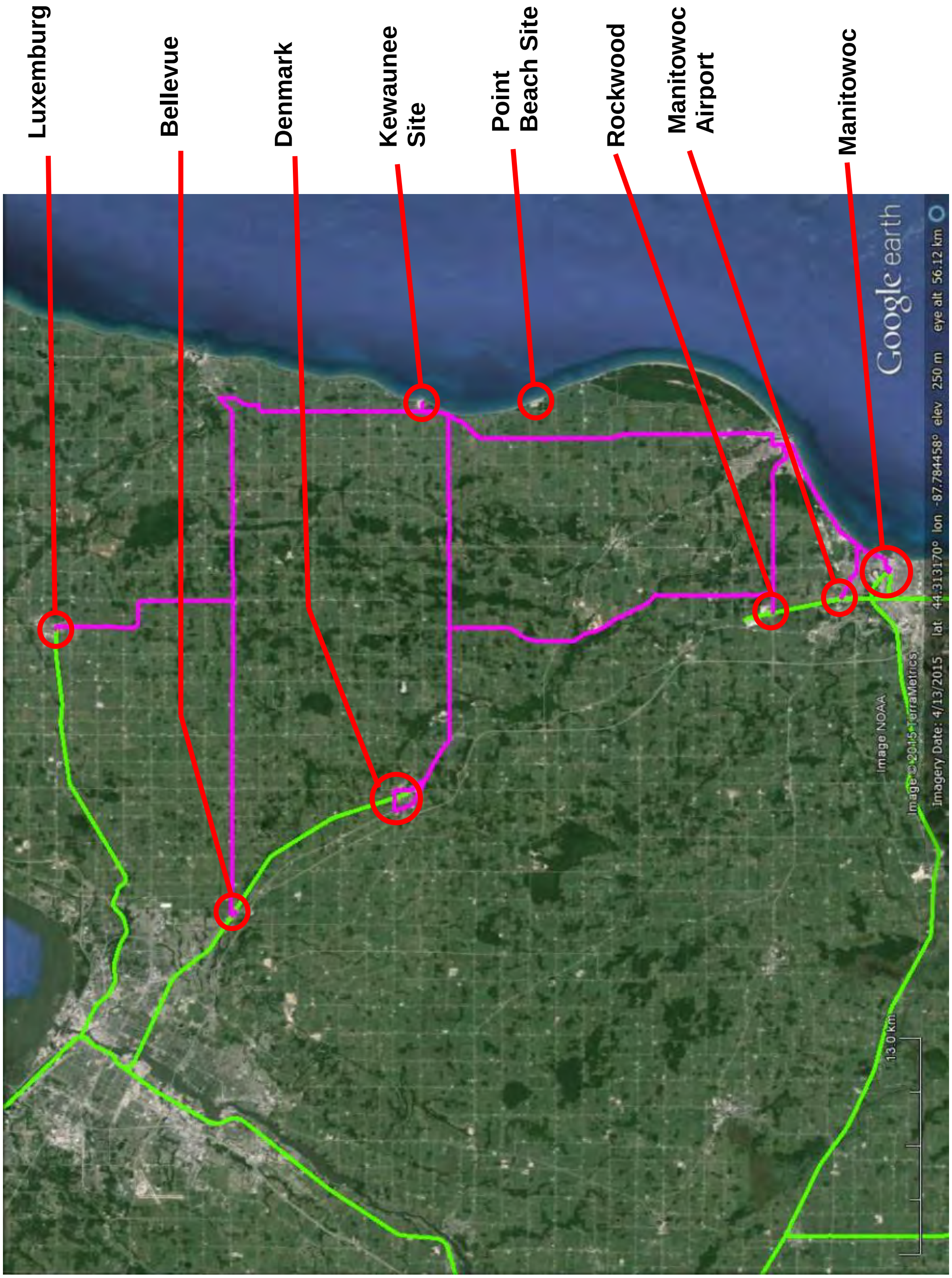


Figure 2-200. Potential Rail Transload Locations and Heavy Haul Truck Routes for the Kewaunee Site (Google 2015)

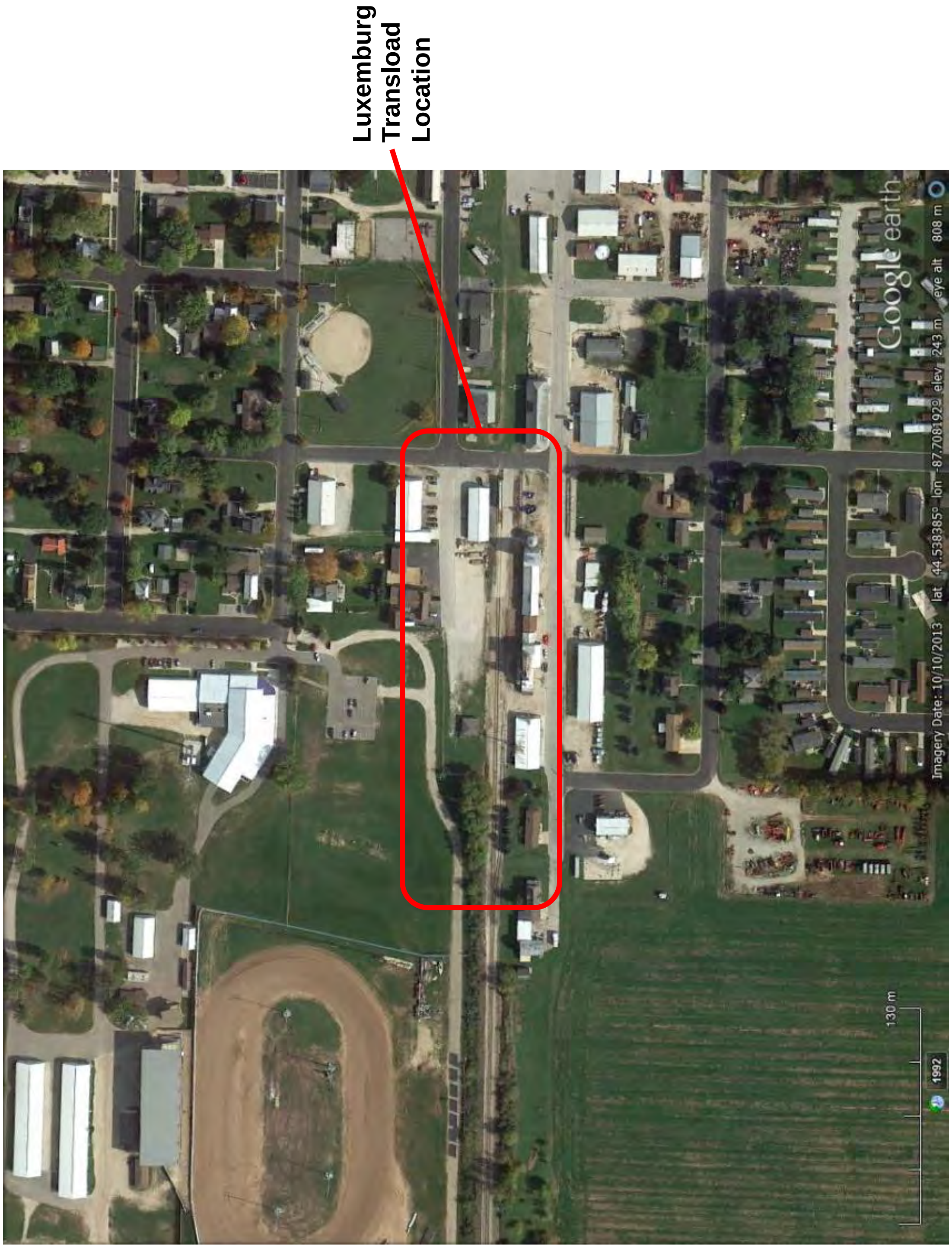


Figure 2-201. Potential Luxemburg Transload Location (Google 2015)

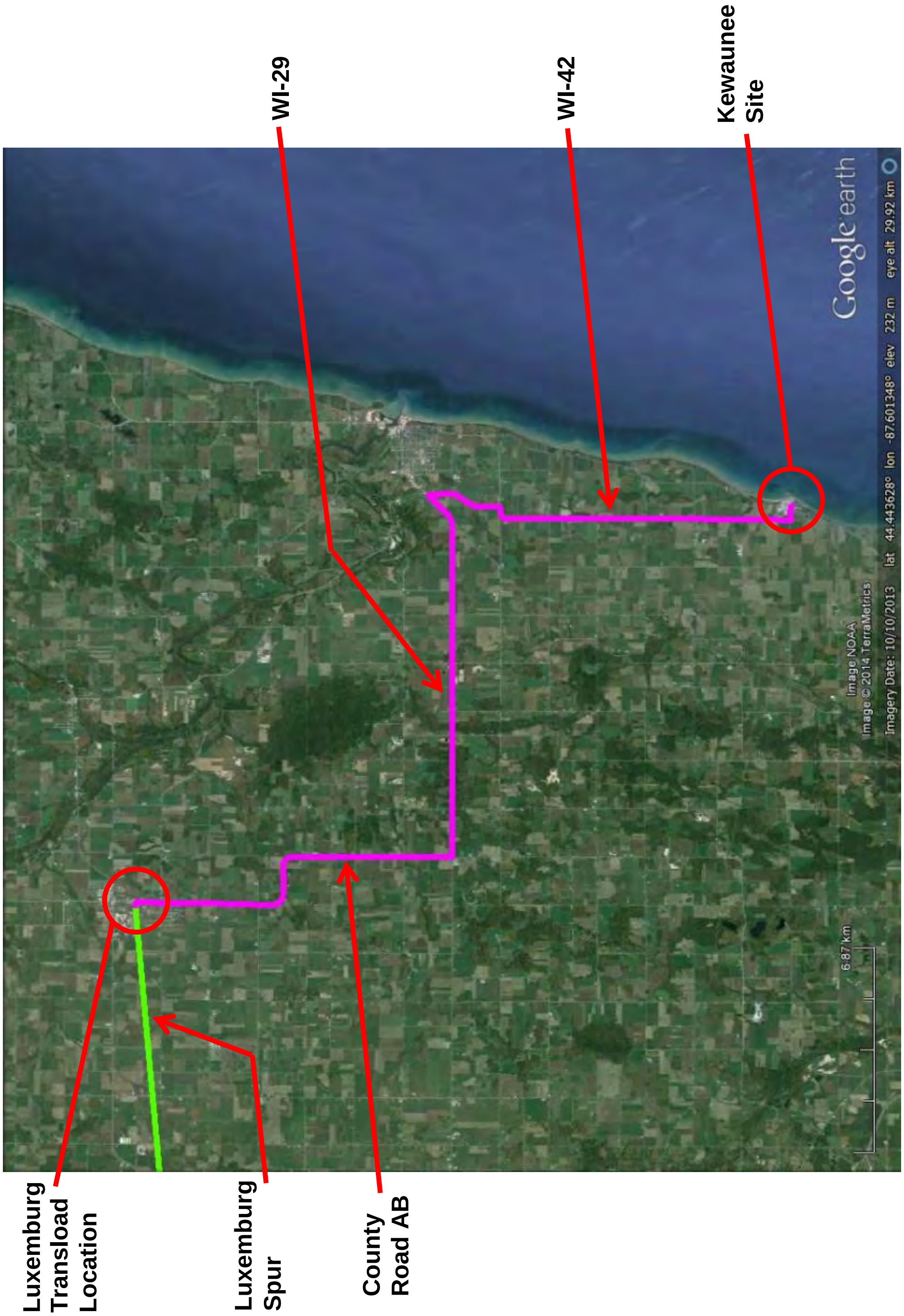


Figure 2-202. Potential Luxemburg Heavy Haul Route (Google 2015)

Figure 2-203. Potential Luxemburg Transload Location (Looking West) (2014)

Figure 2-204. Potential Luxemburg Transload Location Further Down Track (Looking West) (2014)

Figure 2-205. Potential Luxemburg Transload Location (Looking East) (2014)

Photo courtesy of Kewaunee

Figure 2-206. Gantry System Used to Transfer Transformers from Railcars to Goldhofer Trailers (2008)

Photo courtesy of Kewaunee

Figure 2-207. Transformer on 15-axle Goldhofer Trailer (2008)

Figure 2-208. Potential Bellevue Transload Location (Google 2015)

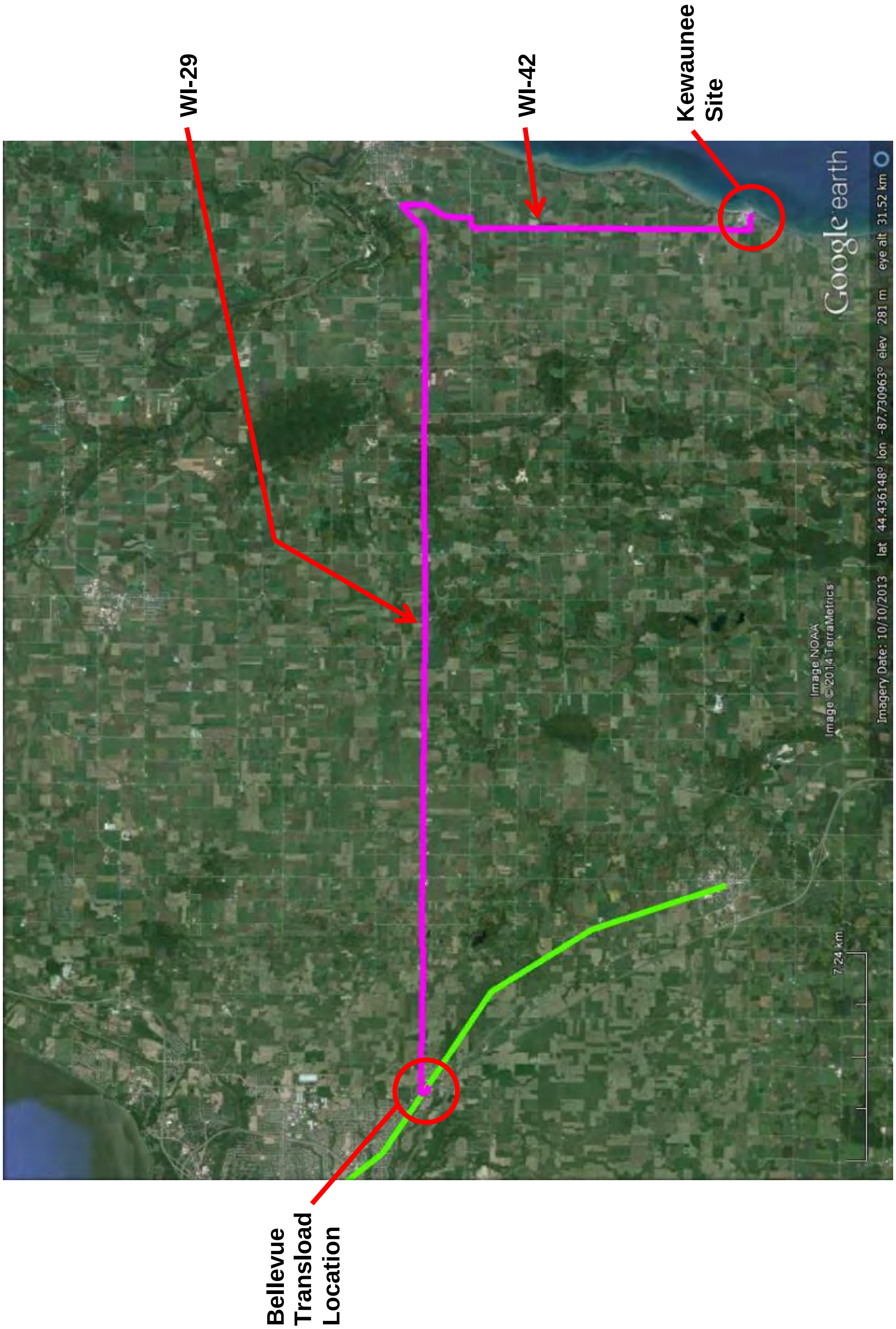


Figure 2-209. Potential Bellevue Heavy Haul Route (Google 2015)

Figure 2-210. Potential Bellevue Transload Location (Looking North) (2014)

Figure 2-211. Potential Bellevue Transload Location (Looking South) (2014)

Figure 2-212. Potential Bellevue Transload Location at WI-29 (2014)

Figure 2-213. Approaching Potential Bellevue Transload Location on WI-29 (Looking West) (2014)

Photo courtesy of Kewaunee

Figure 2-214. Horizontal Storage Module at Bellevue Transload Location (2008)

Photo courtesy of Kewaunee

Figure 2-215. Horizontal Storage Module on 6-axle Goldhofer Trailer (2008)

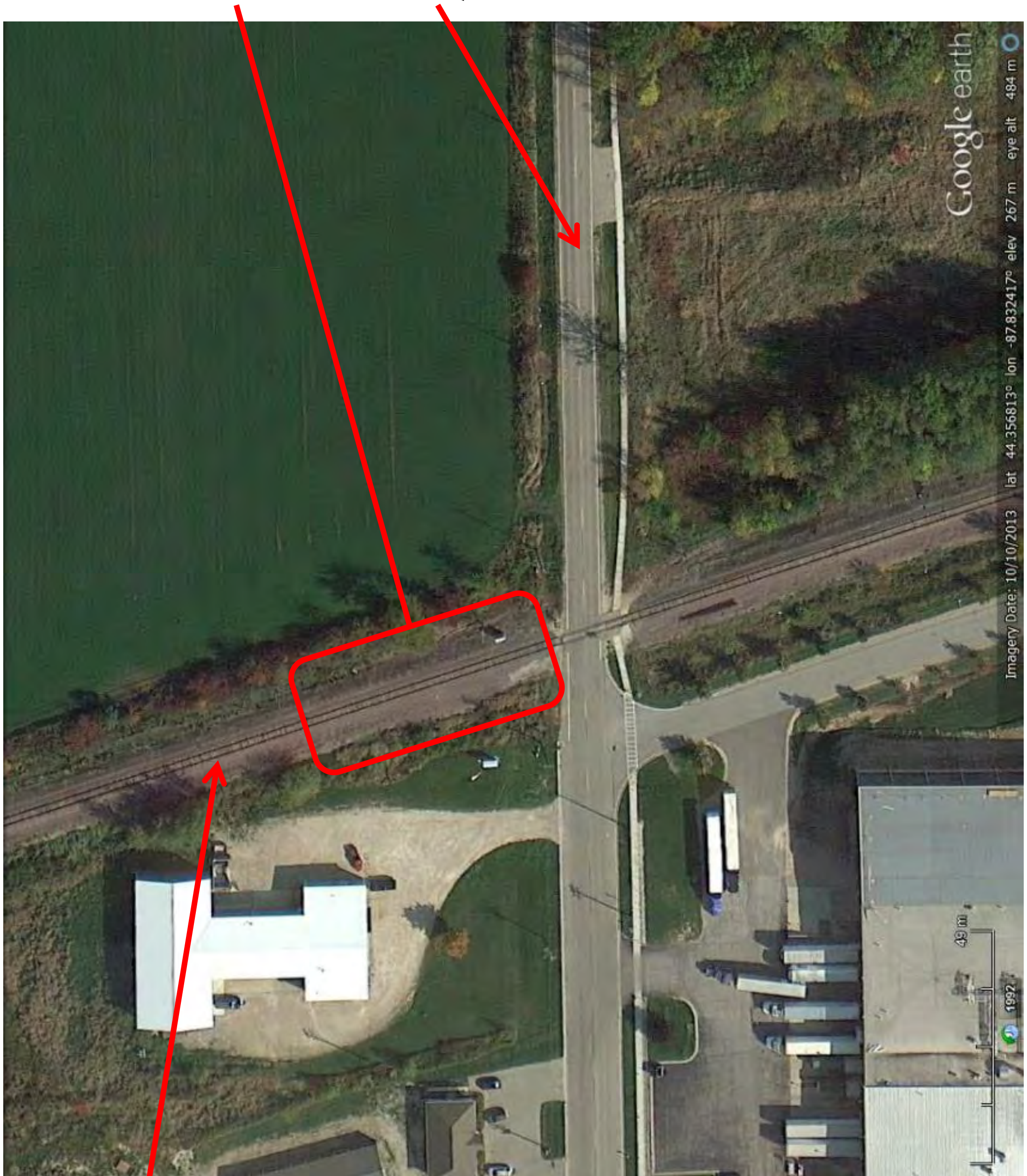


Figure 2-216. Potential Denmark Transload Location (Google 2015)

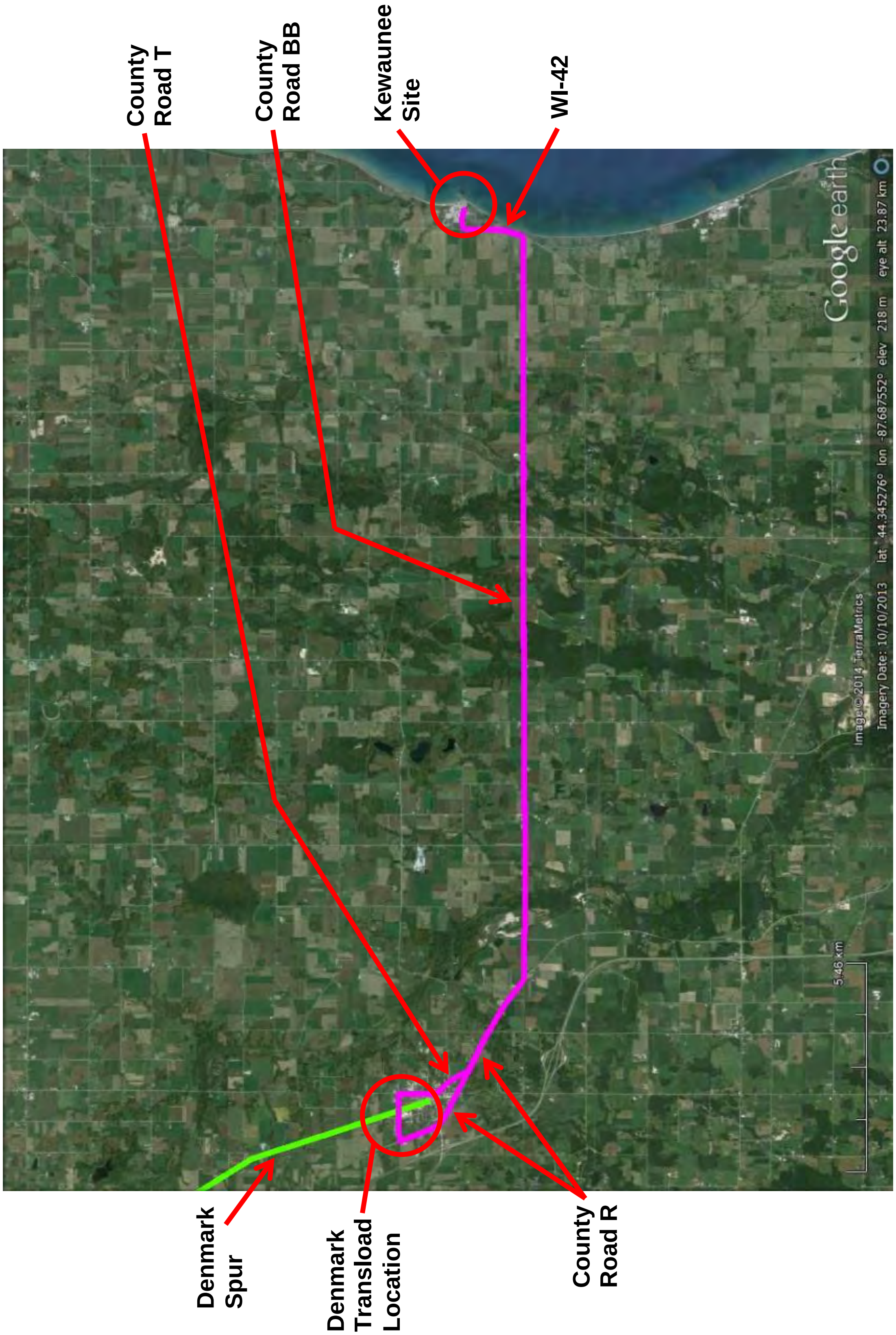


Figure 2-217. Potential Denmark Heavy Haul Route (Google 2015)

Figure 2-218. Potential Denmark Transload Location (Looking South) (2014)

Figure 2-219. Potential Denmark Transload Location (Looking North) (2014)

Figure 2-220. Potential Denmark Transload Location (Looking West) (2014)

Figure 2-221. Potential Denmark Transload Location (Looking East) (2014)

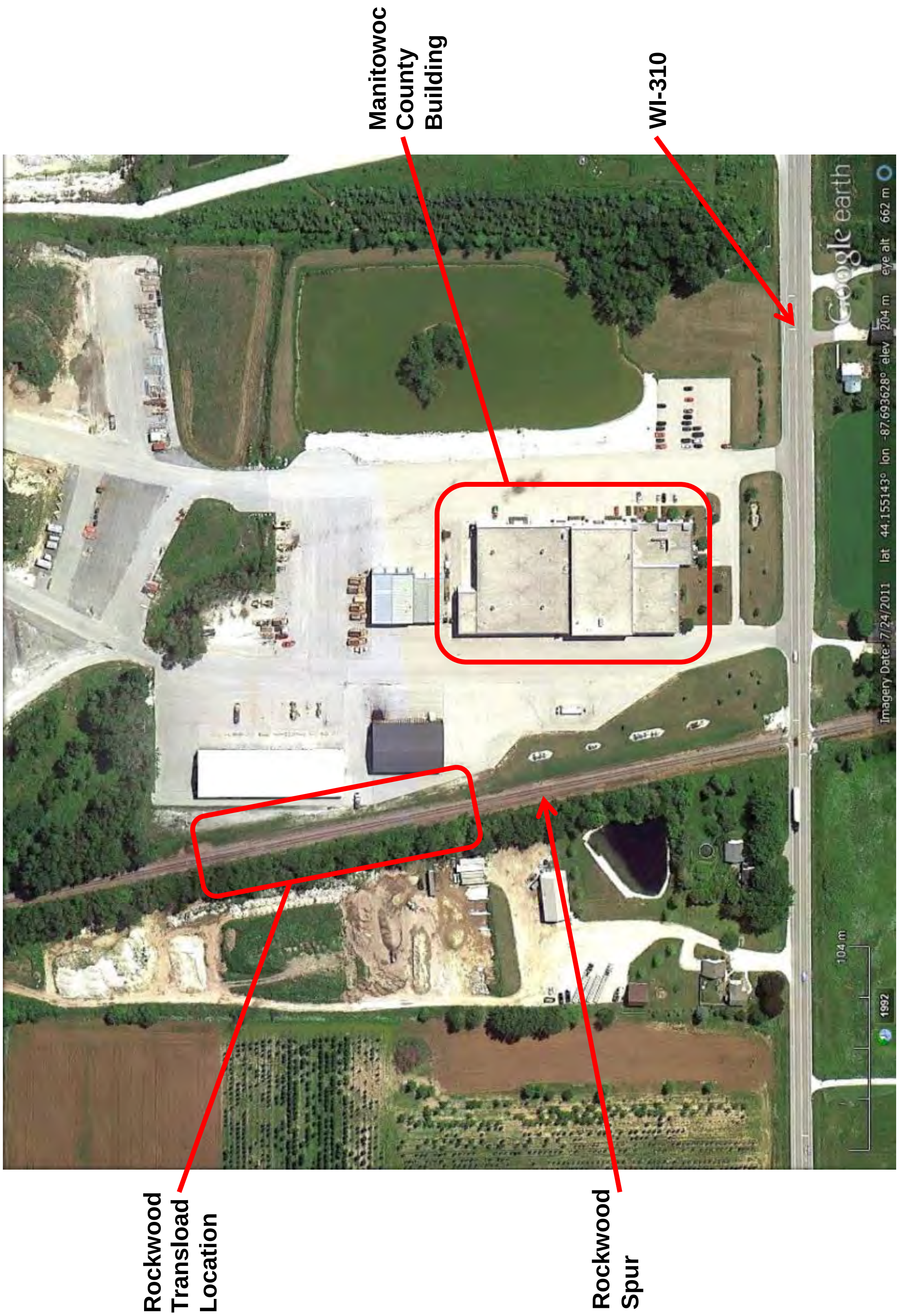


Figure 2-222. Potential Rockwood Spur at WI-310 Transload Location (Google 2015)

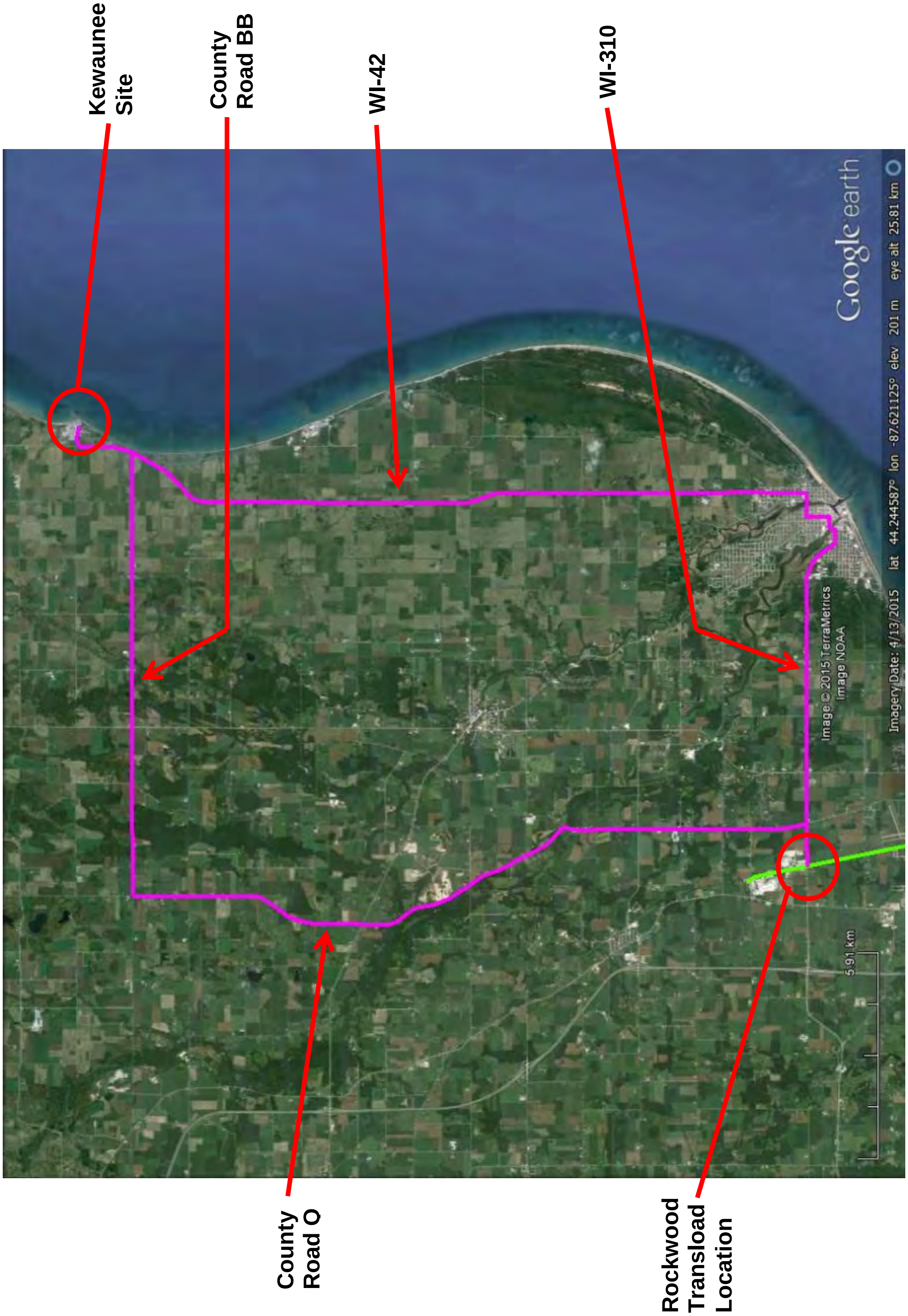


Figure 2-223. Potential Rockwood Spur at WI-310 Heavy Haul Routes (Google 2015)

Figure 2-224. Potential Rockwood Spur at WI-310 Transload Location (Looking North) (2014)

Figure 2-225. Potential Rockwood Spur at WI-310 Transload Location (Looking South) (2014)

Figure 2-226. Approaching Rockwood Spur at WI-310 from the East (2014)

Figure 2-227. Turning into Parking Lot at Rockwood Spur at WI-310 (2014)

Figure 2-228. Traffic Circle on WI-310 (Looking East) (2014)

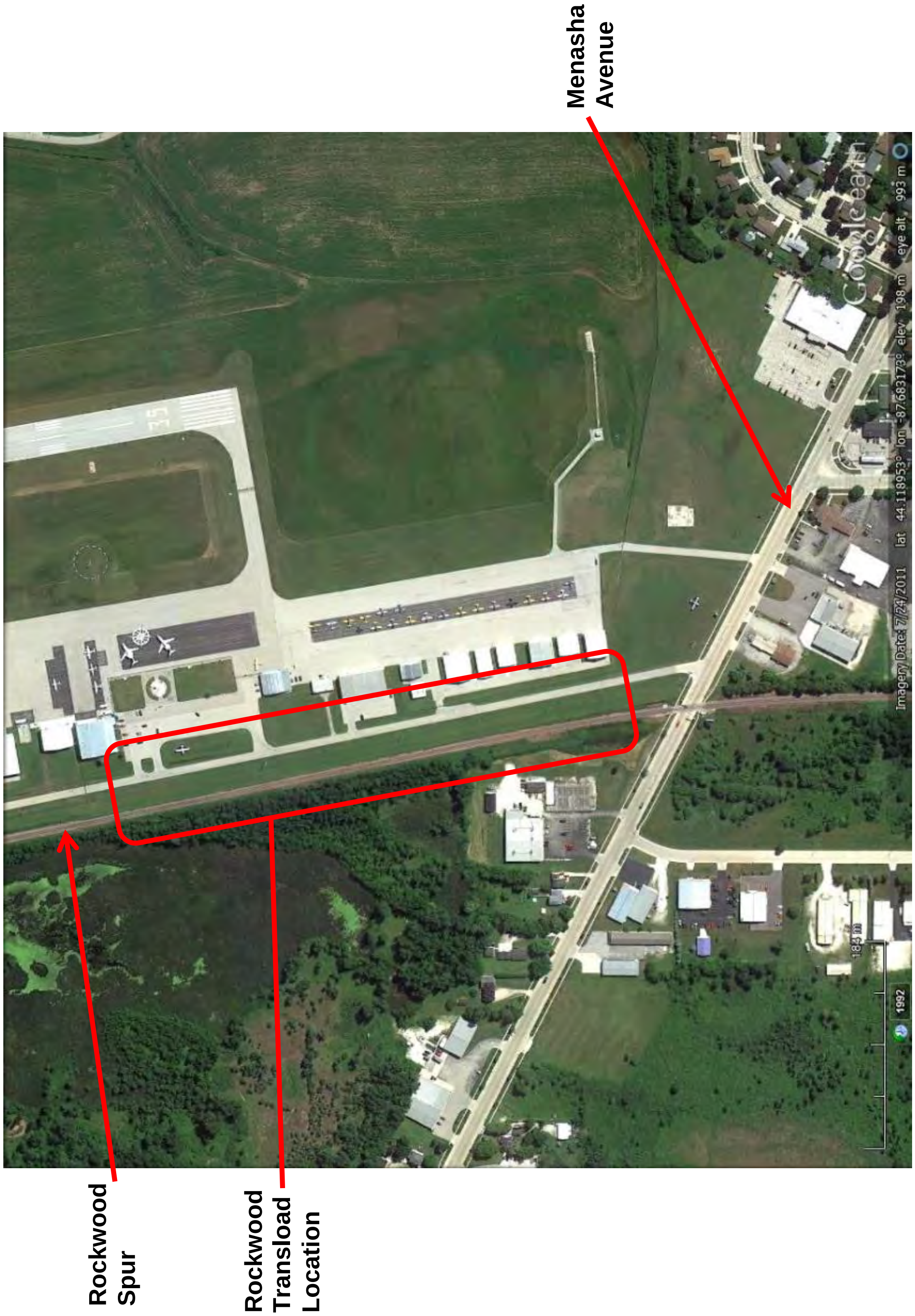


Figure 2-229. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Google 2015)

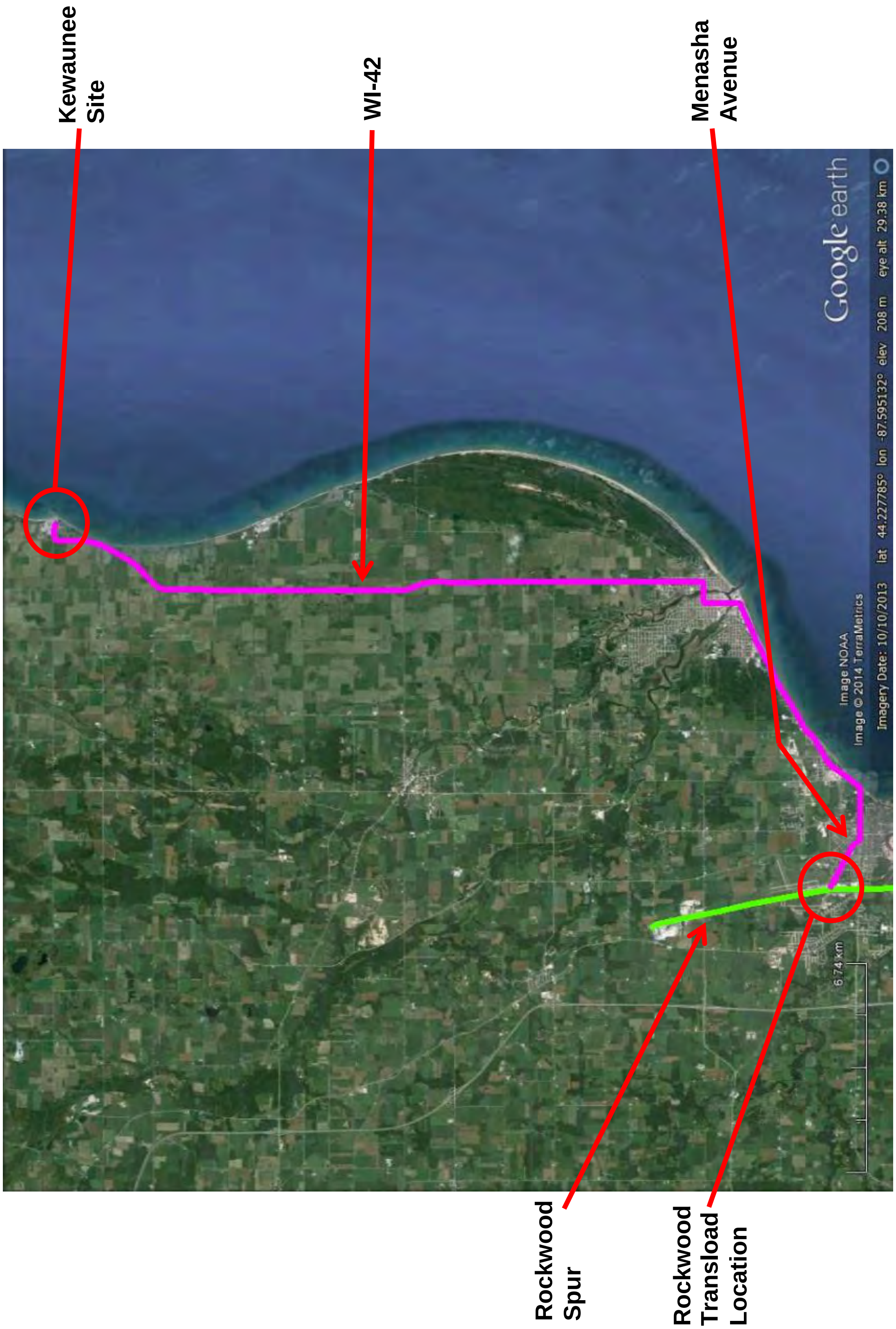


Figure 2-230. Potential Rockwood Spur at the Manitowoc Airport Heavy Haul Route (Google 2015)

Figure 2-231. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) (2014)

Figure 2-232. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking South) (2014)

Figure 2-233. Access Road at Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) (2014)

Figure 2-234. Potential Manitowoc Transload Location (Google 2015)

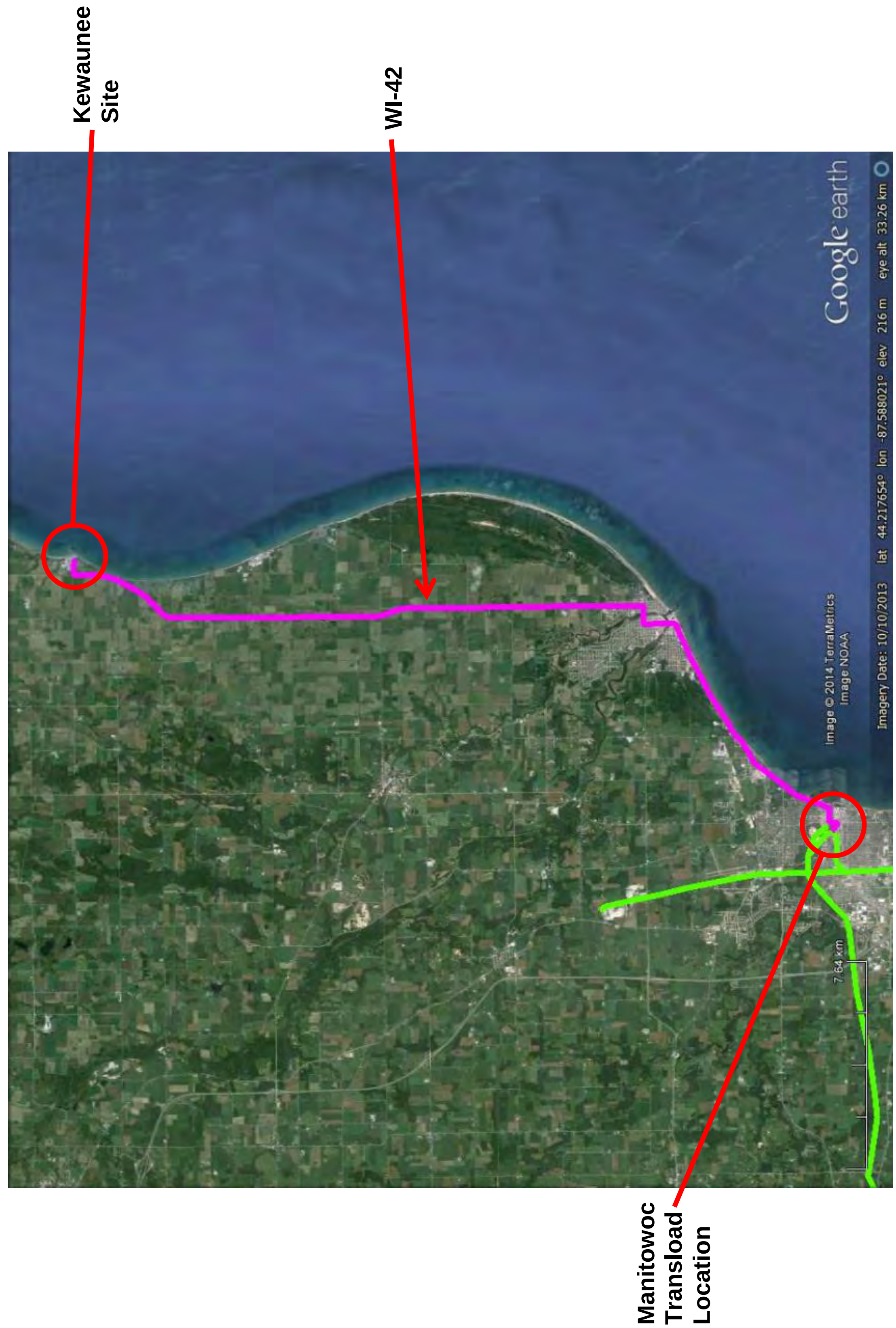


Figure 2-235. Potential Manitowoc Heavy Haul Routes (Google 2015)

Figure 2-236. Potential Manitowoc Transload Location (Looking Northwest) (2014)

Figure 2-237. Potential Manitowoc Transload Location (Looking Southeast) (2014)

Figure 2-238. Potential Manitowoc Transload Location (Looking South) (2014)

The closest barge terminal to the Kewaunee site is located in the city of Kewaunee, about 10 miles from the Kewaunee site. The city of Kewaunee is located on the west shore of Lake Michigan about 105 miles north of Milwaukee, Wisconsin and about 32 miles east of Green Bay. Kewaunee Harbor is a commercial harbor that currently serves primarily recreational boat traffic. The harbor also supports transitory barge traffic. There are approximately 6,500 feet of breakwater and pier structures and approximately 5,500 feet of maintained channel (USACE 2014).

Figure 2-239 shows an aerial view of a potential barge transload location in the city of Kewaunee. Figure 2-240 shows a potential heavy haul truck route from the Kewaunee site to the barge transload location. As with the routes to the rail access locations, this route has not been evaluated for attributes such as weight limitations, bridge or tunnel limitations, turning radii, vertical or horizontal clearances, seasonal restrictions, presence of culverts, etc. Figure 2-241 and Figure 2-242 show the current condition of the transload location.

In 2013, the Kewaunee barge transload location was used to transload ten 82-ton NUHOMS horizontal storage modules from railcars to 6-axle Goldhofer trailers using a 550-ton crane. Figure 2-243 shows horizontal storage modules being unloaded from a barge and Figure 2-244 shows a horizontal storage module on a 6-axle Goldhofer trailer.

In 2000, replacement steam generators were shipped from Milan, Italy to the Kewaunee barge transload location via the Atlantic Ocean, Saint Lawrence Seaway, and the Great Lakes. At the Kewaunee transload location, the replacement steam generators were transloaded from barge to a

14-axle transporter and moved to the Kewaunee site by road. In 2001, the old steam generators were moved from the Kewaunee site to the Kewaunee barge transload location using a 14-axle transporter, transloaded to barge and shipped to Memphis, Tennessee for decontamination via Lake Michigan, the Illinois Waterway System, and the Mississippi River. Speeds during barge transport were limited to 10 knots.

In 2014, four old steam generators from the Point Beach Nuclear Power Plant (located about 4 miles south of the Kewaunee site) were shipped to the Waste Control Specialists low-level radioactive waste disposal facility located in Andrews, Texas. The steam generators were transported from the Point Beach site using Goldhofer trailers (see Figure 2-245) and transloaded onto a barge at the Kewaunee barge transload location (see Figure 2-246 through Figure 2-249). The steam generators were transported on Lake Michigan, through Chicago, Illinois to the Mississippi River to the Intracoastal Waterway to Houston, Texas, where the steam generators were transloaded to railcars (see Figure 2-250) and transported through Texas to the Waste Control Specialists low-level radioactive waste disposal facility in Andrews, Texas (see Figure 2-251).

Heavy haul truck transport has been used to move large components to and from the Kewaunee site. For example, in 2004, the replacement Kewaunee site reactor pressure vessel head was shipped from Houston, Texas to the Kewaunee site using a heavy haul truck (see Figure 2-252), and the old Kewaunee site reactor pressure vessel head was shipped to Clive, Utah for disposal using a heavy haul truck (see Figure 2-253).

Figure 2-239. Aerial View of Potential Kewaunee Barge Transload Location (Google 2015)

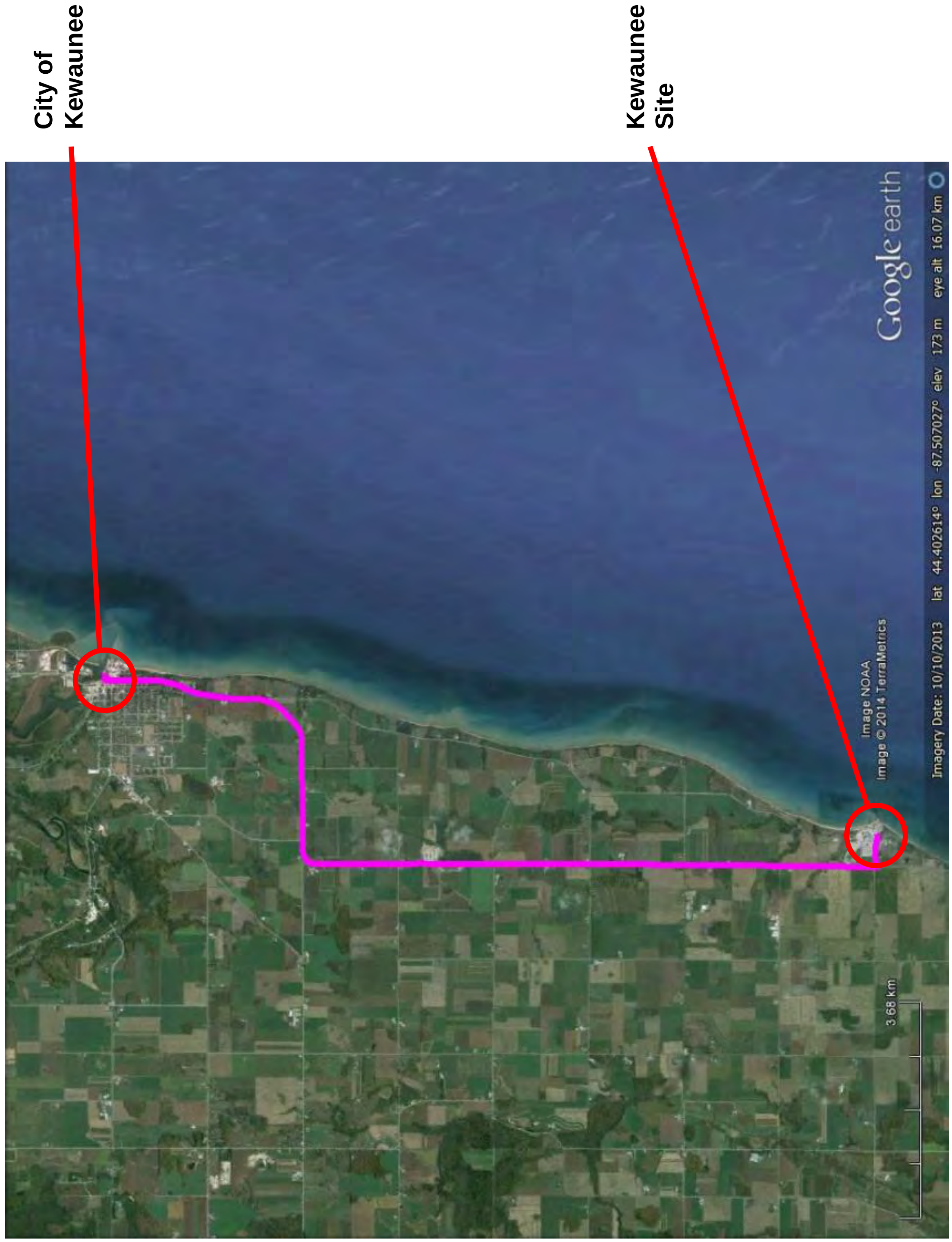


Figure 2-240. Potential Heavy Haul Truck Route to City Of Kewaunee Dock Facilities (Google 2015)

Figure 2-241. Potential Kewaunee Barge Transload Location Parking Lot (2014)

Figure 2-242. Potential Kewaunee Barge Transload Location Water Front (2014)

Photo courtesy of Kewaunee

Figure 2-243. Horizontal Storage Modules Being Unloaded from a Barge (2013)

Photo courtesy of Kewaunee

Figure 2-244. Horizontal Storage Module on 6-axle Goldhofer Trailer (2013)

Photo courtesy of Point Beach

Figure 2-245. Steam Generator on Goldhofer Trailer (2014)

Photo courtesy of Point Beach

Figure 2-246. First Steam Generator on Goldhofer Trailer Moving onto Barge (2014)

Photo courtesy of Point Beach

Figure 2-247. Barge with Two Steam Generators at Kewaunee Barge Transload Location (2014)

Photo courtesy of Point Beach

Figure 2-248. Fourth Steam Generator Moving onto Barge (2014)

Photo courtesy of Point Beach

Figure 2-249. Barge with Four Steam Generators at Kewaunee Barge Transload Location (2014)

Photo courtesy of Point Beach

Figure 2-250. Transloading of Steam Generator from Barge to Railcar in Houston, Texas (2014)

Photo courtesy of Point Beach

Figure 2-251. Steam Generators Arriving at Waste Control Specialists Low-Level Radioactive Waste Disposal Facility (2014)

Photo courtesy of Kewaunee

Figure 2-252. Replacement Reactor Pressure Vessel Head on Heavy Haul Truck (2004)

Photo courtesy of Kewaunee

Figure 2-253. Old Reactor Pressure Vessel Head on Heavy Haul Truck (2004)

2.11.4 Gaps in Information

The Kewaunee site does not have direct rail access or an on-site barge facility. Off-site shipment of transportation casks from the Kewaunee site would require either the use of heavy haul trucks for transport of casks to nearby rail sidings or spurs, or the use of heavy haul trucks for transport of casks to a nearby barge facility, likely followed by barge transport to a port on the Great Lakes that is served by a railroad. Potential nearby rail transload locations include Luxemburg, Bellevue, Denmark, Rockwood, and Manitowoc, Wisconsin; these locations are 16.7 to 27.9 miles from the Kewaunee site. At Luxemburg, the track is built using 80 lb. rail, while at Bellevue, Denmark, and Rockwood, the track is built using 110 to 115 lb. rail. The track at these locations is track class 1. Canadian National Railroad staff stated that to rehabilitate the track to track class 2 would require replacing every third or fourth tie at a cost of about $90,000 per mile. At Manitowoc, the track is track class 2.

The city of Kewaunee dock facilities are located 10 miles from the Kewaunee site. The roads to these rail or barge locations have not been evaluated for attributes such as weight limitations, bridge or tunnel limitations, turning radii, vertical or horizontal clearances, seasonal restrictions, presence of culverts, etc.

High burnup (> 45 GWd/MTHM) used nuclear fuel is not stored in 32PT canisters so the certificate of compliance for the MP197HB transportation cask would not have to be revised before transport of 32PT canisters. However, the application for a certificate of compliance for the MAGNATRAN transportation cask is currently under review by the NRC and has not been issued.

2.12 San Onofre

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the San Onofre site. The San Onofre site is located on California's Pacific coast, about 70 miles southeast of Los Angeles and about 60 miles northwest of San Diego, near the town of San Clemente, California (TOPO 1993f, 1994e; Google 2015).

2.12.1 Site Inventory

San Onofre Unit 1 (San Onofre-1) ceased operation in 1992 and San Onofre Units 2 and 3 (San Onofre-2 and -3) ceased operation on June 7, 2013 (Dietrich 2013a), although the reactors did not operate after January 2012. The final removal of used nuclear fuel from the San Onofre-2 reactor vessel was completed on July 18, 2013 (Dietrich 2013b). Final removal of used nuclear fuel from the San Onofre-3 reactor vessel was completed on October 5, 2012 (Dietrich 2013c).

For used nuclear fuel already in dry storage, San Onofre has used the Standardized Advanced NUHOMS System (Docket No. 72-1029). This system consists of transportable dry shielded canisters, reinforced concrete horizontal storage modules, and a transfer cask. The specific dry shielded canisters that have been used at San Onofre are the 24PT1 and 24PT4, which each hold 24 pressurized water reactor used nuclear fuel assemblies.

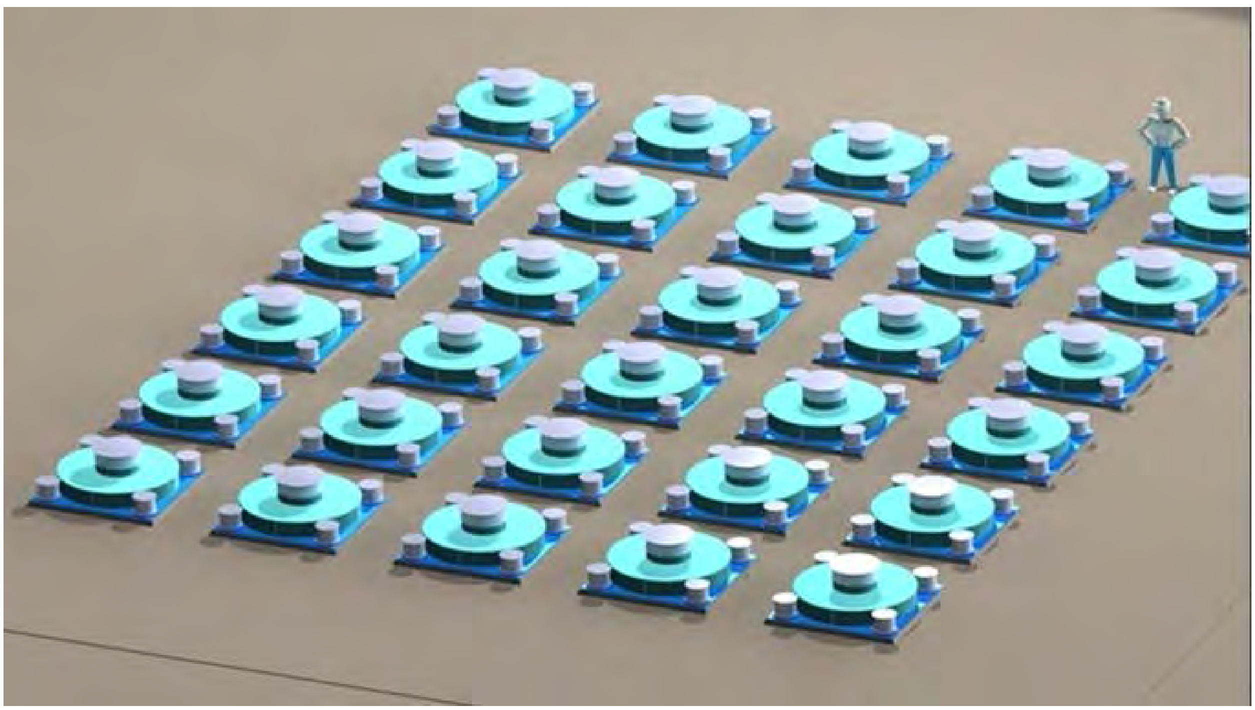
San Onofre has announced that the HI-STORM UMAX System (Docket No. 72-1040) will be used for future dry storage of used nuclear fuel. This system consists of transportable multipurpose canisters, which contain the fuel; underground vertical ventilated modules, which contain the multipurpose canisters during storage; and a transfer cask (HI-TRAC VW), which contains the multipurpose canister during loading, unloading and transfer operations. The multipurpose canister (MPC-37) stores up to 37 pressurized water reactor used nuclear fuel assemblies. An application for a certificate of compliance for the HI-STAR 190 transportation cask (Docket No. 71-9373) that would be used to transport the MPC-37 multipurpose canister has been submitted to the NRC (Manzione 2015). Figure 2-254 shows a representation of the San Onofre HI-STORM UMAX ISFSI and Figure 2-255 shows a cutaway view of the HI-STORM UMAX dry storage system.

At the San Onofre site, there are also 12 additional unused 24PT4 dry shielded canisters and 12 reinforced concrete horizontal storage modules, and in the future there will be up to six 32PTH2 unused dry shielded canisters and eight additional reinforced concrete horizontal storage modules at the site. The 32PTH2 canister is not certified for use in transportation. Figure 2-256 through Figure 2-259 show 24PT4 and 32PTH2 dry storage canisters, a transfer cask, and horizontal storage modules, respectively. The San Onofre site has not decided whether to use these unused canisters for storage of used nuclear fuel or GTCC low-level radioactive waste.

There are 395 pressurized water reactor used nuclear fuel assemblies in 17 24PT1 dry shielded canisters from San Onofre-1 in dry storage at the San Onofre site. Four of these assemblies (D049, D050, D051, and D052) are mixed oxide used nuclear fuel assemblies. There is also one

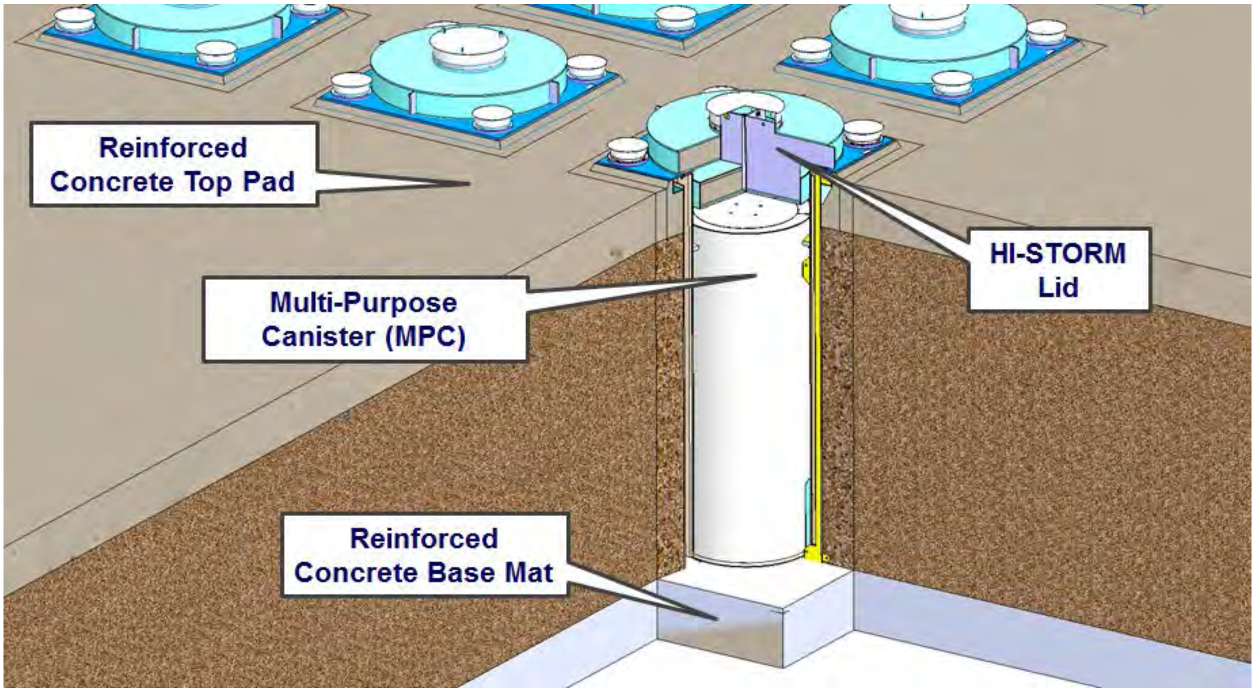
24PT1 dry shielded canister containing GTCC low-level radioactive waste from the segmentation of reactor vessel internals during the decommissioning of San Onofre-1 stored at the San Onofre site. It was initially estimated that two canisters would be required; however, due to packaging efficiencies, only one canister was required (EPRI 2005, 2008b).

The MP187 transportation cask (Docket No. 71-9255) is certified to ship used nuclear fuel in the 24PT1 canister. However, the MP187 transportation cask is not certified for the transport of GTCC low-level radioactive waste. As discussed in Section 2.6.1, a single MP187 transportation cask is stored at the Rancho Seco site, but impact limiters would need to be fabricated before this MP187 transportation cask could be used to ship used nuclear fuel or GTCC low-level radioactive waste. A -96 designation must be obtained before impact limiters are fabricated for the existing MP187 transportation cask. A -96 designation must also be obtained before the MP187 transportation cask is certified for the transport of GTCC low-level radioactive waste. The effort to accomplish these changes and to obtain NRC review and approval is estimated to range from one to three years. It may also be possible to transport the 24PT1 canister containing GTCC low-level radioactive waste using the MP197HB transportation cask.



Graphic courtesy of Holtec International

Figure 2-254. Representation of the San Onofre HI-STORM UMAX Independent Spent Fuel Storage Installation



Graphic courtesy of Holtec International

Figure 2-255. Cutaway View of the HI-STORM UMAX Dry Storage System

Photo courtesy of San Onofre

Figure 2-256. 24PT4 Dry Storage Canisters

Figure 2-257. 32PTH2 Dry Storage Canisters (On Left) (2015)

Figure 2-258. Transfer Cask for 32PTH2 Canisters (2015)

Figure 2-259. Horizontal Storage Modules (2015)

There are also 792 pressurized water reactor used nuclear fuel assemblies in 33 24PT4 dry shielded canisters from San Onofre-2 and -3 stored at the San Onofre site. The MP197HB transportation cask (Docket No. 71-9302) is certified to ship used nuclear fuel in the 24PT4 canister. The MP197HB is also certified to ship GTCC low-level radioactive waste. An MP197HB transportation cask is being fabricated in Japan (Vanderniet 2012). Fabrication is expected to be completed in 2015.

The fuel rods in the 395 used nuclear fuel assemblies (146.2 MTHM) from San Onofre-1 stored at the San Onofre site are stainless steel-clad. There are also an additional 270 stainless steel-clad used nuclear fuel assemblies from San Onofre-1 that are stored at the Morris, Illinois ISFSI. Figure 2-260 illustrates the number of used nuclear fuel assemblies from San Onofre-1 stored at the San Onofre site, based on their discharge year. The oldest fuel was discharged in 1971 and the last fuel was discharged in 1992. The median discharge year of the fuel is 1988.

Figure 2-261 illustrates the number of used nuclear fuel assemblies from San Onofre-1 stored at the San Onofre site based on their burnup. The lowest burnup is 6.8 GWd/MTHM and the highest burnup is 39.3 GWd/MTHM. The median burnup is 30.0 GWd/MTHM. No high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) from San Onofre-1 is stored at the San Onofre site.

There are a total of 3460 used nuclear fuel assemblies (1462.6 MTHM) from San Onofre-2 and -3 stored at the San Onofre site.[28] This total includes the 792 assemblies (330.4 MTHM) in dry storage and 2668 assemblies (1132.2 MTHM) stored in the spent fuel pools at the San Onofre site. The fuel rods in these fuel assemblies are zirconium alloy-clad. There is also one rod storage basket containing rods from reconstituted fuel assemblies in each San Onofre -2 and -3 spent fuel pool. The 2668 used nuclear fuel assemblies in the spent fuel pools do not include 108 fuel assemblies that were inserted into the San Onofre-2 reactor but that were not made critical. These assemblies were transported off-site to a fuel fabricator for uranium recovery.

As mentioned previously, the San Onofre site has not decided whether to use the unused 24PT4 or 32PTH2 canisters for storage of used nuclear fuel or GTCC low-level radioactive waste. If these canisters are not used, 73 MPC-37 canisters would be required to store the 2668 assemblies that are currently stored in the spent fuel pools at the San Onofre site. If these canisters are used, a maximum of 79 canisters would be required to store the 2668 assemblies. The San Onofre site also estimates that 10 canisters would be required to store the GTCC low-level radioactive waste from decommissioning of San Onofre-2 and -3. A total of 123 to 129 canisters containing used nuclear fuel from San Onofre-1, -2, and -3, and 11 canisters containing GTCC low-level radioactive waste would be required to store the entire inventory of used nuclear fuel and GTCC low-level radioactive waste at the San Onofre site.

High burnup used nuclear fuel stored in 24PT4 canisters at San Onofre would be transportable in the MP197HB transportation cask; as mentioned previously, an application for a certificate of compliance for the HI-STAR 190 that would be used to transport the MPC-37 canisters has been submitted to the NRC (Manzione 2015). If used for storage of used nuclear fuel or GTCC low-level radioactive waste, the 32PTH2 canisters would not be transportable without changes to the list of approved contents in the certificate of compliance for the MP197HB transportation cask.

There are 94 damaged used nuclear fuel assemblies from San Onofre-1, -2, and -3 in dry storage. There are 27 assemblies from San Onofre-1 stored in 9 canisters, 46 assemblies from San Onofre-2 stored in 4 canisters, and 21 assemblies from San Onofre-3 stored in 2 canisters. These assemblies are packaged in damaged fuel cans. There are also 15 damaged assemblies from San Onofre-2 and 16 suspect or damaged assemblies from San Onofre-3 stored in the spent fuel pools.

Figure 2-262 illustrates the number of used nuclear fuel assemblies from San Onofre-2 and -3, based on their discharge year. The oldest fuel was discharged in 1984 and the last fuel was discharged in 2012. The median discharge year of the fuel is 1999.

Figure 2-263 illustrates the number of used nuclear fuel assemblies from San Onofre-2 and -3 based on their burnup. The lowest burnup is 9.3 GWd/MTHM and the highest burnup is 55.1 GWd/MTHM. The median burnup is 40.7 GWd/MTHM. There are 1123 used nuclear fuel assemblies from San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. These 1123 fuel assemblies are classified by the NRC as high burnup used nuclear fuel.

[28] Granaas R. 2013. Email messages from R Granaas (San Onofre Nuclear Generating Station) to SJ Maheras (Pacific Northwest National Laboratory), "RE: san onofre sections of draft shutdown sites report," September 11-24, 2013.

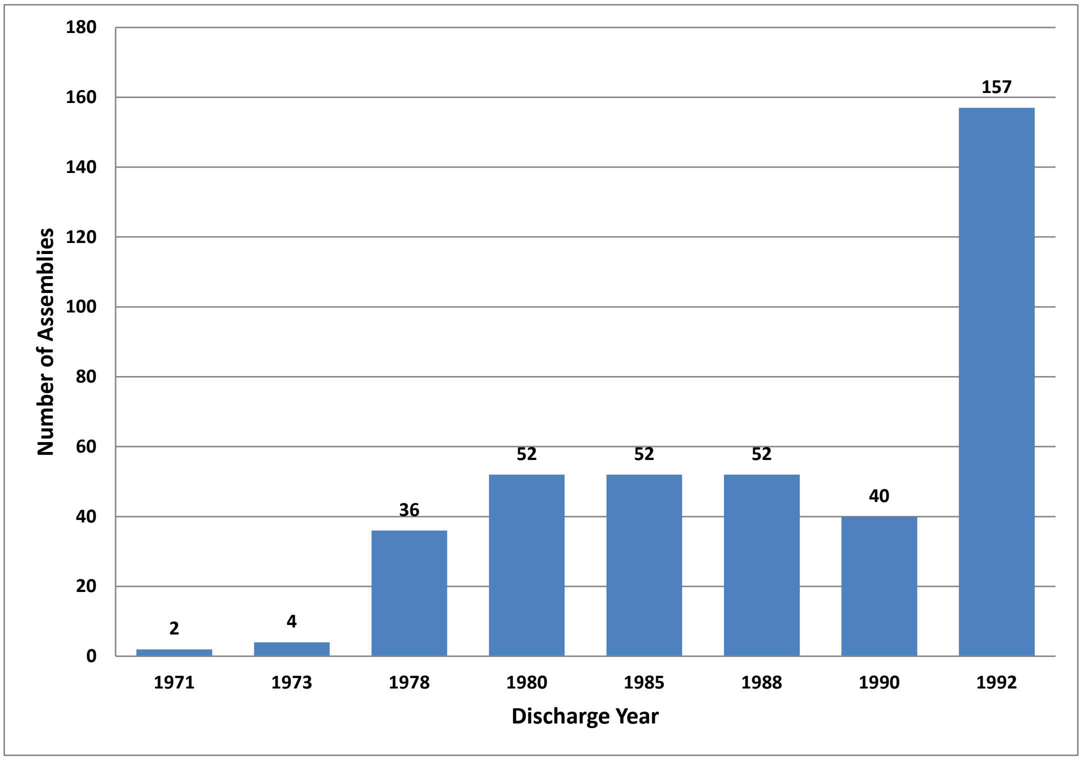


Figure 2-260. San Onofre-1 Number of Onsite Assemblies versus Discharge Year (EIA 2002)

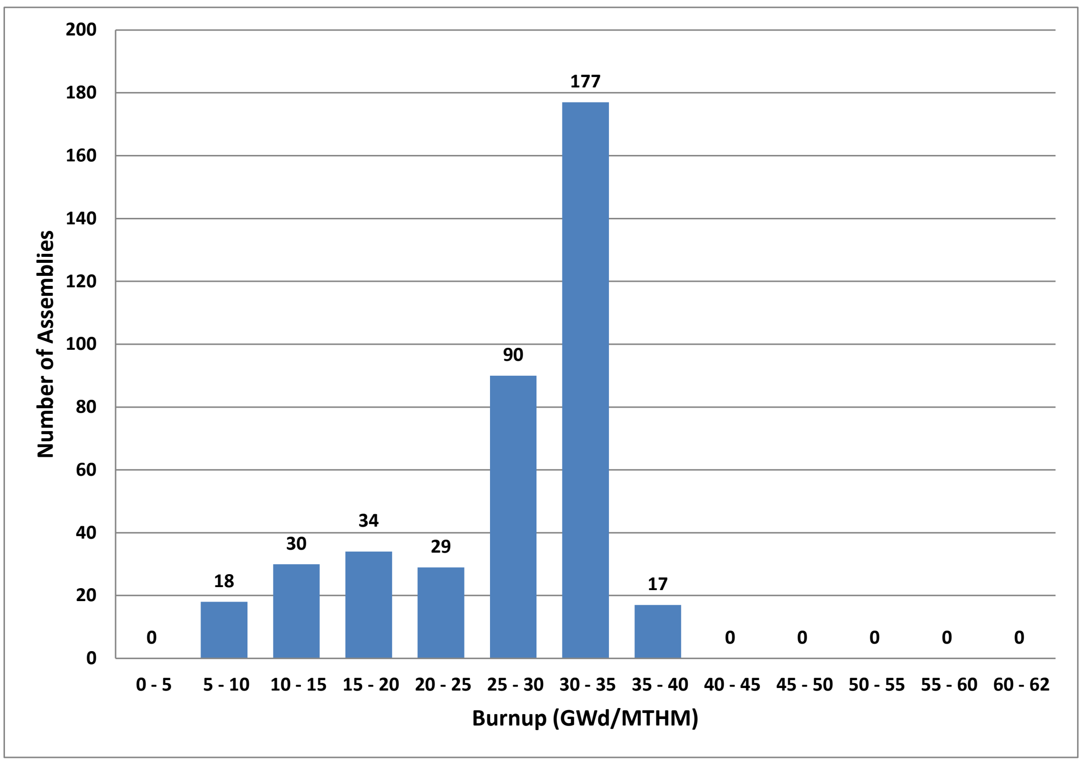


Figure 2-261. San Onofre-1 Number of Onsite Assemblies versus Burnup (EIA 2002)

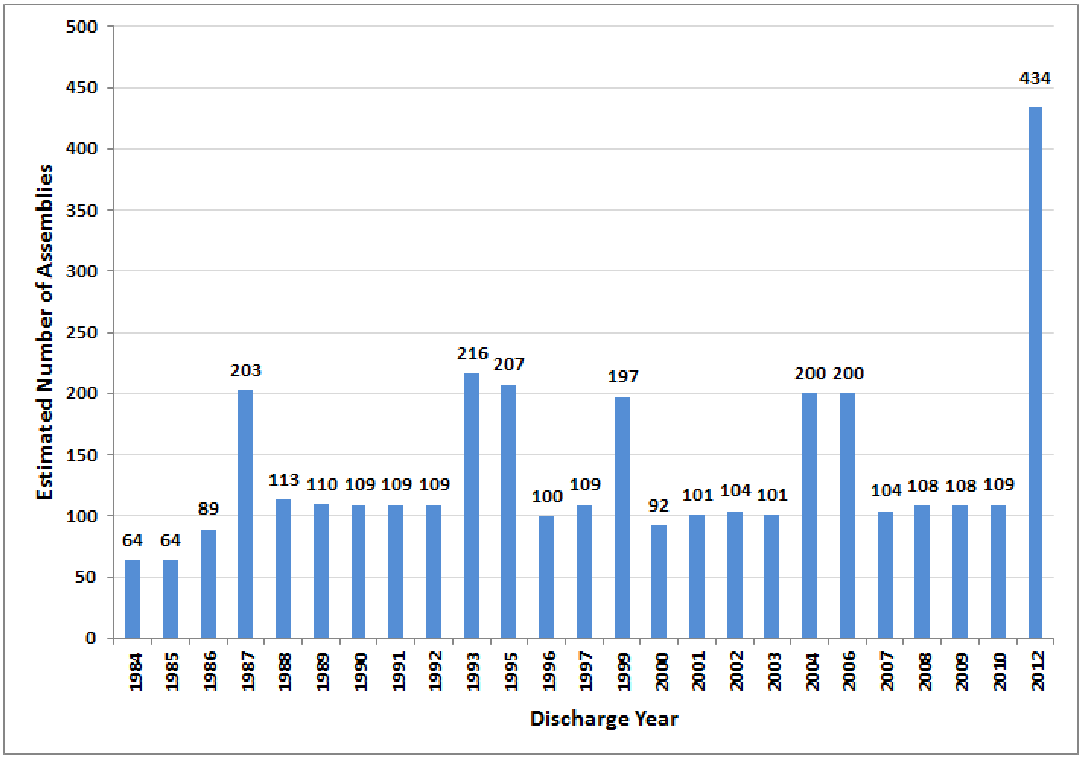


Figure 2-262. San Onofre-2 and -3 Number of Assemblies versus Discharge Year

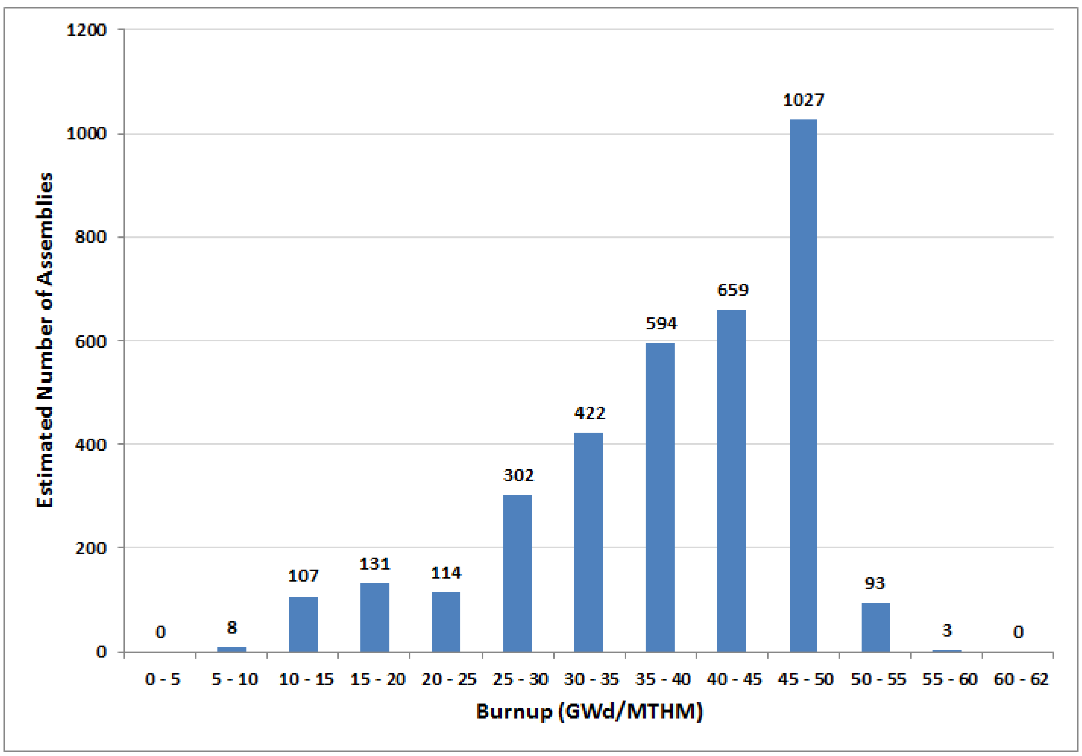


Figure 2-263. San Onofre-2 and -3 Number of Assemblies versus Burnup

As mentioned previously, there are 792 used nuclear fuel assemblies from San Onofre-2 and -3 stored in 33 dry storage canisters. Figure 2-264 and Figure 2-265 illustrate the number of canistered fuel assemblies based on their discharge year and burnup. The oldest canistered fuel was discharged in 1984 and the last fuel was discharged in 2004. The median discharge year of the canistered fuel is 1993. The lowest burnup is 11.1 GWd/MTHM and the highest burnup is 48.0 GWd/MTHM. The median burnup is 34.2 GWd/MTHM. There are 8 canistered fuel assemblies from San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. These 8 assemblies are not packaged in damaged fuel cans.

Figure 2-266 and Figure 2-267 illustrate the number of fuel assemblies based on their discharge year and burnup for the 2668 uncanistered fuel assemblies from San Onofre-2 and -3. The oldest uncanistered fuel was discharged in 1984 and the last fuel was discharged in 2012. The median discharge year of the uncanistered fuel is 2002. The lowest burnup is 9.3 GWd/MTHM and the highest burnup is 55.1 GWd/MTHM. The median burnup is 43.1 GWd/MTHM. There are 1115 uncanistered fuel assemblies from San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. The San Onofre site has not decided whether these assemblies will be packaged in damaged fuel cans.

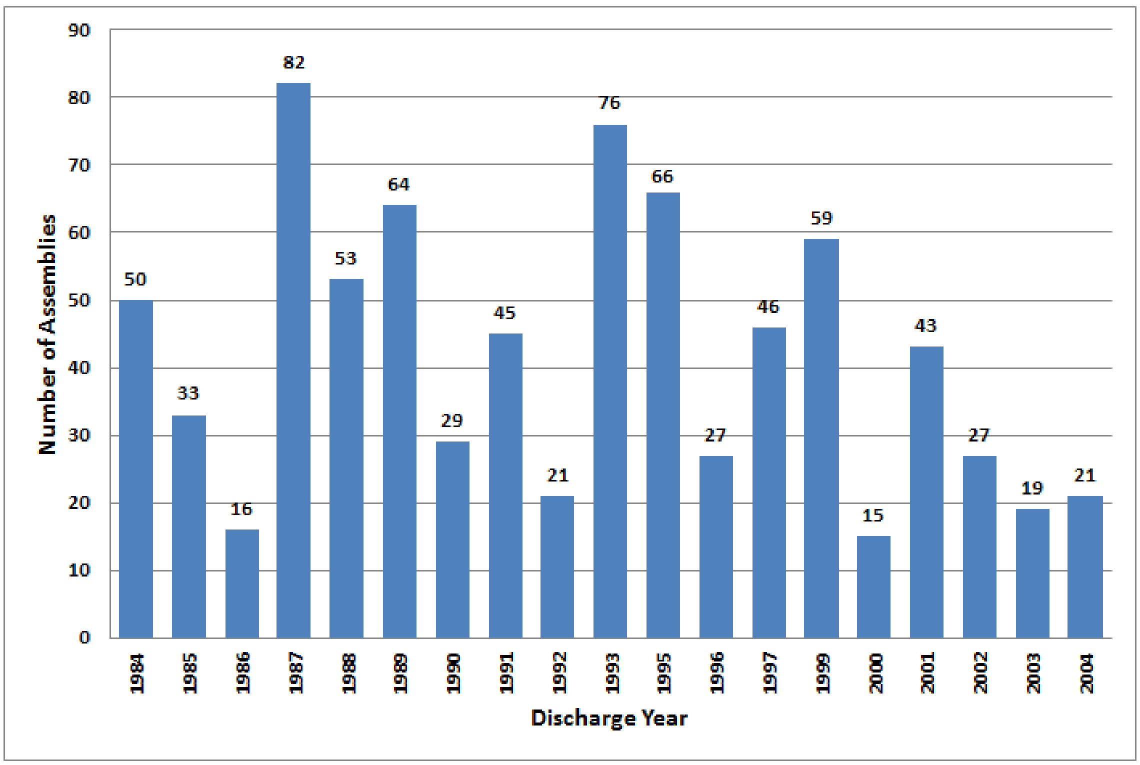


Figure 2-264. San Onofre-2 and -3 Number of Canistered Assemblies versus Discharge Year

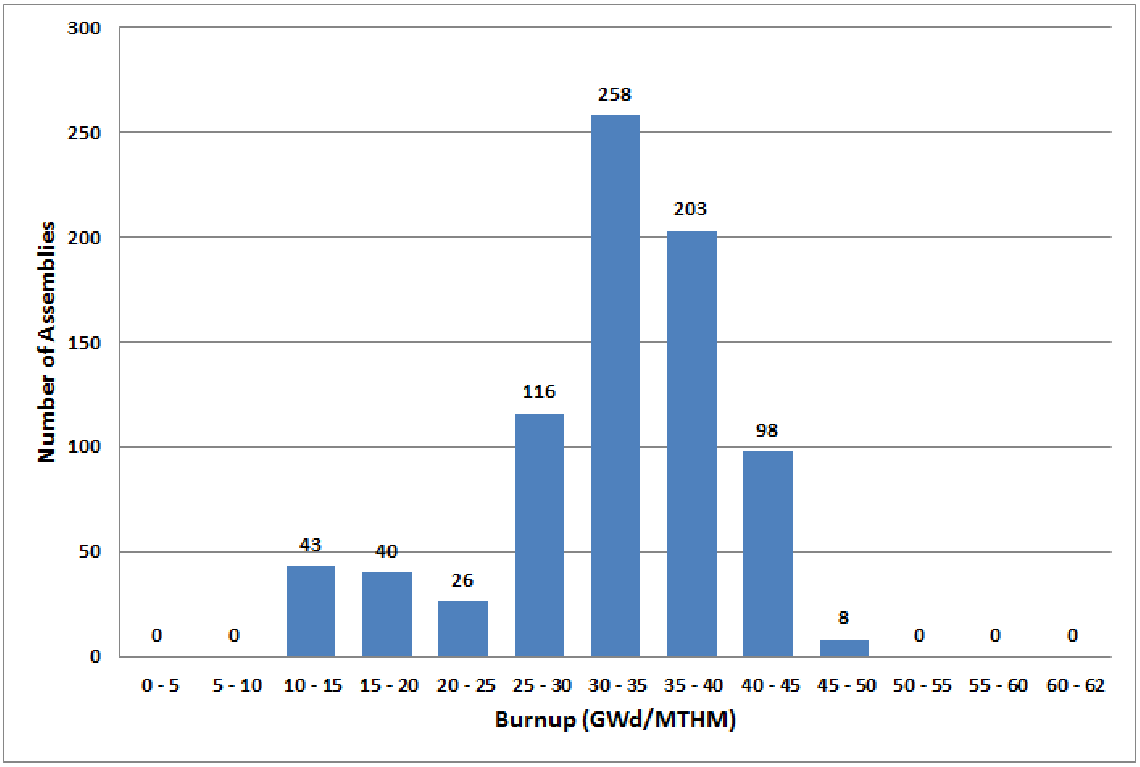


Figure 2-265. San Onofre-2 and -3 Number of Canistered Assemblies versus Burnup

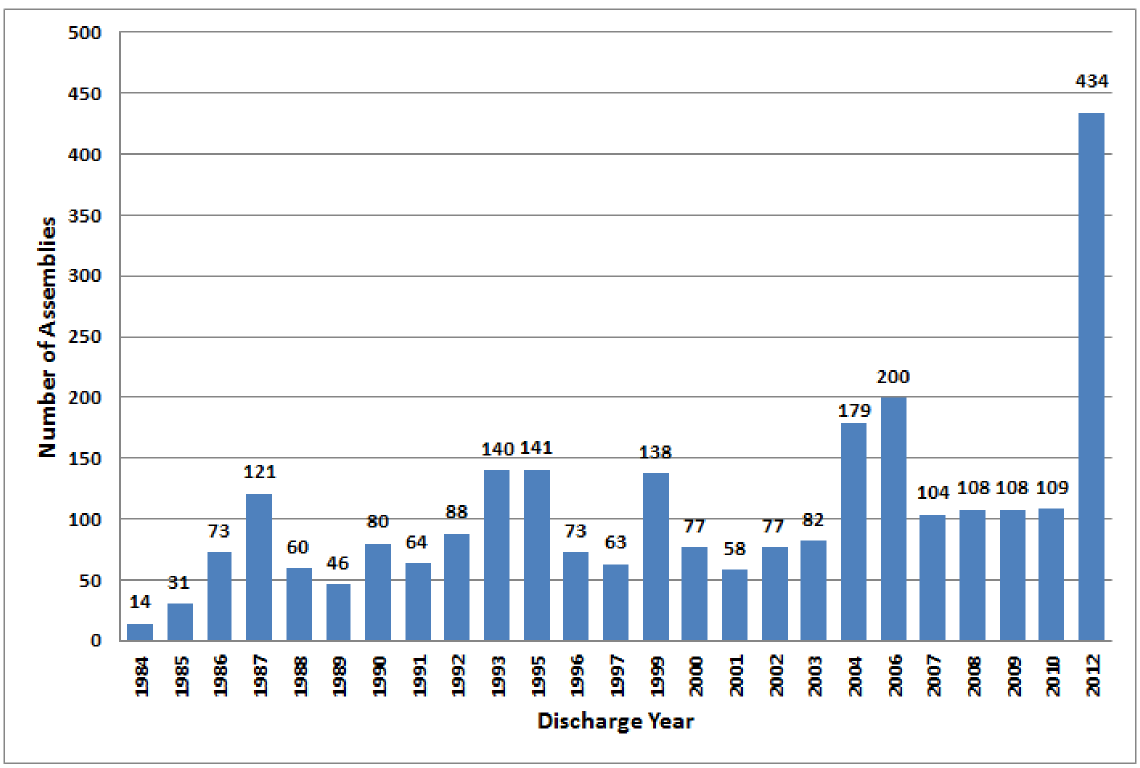


Figure 2-266. San Onofre-2 and -3 Number of Uncanistered Assemblies versus Discharge Year

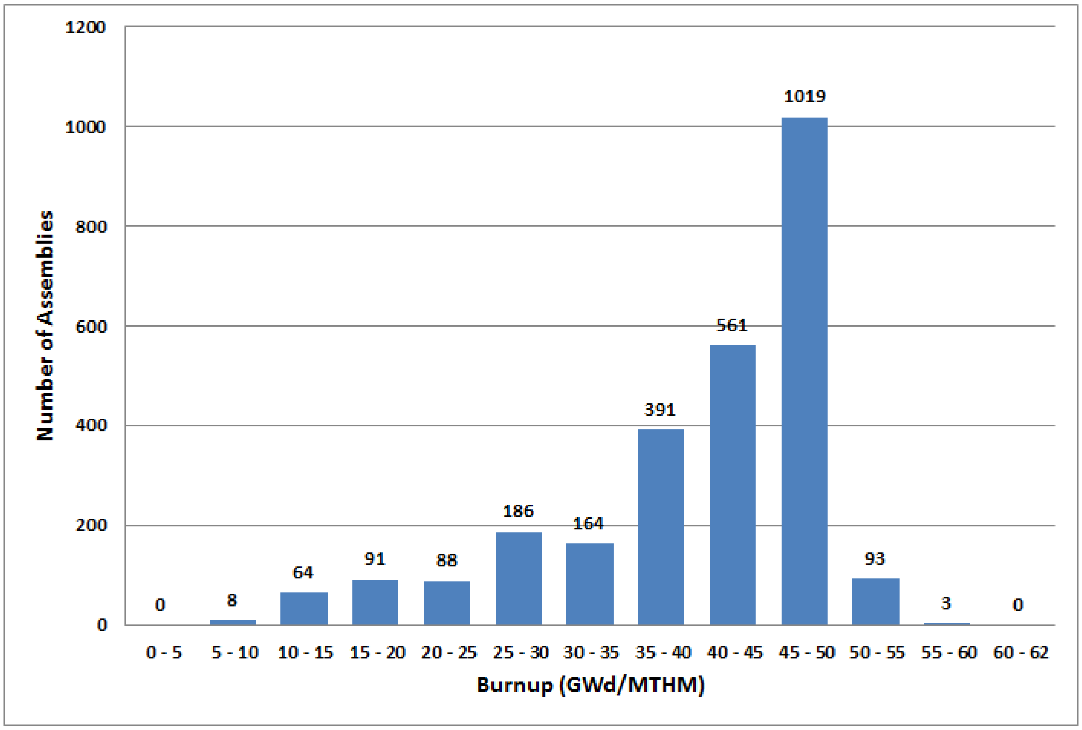


Figure 2-267. San Onofre-2 and -3 Number of Uncanistered Assemblies versus Burnup

2.12.2 Site Conditions

The San Onofre site is located on the Pacific coast in southern California. The San Onofre ISFSI (Docket No. 72-41) (see Figure 2-268 and Figure 2-269) is located at the northwestern end of the site. Figure 2-270 provides an aerial view of the San Onofre site.

The San Onofre ISFSI will be expanded to accommodate additional dry storage in HI-STORM UMAX underground vertical storage modules. The proposed expansion will be in an area adjacent to the current ISFSI (see Figure 2-271 and Figure 2-272). This area will be excavated to a depth of approximately 12 feet to install the underground vertical storage modules. Following installation of the modules, the area will be built up approximately 12 feet from the current ground level.

The San Onofre site is served by the Pacific Sun Railroad and has an on-site rail spur (TOPO 1993f, 1994e; TriVis Incorporated 2005). The rail spur is about 0.8 mile long and was originally built in the 1960s to support construction of San Onofre-1 and was subsequently used to support construction of San Onofre-2 and -3 in the 1970s (Gilson 2005, Gilson and Blythe 2005). The rail spur connects with the Pacific Sun Railroad mainline about 0.6 mile northwest of the site. The rail spur was reactivated in 2000 to support the decommissioning of San Onofre-1 (Gilson 2005, Gilson and Blythe 2005). Figure 2-273 through Figure 2-277 show the onsite rail system at San Onofre, the onsite spur, and the junction of the rail spur with the mainline. San Onofre staff stated that use of the onsite rail spur would require removal or modification of the vehicle barrier and maintenance of the rail.

The San Onofre site has no on-site barge facilities (TOPO 1993f, 1994e; TriVis Incorporated 2005). Construction of an on-site barge facility was attempted during construction of the San Onofre site, but this effort was unsuccessful because of currents and wave activity.

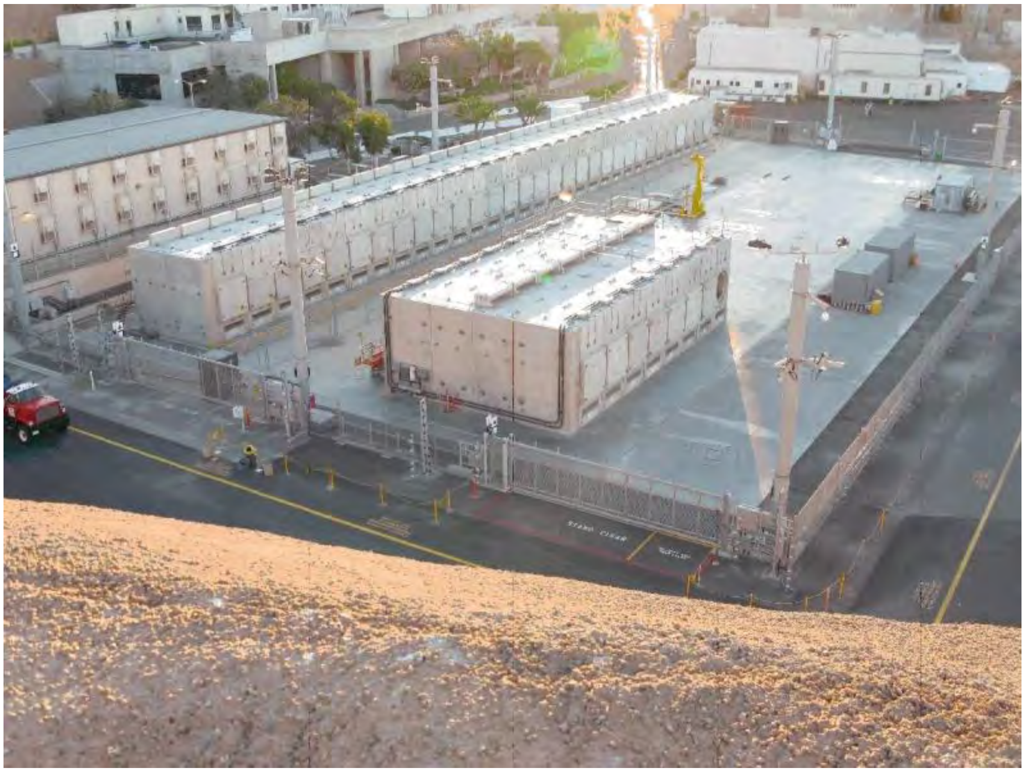


Photo courtesy of San Onofre

Figure 2-268. San Onofre Independent Spent Fuel Storage Installation (2009)

Figure 2-269. Close-up View of San Onofre Independent Spent Fuel Storage Installation (2015)

Figure 2-270. Aerial View of San Onofre Site (Google 2015)

Figure 2-271. Aerial View of Area of Proposed San Onofre Independent Spent Fuel Storage Installation Expansion (Google 2015)

Figure 2-272. Future Expanded San Onofre Independent Spent Fuel Storage Installation Location (2015)

Figure 2-273. Onsite Rail System at San Onofre Site (2015)

Figure 2-274. Onsite Rail System near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Southwest) (2015)

Figure 2-275. Onsite Rail System and Vehicle Barrier near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Northeast) (2015)

Figure 2-276. Onsite Rail Spur at San Onofre Site (2015)

Figure 2-277. Junction of Onsite Rail Spur with Mainline at San Onofre Site (2015)

2.12.3 Near-site Transportation Infrastructure and Experience

As discussed in Section 2.12.2, the San Onofre site has direct rail access to the Pacific Sun Railroad through an on-site rail spur, and the rail spur has been used to ship several large turbine shells, turbine rotors, three steam generators, and a pressurizer during the decommissioning of San Onofre-1 (Gilson 2005, Gilson and Blythe 2005). Each steam generator weighed approximately 209 tons, was cylindrical with spherical ends, measured approximately 11 ft. 4.5 in. in diameter at the upper dome and was approximately 45 ft. long (EPRI 2008b). Lifting trunnions were attached to the exterior of the steam generators and increased the maximum width of the steam generators to approximately 14 ft. 5 in. (EPRI 2008b). The pressurizer weighed approximately 105 tons, was cylindrical with spherical ends, measured approximately 7 ft. 6.5 in. in diameter, and was about 42 ft. 7 in. long (EPRI 2008b). Low-level radioactive waste was also shipped by rail using gondola cars (Figure 2-278) and intermodal containers loaded onto rail cars (Figure 2-279) (EPRI 2008b).

Truck shipments of 270 used nuclear fuel assemblies were also made from San Onofre-1 to Morris, Illinois from 1972 through 1980 (SAIC 1991). Ninety-five shipments were made using the IF-100 truck transportation cask and 175 shipments were made using the NAC-1 truck transportation cask (SAIC 1991). Southern California Edison does not intend to return these assemblies to the San Onofre site (EPRI 2008b).

The mainline track in the vicinity of the San Onofre site is designated as track class 5 and is built with 115 lb. rail; the on-site spur is built with 90 lb. rail. Figure 2-280 and Figure 2-281 show the mainline. The mainline is owned by the North County Transit District. Amtrak Pacific Surfliner and Metrolink commuter rail service operate over the same track between Orange County and Oceanside, California, which limits freight service to 12:00 a.m. to 5:00 a.m. The North County Transit District also provides Coaster and Sprinter commuter rail service between Oceanside and San Diego, and Oceanside and Escondido, California. The Pacific Sun Railroad interchanges with the BNSF Railroad at the Stuart Mesa rail yard, which is located about 13 miles south of the San Onofre site.

Photo courtesy of San Onofre

Figure 2-278. Gondola Railcar Used to Transport Large Non-Containerized Components

Photo courtesy of San Onofre

Figure 2-279. Articulating Intermodal Railcar Transporting Low-Level Radioactive Waste

Figure 2-280. Mainline at San Onofre Site (Looking North) (2015)

Figure 2-281. Mainline at San Onofre Site (Looking South) (2015)

In addition to rail shipments of large components, ship, barge, platform trailer, tracked vehicle, and heavy haul truck transport were used to transport four replacement steam generators from Mitsubishi Heavy Industries in Kobe, Japan to the San Onofre site. The steam generators weighed approximately 650 tons each. The two replacement steam generators for San Onofre-2 were transported from Kobe, Japan by the heavy lift cargo ship Happy Ranger to the Port of Long Beach in 2008; the two replacement steam generators for San Onofre-3 were transported from Kobe, Japan by the heavy lift cargo ship Enchanter to the Port of Los Angeles in 2010. At the ports, the steam generators were transloaded to an ocean-going barge (see Figure 2-282) and transported to the Del Mar Boat Basin (see Figure 2-283) which is located at Marine Corps Base Camp Pendleton (MCBCP). At a pre-existing bulkhead at the Del Mar Boat Basin, each steam generator was then transloaded onto a Goldhofer trailer that had been rolled from the bulkhead onto the barge under the steam generator (see Figure 2-284). The Goldhofer trailer with its steam generator was then rolled off of the barge.

After being rolled off of its barge at the Del Mar Boat Basin, each steam generator was then transloaded onto a tracked vehicle (see Figure 2-285). The tracked vehicle then traveled north on military roads. From the paved road behind the Camp Del Mar recreational vehicle park at the north end of Camp Pendleton's Camp Del Mar Beach and Recreational Area, the tracked vehicle followed the Amphibious Tracked Vehicle access road and proceeded to the beach and past the Santa Margarita Estuary.

During travel on the beach, several natural drainages were crossed, the most important of which was the Santa Margarita River. North of the Santa Margarita Estuary, the tracked vehicle traveled along military transit routes on the beach for approximately 8 miles. Travel on the beach was below the high tide line; layovers were above the high tide line. The tracked vehicle then followed a military transport dirt road that heads east and northeast from Red Beach at the MCBCP Uniform Training Area to the MCBCP Las Pulgas gate. At the Las Pulgas Gate, each steam generator was transloaded from its tracked vehicle onto a Goldhofer trailer (see Figure 2-286). From the Las Pulgas gate, the Goldhofer trailer turned north onto a MCBCP road that parallels Interstate-5 for 0.2 miles.

The Goldhofer trailer then moved to the south bound lanes of Interstate-5 through a temporary opening made in the fencing along Interstate-5. The transfer to the south bound lanes of Interstate-5 was necessary to avoid the environmentally sensitive Skull Canyon area of the Southern California Coast. The Goldhofer trailer traveled north on the south bound lanes of Interstate-5 for approximately 0.2 miles, and then transitioned back to a MCBCP dirt road through another temporary opening made in the fencing along Interstate-5.

Travel north on south-bound Interstate-5 necessitated the closure of three of the four south-bound lanes of Interstate-5 for approximately 1 hour, and no special grading was necessary to transfer to and from Interstate-5. The transporter then traveled north on the MCBCP dirt road for approximately 1 mile and transitioned onto Old Highway 101, which is paved. The distance traveled along Old Highway 101 was approximately 5.5 miles, and transitioned from MCBCP property to State of California State Park property. Travel on Old Highway 101 required the reinforcement of drainage culverts and underground utilities which were protected with steel plates or mats. Old Highway 101 is also the main access road into the San Onofre State Beach and required the use of flaggers to direct traffic around the steam generators. From

Old Highway 101, the Goldhofer trailer moved to the San Onofre site where each steam generator was offloaded. The overall length of the route from the Del Mar Boat Basin to the San Onofre site was about 15 miles (see Figure 2-287).

Heavy haul truck transport was also used to ship the four old steam generators from San Onofre to Clive, Utah for disposal; a distance of about 830 miles. Each steam generator weighed 760,335 lb., and was 15.5 ft. wide, 15.5 ft. tall, and 43 ft. long (Morgan 2015). The gross vehicle weight of each shipment was 1,561,050 lb. and each shipment required 14 days of travel time (Morgan 2015). Figure 2-288 shows a steam generator (without its steam dome) on its heavy haul truck transporter.

Photo courtesy of California Public Utilities Commission

Figure 2-282. San Onofre Steam Generators on Barge Arriving at Del Mar Boat Basin (2009)

Figure 2-283. Del Mar Boat Basin (Google 2015)

Photo courtesy of California Public Utilities Commission

Figure 2-284. Offloading of Steam Generator on Goldhofer Trailer at Del Mar Boat Basin Bulkhead (2009)

Photo courtesy of California Public Utilities Commission

Figure 2-285. Steam Generator on Tracked Vehicle on Beach (2009)

Photo courtesy of San Diego Union-Tribune

Figure 2-286. Steam Generator on Goldhofer Trailer (2009)

Figure 2-287. Steam Generator Route from the Del Mar Boat Basin to the San Onofre Site (Google 2015)

Photo courtesy of San Diego Union-Tribune

Figure 2-288. Old Steam Generator on Heavy Haul Truck Transporter (2011)

2.12.4 Gaps in Information

At the San Onofre site, an on-site rail spur provides direct access to the Pacific Sun Railroad which interchanges with the BNSF Railroad and consequently, barge or heavy haul truck transport of used nuclear fuel and GTCC low-level radioactive waste would be unlikely from the San Onofre site.

There are 1123 used nuclear fuel assemblies at San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. Revision 7 of the certificate of compliance for the MP197HB transportation cask authorizes the transport of high burnup fuel in the 24PT4 canister; therefore, the 8 high burnup fuel assemblies stored in 24PT4 canisters would be transportable. An application for a certificate of compliance for the HI-STAR 190 transportation cask has been submitted to the NRC and the additional 1115 high burnup fuel assemblies would be transportable if they are included in the list of approved contents in the certificate of compliance for the HI-STAR 190 transportation cask. The certificate of compliance for the MP197HB transportation cask would also have to be revised before used nuclear fuel or GTCC low-level radioactive waste that may be stored in 32PTH2 canisters could be transported using the MP197HB transportation cask from the San Onofre site.

2.13 Vermont Yankee

This section describes the inventory of used nuclear fuel and GTCC low-level radioactive waste, site conditions, near-site transportation infrastructure and experience, and gaps in information for the Vermont Yankee site. The site is located at the southeast corner of Vermont in the town of

Vernon, Vermont in Windham County on the western shore of the Connecticut River (TOPO 1994f).

2.13.1 Site Inventory

Vermont Yankee ceased operation on December 29, 2014 and all used nuclear fuel has been removed from the Vermont Yankee reactor vessel (Wamser 2015). A total of 3879 used nuclear fuel assemblies and one fuel debris canister are stored at Vermont Yankee, of which 2995 boiling water reactor used nuclear fuel assemblies and one fuel debris canister are stored in the spent fuel pool and 884 boiling water reactor used nuclear fuel assemblies are in dry storage at the Vermont Yankee ISFSI (Docket No. 72-59). The fuel rods in the fuel assemblies are zirconium alloy-clad. The 884 fuel assemblies are stored in 13 MPC-68 multipurpose canisters. The MPC-68 multipurpose canister holds 68 boiling water reactor used nuclear fuel assemblies and is part of the HI-STORM 100S System (Docket No. 72-1014). This system consists of a multipurpose canister, which contains the fuel; a vertical concrete storage overpack (HI-STORM), which contains the multipurpose canister during storage; and a transfer cask (HI-TRAC), which contains the multipurpose canister during loading, unloading and transfer operations. The HI-STORM 100S is a variation of the HI-STORM 100 overpack design that includes a modified lid which incorporates the air outlet ducts into the lid, allowing the overpack body to be shortened.

The HI-STAR 100 transportation cask (Docket No. 71-9261) is certified to ship MPC-68 canisters. Transport of GTCC low-level radioactive waste and high burnup (> 45 GWd/MTHM) used nuclear fuel is not authorized in Revision 9 of the certificate of compliance for the HI-STAR 100. Although HI-STAR 100 casks have been constructed for use in the United States, these casks are being used as storage casks at the Dresden (4 casks) and Hatch (3 casks) sites (Ux Consulting 2015a). For these HI-STAR 100 casks to be used to ship used nuclear fuel from the Vermont Yankee site, they would need to be unloaded, their contents placed in other storage overpacks, and the casks transported to the Vermont Yankee site. It would also be necessary to procure impact limiters for these HI-STAR 100 casks.

At the Vermont Yankee site, it is estimated that a total of 58 canisters containing used nuclear fuel and fuel debris (Wamser 2014) and 2 canisters containing GTCC low-level radioactive waste will be stored.

Figure 2-289 illustrates the number of used nuclear fuel assemblies at Vermont Yankee, based on their discharge year. The oldest fuel was discharged in 1973 and the last fuel was discharged in 2014. The median discharge year of the fuel is 1993. To estimate the used nuclear fuel discharges and assembly burnups for the last Vermont Yankee core (368 assemblies), the TSL-CALVIN computer code (Nutt et al. 2012) was used.

Figure 2-290 illustrates the number of used nuclear fuel assemblies at Vermont Yankee, based on their burnup. The lowest burnup is 0.96 GWd/MTHM and the highest burnup is 52.9 GWd/MTHM. The median burnup is 30.1 GWd/MTHM. There are 248 high burnup used nuclear fuel (burnup greater than 45 GWd/MTHM) assemblies stored at Vermont Yankee. These 248 fuel assemblies are classified by the NRC as high burnup used nuclear fuel.

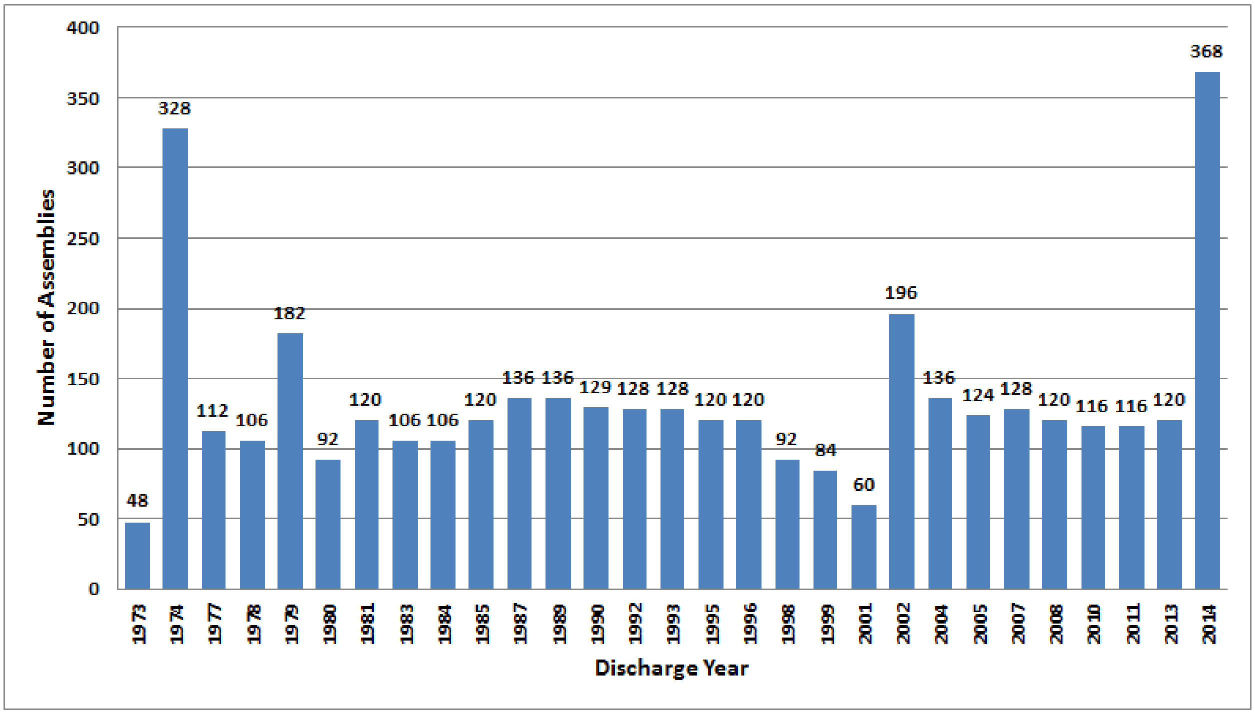


Figure 2-289. Vermont Yankee Number of Assemblies versus Discharge Year

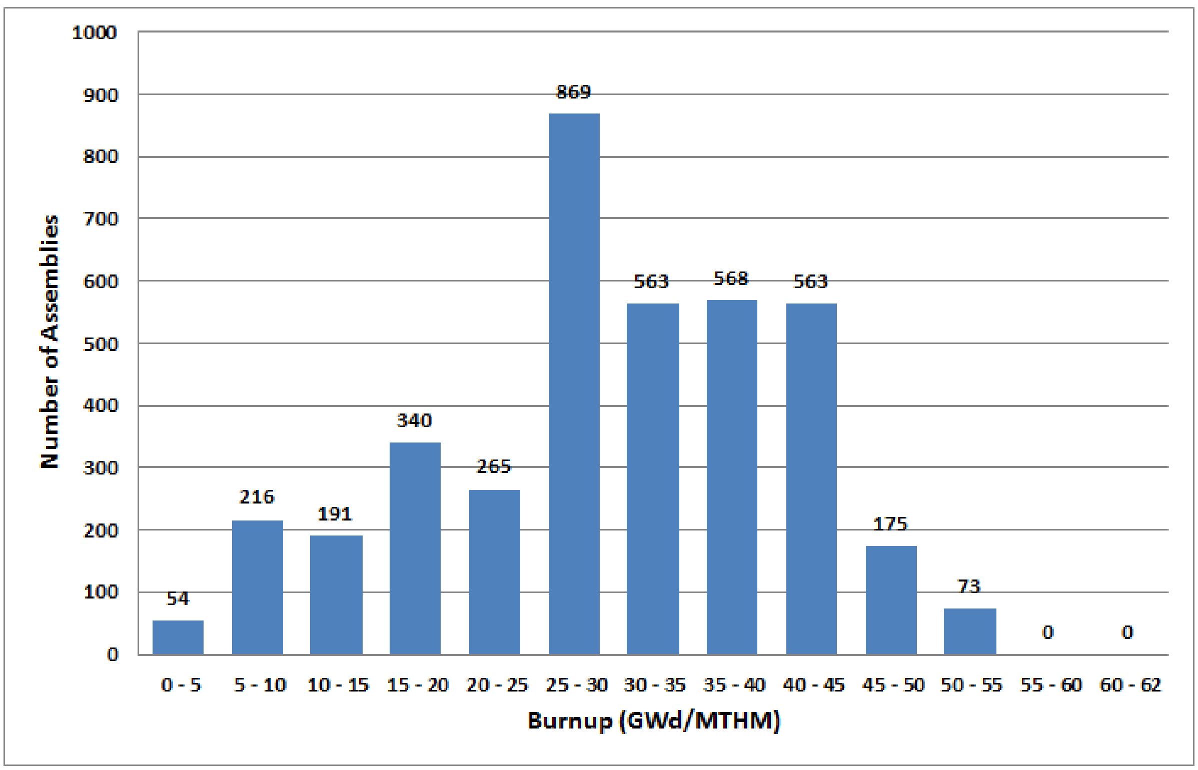


Figure 2-290. Vermont Yankee Number of Assemblies versus Burnup

As mentioned previously, Vermont Yankee has 884 used nuclear fuel assemblies stored in 13 dry storage canisters. Figure 2-291 and Figure 2-292 illustrate the number of canistered fuel assemblies based on their discharge year and burnup. The oldest canistered fuel was discharged in 1977 and the last fuel was discharged in 2004. The median discharge year of the canistered fuel is 1993. The lowest burnup is 17.0 GWd/MTHM and the highest burnup is 42.5 GWd/MTHM. The median burnup is 32.3 GWd/MTHM. There are no canistered fuel assemblies at Vermont Yankee that have burnups greater than 45 GWd/MTHM.

Figure 2-293 and Figure 2-294 illustrate the number of fuel assemblies based on their discharge year and burnup for the 2996 uncanistered fuel assemblies at Vermont Yankee. The oldest uncanistered fuel was discharged in 1973 and the last fuel was discharged in 2014. The median discharge year of the uncanistered fuel is 1992. The lowest burnup is 0.96 GWd/MTHM and the highest burnup is 52.9 GWd/MTHM. The median burnup is 29.4 GWd/MTHM. There are 248 uncanistered fuel assemblies at Vermont Yankee that have burnups greater than 45 GWd/MTHM.

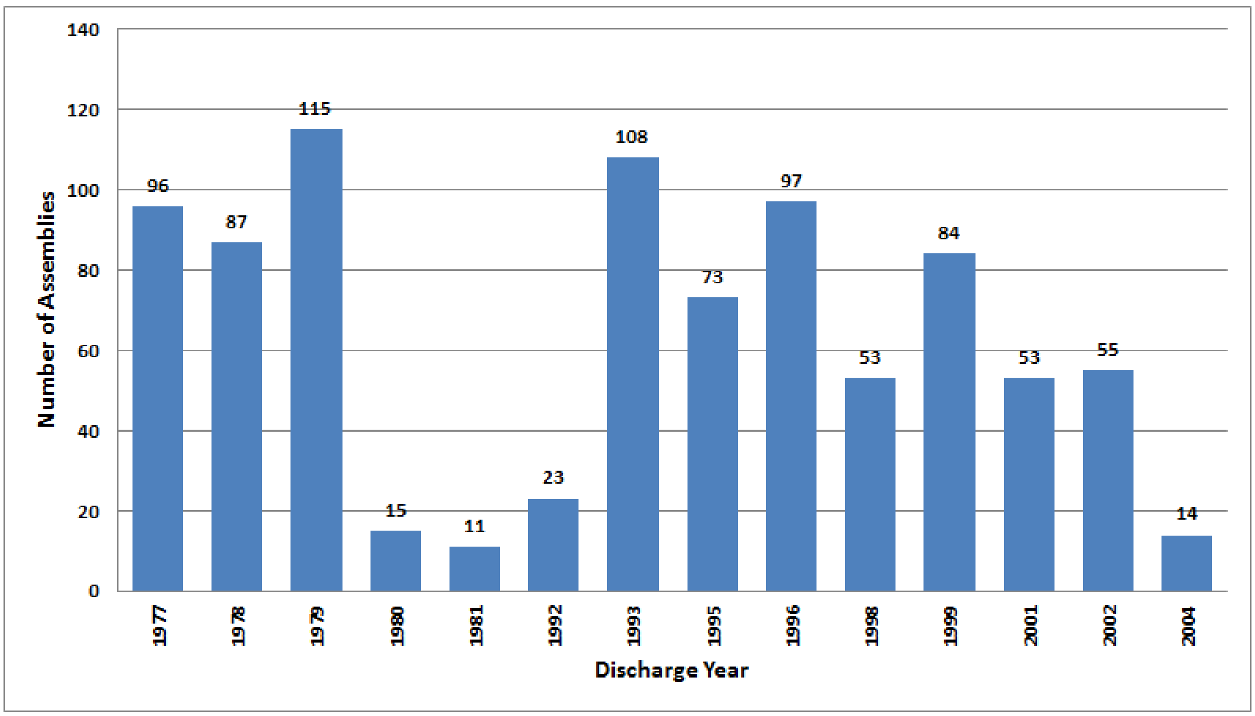


Figure 2-291. Vermont Yankee Number of Canistered Assemblies versus Discharge Year

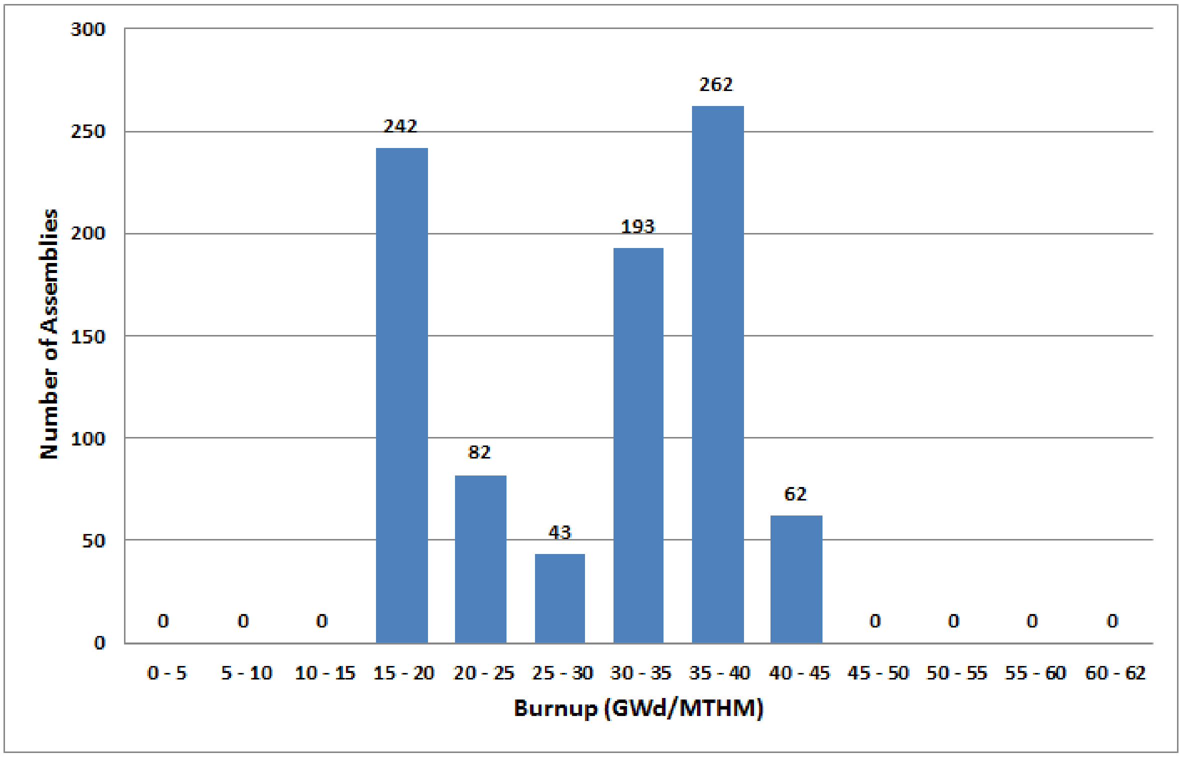


Figure 2-292. Vermont Yankee Number of Canistered Assemblies versus Burnup

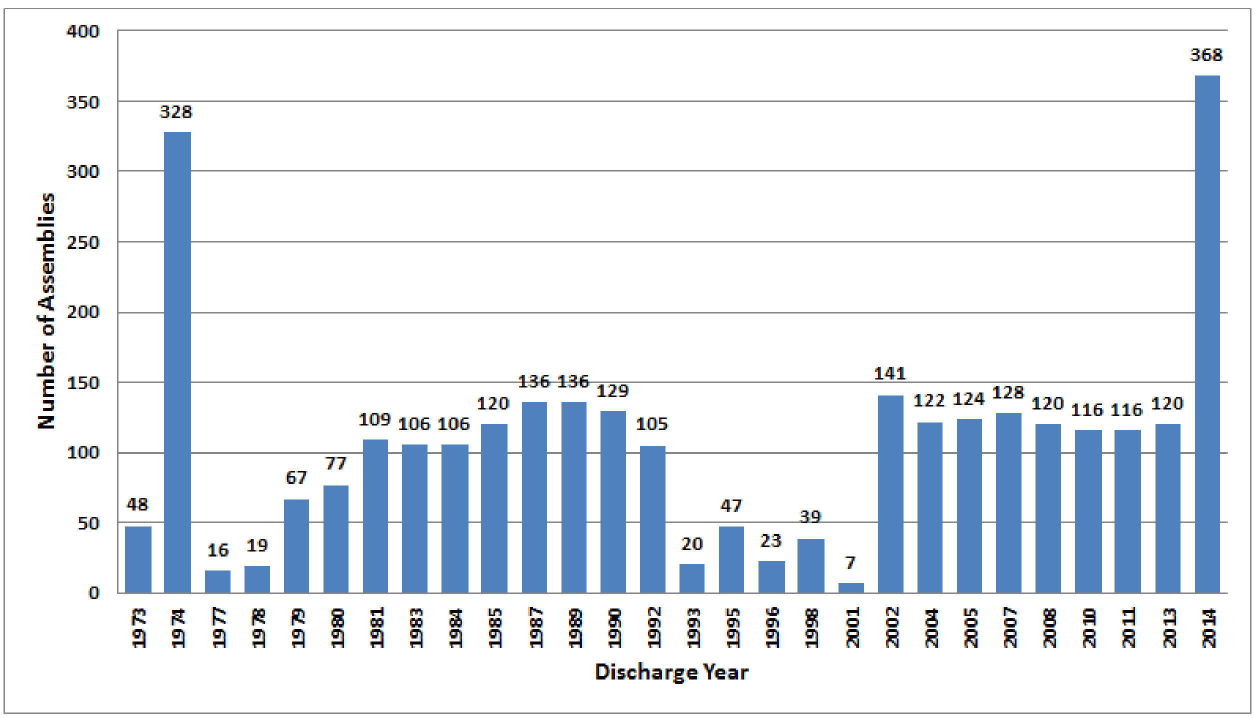


Figure 2-293. Vermont Yankee Number of Uncanistered Assemblies versus Discharge Year

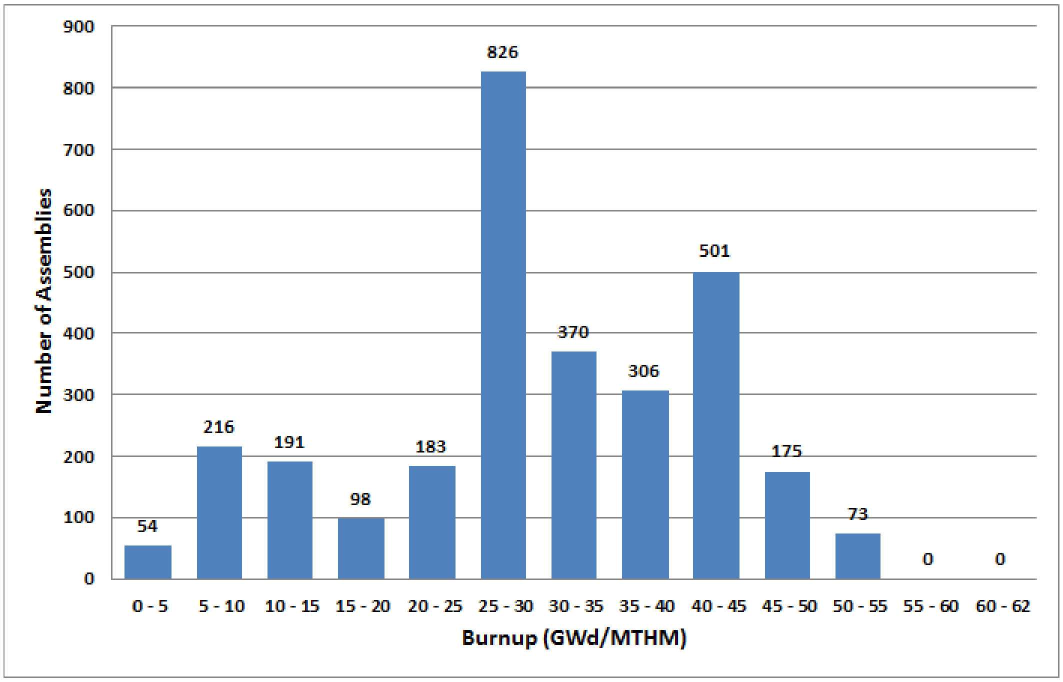


Figure 2-294. Vermont Yankee Number of Uncanistered Assemblies versus Burnup

2.13.2 Site Conditions

The Vermont Yankee site is located on the western shore of the Connecticut River, across from Hinsdale, New Hampshire, which is located on the eastern side of the Connecticut River. The site is about 5 miles southeast of Brattleboro, Vermont, and about 45 miles north of Springfield, Massachusetts. The site is located on Vernon Pond, formed by Vernon Dam and Hydroelectric Station located immediately downstream 0.75 miles from the site (NRC 2007b). Figure 2-295 provides an aerial view of the Vermont Yankee site. Figure 2-296 shows the Vernon Dam and Hydroelectric Station.

The current Vermont Yankee ISFSI (see Figure 2-297) is located at the northern end of the Vermont Yankee site (see Figure 2-298). This ISFSI pad has a capacity of 36 dry storage casks in an eight by five arrangement (the pad has four unused storage locations to allow dry storage casks to be moved if needed). A second dry storage cask pad will be built approximately 30 feet immediately to the west of the existing ISFSI pad. The second pad is being designed for storage of 25 casks in a five by five arrangement and, when combined with the existing ISFSI storage pad, a total of 58 dry fuel storage casks can be stored on the pads. In addition, the pads will allow storage of up to three casks of GTCC low-level radioactive waste (Entergy 2014).

Rail service to the Vermont Yankee site is provided by the New England Central Railroad. However, the Vermont Yankee rail spur no longer extends into the site. In the past, the Vermont Yankee onsite rail system had two branches, one spur that ran to the cask receiving area and a second spur that ran to the turbine building (TOPO 1994f).

In 2008, DOE, Federal Railroad Administration, and the Council of State Governments – Eastern Regional Conference conducted an assessment of the rail infrastructure at and near the Vermont Yankee site. Figure 2-299 from this assessment shows the rail line at the entrance of the Vermont

Yankee site, Figure 2-300 shows the junction of the two branches of the onsite rail system, and Figure 2-301 and Figure 2-302 show portions of the two onsite rail spurs that ran to the turbine building and cask receiving area, respectively.

To support decommissioning, the onsite rail spur that ran to the turbine building will be reactivated. The onsite portion of the rail spur (see Figure 2-303) will follow the existing rail line on the northwest side of the property and additional track will be installed to a point inside the current Protected Area (Entergy 2014).

Dams on the Connecticut River to the north and south of the Vermont Yankee site preclude barge access and consequently there is no onsite barge facility at Vermont Yankee (TOPO 1994f).

2.13.3 Near-site Transportation Infrastructure and Experience

As mentioned in Section 2.13.2, rail service to the Vermont Yankee site is provided by the New England Central Railroad. In the vicinity of the Vermont Yankee site, the New England Central Railroad is track class 3. The New England Central Railroad is a Class III railroad and operates 394 miles of track from the Canadian border at East Alburgh, Vermont to New London, Connecticut. The New England Central Railroad interchanges with the Claremont Concord Railroad, the Canadian National, the Canadian Pacific, the CSXT, the Massachusetts Central Railroad, the Norfolk Southern, the Pan Am Southern, the Providence and Worcester Railroad, and the Vermont Railway. The Pan Am Southern also operates trains via trackage rights on the New England Central Railroad between East Northfield, Massachusetts and White River Junction, Vermont. The New England Central Railroad hosts the Amtrak Vermonter passenger service from East Northfield, Massachusetts to St. Albans, Vermont, including over the tracks in the vicinity of the Vermont Yankee site.

The Connecticut River is dammed both upstream and downstream from the Vermont Yankee site. For example, the Vernon Dam is located 0.75 mile downstream of the Vermont Yankee site at river mile 142, and the Bellows Falls Dam is located upstream of the Vermont Yankee site at river mile 174 (NRC 2007b). TOPO (1994f) states that the nearest offsite barge terminal is located 60 miles from the Vermont Yankee site.

In 2008, DOE, the Federal Railroad Adminstration, and the Council of State Governments – Eastern Regional Conference conducted an assessment of the rail infrastructure at and near the Vermont Yankee site. The assessment was focused on the New England Central Railroad from the Vermont Yankee site to Palmer, Massachusetts, where the New England Central Railroad interchanges with the CSXT, a distance of about 51 miles. The assessment identified one major bridge over the Connecticut River, 13 other bridges, and 17 grade crossings.

Figure 2-304 from this assessment shows the Vermont Yankee rail spur switch at milepost 116.08 of the New England Central Railroad, Figure 2-305 shows the State Route 142 railroad grade crossing at milepost 115.97, Figure 2-306 shows the grade crossing at milepost 112.68, Figure 2-307 shows the railroad bridge over the Connecticut River at milepost 109.15, and Figure 2-308 shows a smaller railroad bridge at milepost 103.33.

Figure 2-295. Aerial View of Vermont Yankee Site (Google 2015)

Photo courtesy of Federal Railroad Administration

Figure 2-296. Vernon Dam and Hydroelectric Station (2008)

Photo courtesy of Vermont Yankee

Figure 2-297. Vermont Yankee Independent Spent Fuel Storage Installation

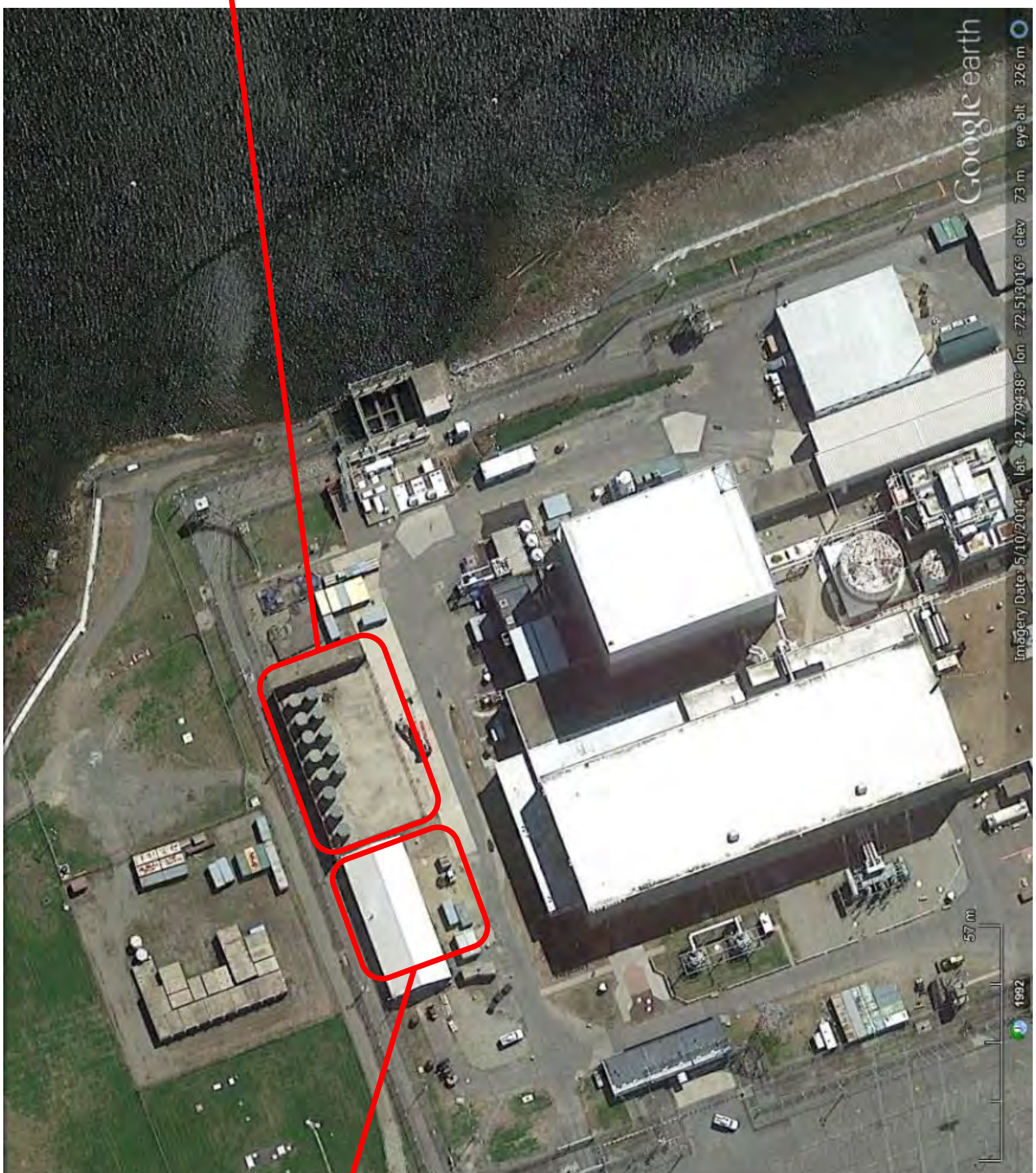


Figure 2-298. Aerial View of Vermont Yankee Independent Spent Fuel Storage Installation (Google 2015)

Photo courtesy of Federal Railroad Administration

Figure 2-299. Rail Spur at Entrance to Vermont Yankee Site (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-300. Junction of Onsite Rail System Branches (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-301. Turbine Building Branch of Onsite Rail System (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-302. Cask Receiving Area Branch of Onsite Rail System (2008)

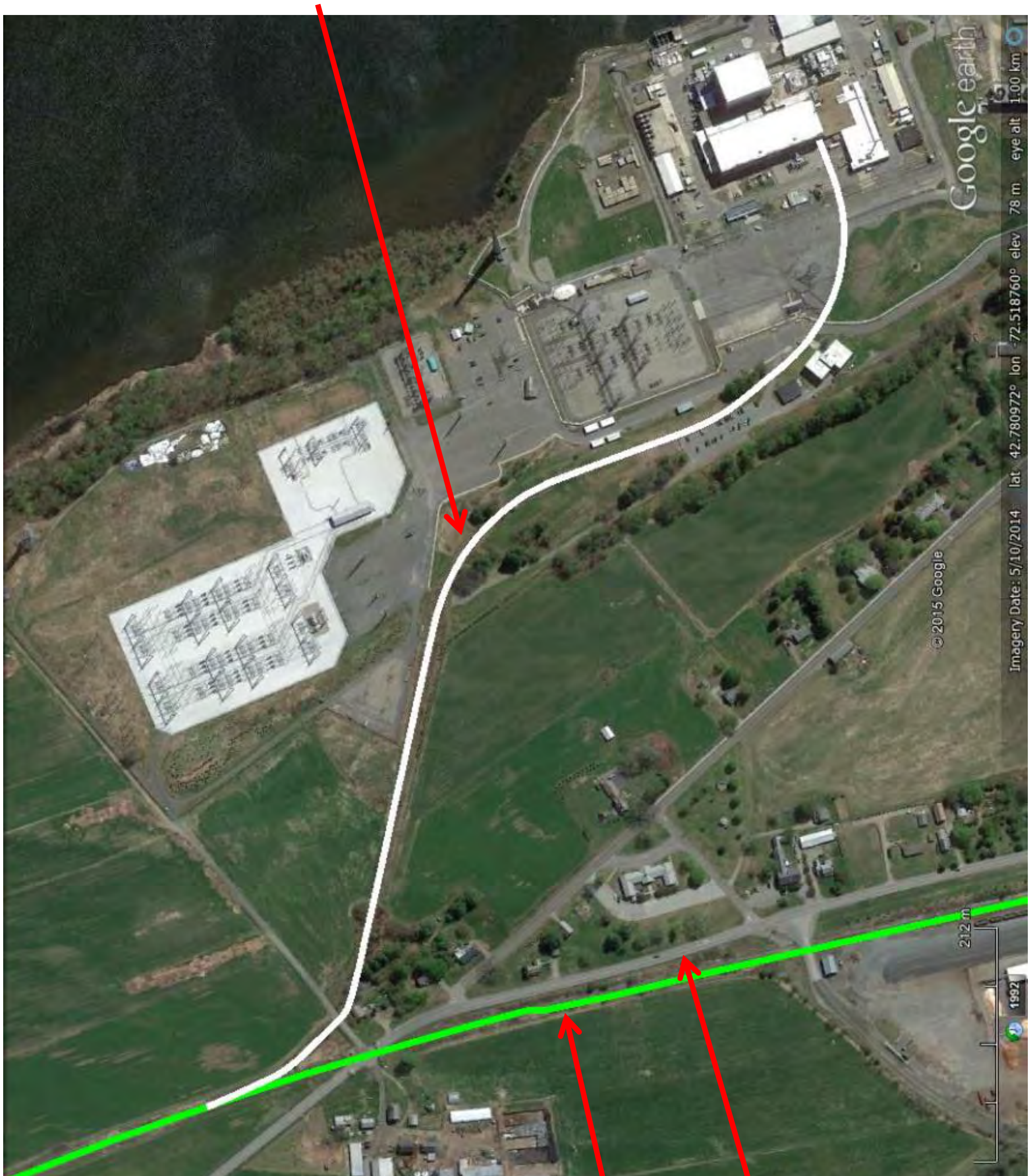


Figure 2-303. Aerial View of Onsite Rail Spur (Google 2015)

Photo courtesy of Federal Railroad Administration

Figure 2-304. Vermont Yankee Rail Spur Switch at Milepost 116.08 (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-305. State Route 142 Grade Crossing at Milepost 115.97 (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-306. Grade Crossing at Milepost 112.68 (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-307. Connecticut River Railroad Bridge at Milepost 109.15 (2008)

Photo courtesy of Federal Railroad Administration

Figure 2-308. Railroad Bridge at Milepost 103.33 (2008)

2.13.4 Gaps in Information

Revision 9 of the certificate of compliance for the HI-STAR 100 transportation cask does not allow the transport of high burnup (> 45 GWd/MTHM) used nuclear fuel or GTCC low-level radioactive waste. Consequently, the certificate of compliance for the HI-STAR 100 would have to be revised before the 248 high burnup used nuclear fuel assemblies or the GTCC low-level radioactive waste from decommissioning at the Vermont Yankee site could be transported.

3. OVERVIEW OF REQUIREMENTS FOR OFF-SITE TRANSPORTATION INFRASTRUCTURE

Off-site transportation of rail/intermodal casks containing used nuclear fuel will require that the off-site rail network, roads, or navigable waters (herein referred to as transportation infrastructure) in the vicinity of each of the shutdown sites be capable of accommodating the size and weight of the rail/intermodal casks containing used nuclear fuel and of the transport vehicles that will be used to move the casks. It will also be necessary for the operational capacities (e.g., traffic flow or re-routing capacity) of the off-site infrastructure to be capable of accommodating the movement of casks on transporters.

3.1 Railroad Requirements

Off-site railroads, either Class I (mainline railroads), II (typically regional railroads), or III (typically short line railroads) railroads, might be used to transport casks from sites that have either direct rail access (Maine Yankee, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, San Onofre, and Vermont Yankee sites) or near-site rail access with an acceptable branch line or rail siding where casks would be transferred to railcars from heavy haul trucks or barges (Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, and Kewaunee sites).

Rail infrastructure components including roadbed, track geometry and track structure to meet track class 2 Track Safety Standards, and over- and under-grade bridges, must be sufficient to ensure that these features of a railroad are capable of supporting a 6-, 8-, or 12-axle cask-railcar that conforms to AAR Standard S-2043 (AAR 2008) and has a gross loaded weight up to 500,000 lb. The railroad's infrastructure must comply with the regulatory standards of the Federal Railroad Administration and also have the capability to accommodate a train consisting of up to five cask-railcars, two or more buffer cars containing ballast, two locomotives, and an escort car.

The height and width clearances of the track alignment also must be sufficient to accommodate a loaded cask-railcar having an overall height up to 15 feet and a width up to 12 feet. Clearance along track curves must be sufficient to accommodate a railcar having a length up to 100 feet and a width of up to 12 feet. The radius of track curves (including curves in switching yards that may be used) must be sufficient to accommodate a 6-, 8-, or 12- axle railcar with a distance between the front and rear truck bolsters up to 80 feet.

For sidings or spurs where casks would be transferred from heavy haul trucks or barges to railcars, the length of rail should accommodate a minimum of one cask-railcar having a length up to 100 feet and a width up to 12 feet. The curvature of the turnout for the siding should allow for a 6-, 8-, or 12-axle cask-railcar with spacing between the front and rear truck bolsters up to 80 feet. Sidings where transloads will be conducted should include a cleared and level adjacent operations area that can support heavy vehicles and equipment and that is no less than 200 feet long and 50 feet wide. For sidings where only one- or two-cask railcars can be accommodated, there should be a nearby rail siding or rail yard where the train can be assembled.

For some sites it may be necessary to conduct intermodal operations at a nearby rail siding that has limited operating space and is close to a railroad's operating track. For such sidings it may not be possible to conduct concurrent railroad train operations on the main rail line while transloads and switching operations necessary for cask shipments are being conducted. To use such sidings, it will be necessary for the railroad to have a flexible operations schedule for, or alternative routing around, the affected track.

3.2 Highway Requirements

All 13 shutdown sites have on-site roads that connect to local roads or highways. Five of these sites (Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, and Kewaunee sites) do not have direct access to a railroad. The standards used for the design, construction, and maintenance of local roads and highways depend on several factors, including whether the road or highway is designated as an interstate highway, U.S. highway, state highway, or local road.

Interstate and U.S. Highway standards are established by the Federal Highway Administration. These standards establish the mechanical requirements for lane width, road shoulder, overhead clearance, grade, curvature, road-bed, bridges and culverts, and primary pavement materials and thickness for all roads designated as Interstates and U.S. Highways. The standards are the basis for federal weight and size limits for trucks and buses. States are authorized to issue special permits for vehicles that exceed these limits for weight and size for trucks and buses. The special permits that states issue typically consider the route to be used, normal traffic on the route, time of day and duration of use, total weight of the permitted vehicle, wheel loads, distribution of the total weight of a vehicle over multiple wheels, axle spacing, and the frequency of overweight and oversize vehicles using the permitted roadways. The permits also consider the condition of designated highways and the load capacities of the highway's bridges, overpasses, and culverts.

Standards for state highways are typically less prescriptive than standards for federal highways. Many state highways are narrower and have steeper grades and sharper curves than do federal highways and often have narrow shoulders and less overhead clearance. In addition, many state highways do not have the substantial roadbed and pavement federal highways do. State highway bridges and culverts also typically have less load capacity than do bridges and culverts for federal highways. State highway departments issue permits for overweight and oversize vehicles that use the state highways. State permitting processes for overweight and oversize vehicles that travel on state highways are generally the same as those for oversize and overweight vehicles that travel on federally designated highways.

For local roads, standards adopted by local governments consider anticipated traffic densities, truck traffic use, climate, terrain, and geology. Local roads may be wide or narrow, often have short-radius curves and sharp corners, may have substantial sub-base and pavements or may be only intended for light vehicle use, and often have low overhead clearances because of utility lines or limited overpass grade separations. Weight limits for bridges and culverts for local roads are typically less than for the same kinds of structures on state or federal highways. In addition, local roads pass through residential and local business communities often with businesses and residences being located close to the right-of-way. These local roads provide commuter, employee, and pickup and delivery vehicles access to retail and other businesses, and provide connectors to state and federal highways.

Although the shutdown sites are generally located in rural areas, all are served by local roads that, if applicable and if practical, would be used by heavy haul vehicles. Local authorities would issue permits for overweight and/or oversize vehicles to travel on non-state, nonfederal, local roads. Such permits may be issued following consultation with local elected officials and thus may consider factors (e.g., desirability of removal of overhanging tree branches) that are in addition to technical factors concerning the proposed vehicle, load, route, and conditions of roads and road structures, and time of day for operations.

It is likely that the travel speeds of the vehicles from the shutdown site to a nearby siding or spur would be limited to an average of less than 5 miles per hour. This slow pace, based on experience, is because the local roads that would be used typically have limited capacity to accommodate oversize and overweight vehicles that would transport rail/intermodal casks from a shutdown site to a nearby rail siding or spur. Owners of sites such as Yankee Rowe and Connecticut Yankee, who have contracted for the use of heavy haul vehicles to move heavy equipment from their sites to rail sidings or spurs, report that travel times can be expected to be 8 hours or more even for distances of less than 10 miles. In addition, the heavy haul vehicle would likely block the flow of traffic on most local roads because of its size and because the roads often have two relatively narrow (10- or 12-feet) lanes and limited shoulders. Thus, one or more alternate routes must be available for use by local traffic at times when the heavy haul vehicle is on the road.

Additional requirements for roads that would be used by heavy haul trucks include the following:

- Overhead clearances must be (or be moveable or clearable to) 15 feet or greater above the roadway.
- The side-to-side width of the narrowest section of a road should be sufficient to allow passage of a 14-foot-wide vehicle.
- Curves and corners must have sufficient inside clearances to allow a 100-foot-long center section of a heavy haul vehicle to negotiate the turns without interference (the greatest requirement is for a clearance of 34 feet on the inside of a 90º corner for a 20-foot-wide road).
- Bridges, bridge supports, dam crossings, and culverts must be capable of supporting the distributed load of the heavy haul vehicle (approximately 4,000 lb. [2 tons] per lineal foot of roadway) or must have spans that are short enough to allow use of jumper bridge-deck reinforcements.
- Road sub-grade and pavement must be firm and stable and be capable of supporting the distributed load of the heavy haul vehicle (approximately 4,000 lb. [2 tons] per lineal foot of roadway over a length of 100 feet). Weak areas of roadway may be temporarily improved by use of top-ballast or jumper reinforcements.

3.3 Navigable Waterway Requirements

Off-site navigable waterways that might be used by barge operators to transport rail/intermodal casks could be accessed directly from on-site barge landings at the Maine Yankee, Trojan, and La Crosse sites; from on-site canals that connect on-site landings to a waterway at the Connecticut Yankee and Crystal River sites; or from off-site landings where rail/intermodal casks would arrive on heavy haul trucks and be off-loaded onto barges at the Humboldt Bay and Kewaunee sites. Barge landings may be docks or unimproved shorelines. Barges might be loaded at shorelines along navigable waterways. The Humboldt Bay, Big Rock Point, and San Onofre sites have unimproved shorelines that might be used to land barges.

Requirements for using navigable waterways to ship rail/intermodal casks containing used nuclear fuel include the following:

- The waterway is an inland or inter-coastal navigable waterway used by commercial maritime traffic and is maintained by the U.S. Army Corps of Engineers, port authorities, or other federal authorities (e.g., Tennessee Valley Authority).
- Docks or shoreline landings for barges must have securing stanchions or other securing points adequate for securing a barge (sea-going, lake, or river barge, depending on the route) having a minimum cargo capacity of 2,000 deadweight tons.
- Navigation from a dock or shoreline landing (where rail/intermodal casks would be on- and off-loaded to and from barges) to the navigable section of the waterway is direct and can be determined by inspection of maritime charts to be safe and clear of marine hazards.

4. ACTIONS NECESSARY TO REMOVE USED NUCLEAR FUEL FROM SHUTDOWN SITES

The Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (DOE 2013) includes siting, designing, licensing, constructing and operating a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shutdown reactor sites. The strategy also includes a phased, adaptive, and consent-based approach to siting. New statutory authority would be required to construct an interim storage facility, but DOE's existing authorities would allow the DOE to begin a consent-based siting process.

The tasks that would need to be undertaken to remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites may be divided into two phases: 1) programmatic activities to prepare for transport operations from a shutdown site, and 2) operational activities to prepare, accept, and transport from a shutdown site. Table 4-1 provides a high-level summary of the tasks that would take place during these two phases. The tasks are described in the following sections. In the descriptions of these tasks, the terms "accept" or "acceptance" are sometimes used. In this report, these terms mean that a shipment has been properly prepared for transport. It should be noted that DOE has not made any decisions regarding the priority or preference for removing used nuclear fuel from shutdown sites.[29]

Table 4-1. Activities to Prepare for and Remove Used Nuclear Fuel from Shutdown Sites

Task	Task Activity Description
Programmatic Activities to Prepare for Transport Operations from a Shutdown Site	
1. Assemble Project Organization	Assemble management teams, identify shutdown site existing infrastructure, constraints, and transportation resource needs and develop interface procedures.
2. Acquire Casks, Railcars, Ancillary Equipment, and Transport Services	Develop specifications, solicit bids, issue contracts, and initiate preparations for shipping campaigns. Includes procurement of transportation casks and revisions to certificates of compliance as may be needed, procurement of AAR Standard S-2043 railcars, and procurement of off-site transportation services.
3. Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport for shutdown site.
4. Coordinate with Stakeholders	Assess and select routes and modes of transport and support training of transportation emergency response personnel.
5. Develop Campaign Plans[a]	Develop plans, policies, and procedures for at-site operational interfaces, support operations, and in-transit security operations.
Operational Activities to Prepare, Accept, and Transport from a Shutdown Site	
6. Conduct Readiness Activities	Assemble and train at-site operations interface team and shutdown site workers. Includes readiness reviews, tabletop exercises and dry run operations.
7. Load for Off-site Transport	Load and prepare loaded casks and place on transporters for off-site transportation.
8. Accept for Off-site Transport	Accept loaded casks on transporters for off-site transportation.
9. Transport	Ship shutdown site casks.

AAR = Association of American Railroads
a. A campaign plan contains step-by-step, real-time instructions for completing a shipment from an origin site.

[29] The Secretary of Energy has discretion under the Standard Contract to decide whether to give priority acceptance to used nuclear fuel at shutdown sites [10 CFR 961.11, Article VI.B.1.(b)].

It should be noted that the tasks listed in Table 4-1 are based on the assumption that DOE or another management and disposal organization would be responsible for shipping to, and the operation of, the pilot interim storage facility. These tasks might differ if a private entity were responsible for shipping to, or the operation of, the pilot interim storage facility. In addition, it is assumed that any refurbishment or upgrade of on-site infrastructure required prior to receipt of equipment for loading and transportation will be performed by the shutdown site organization to facilitate timely shipping of used nuclear fuel and GTCC low-level radioactive waste from the site.

4.1 Programmatic Activities to Prepare for Transport Operations from a Shutdown Site

Activities that would need to be taken to prepare for transport operations at each of the shutdown sites and to ship the fuel to an off-site destination can be rolled up to the first five major groups of activities listed in Table 4-1.

4.1.1 Task 1 – Assemble Project Organization

For the initial project organization, it would be necessary to assemble the personnel and supporting resources to begin planning, collecting information, conducting analyses, developing interface procedures, and undertaking other preparations to remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites. These activities would establish organizations, policies, plans, and procedures necessary for the project to begin the work necessary to acquire and qualify the physical and personnel resources that would be needed to make the shipments of used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

Among the key activities would be to develop and implement the quality assurance plan for

- acquisitions of transportation casks and safety-related components
- selection and training of management and operations personnel
- used nuclear fuel transportation interface operations
- transportation cask maintenance and support operations.

At a minimum, the quality assurance plan would meet the requirements of 10 CFR Part 71, Subpart H.

Another key activity would be to establish interface procedures for each of the shutdown sites. Areas addressed in these interface procedures could include

- description of the transportation casks, associated equipment, and transportation vehicles/conveyances that would be delivered to the shutdown site
- delivery of transportation casks and associated ancillary equipment to the shutdown site
- description of the assistance available to train and advise site personnel regarding the operation and use of transportation casks and ancillary equipment at the shutdown site

- descriptions of the used nuclear fuel and GTCC low-level radioactive waste that would be loaded into the transportation casks at the shutdown site
- descriptions of the canisters that contain the used nuclear fuel and GTCC low-level radioactive waste that, with their contents, would be loaded into transportation casks by the shutdown site operations organization.

During this stage, it is assumed that any necessary site work and equipment acquisitions would occur in a timely manner to support transportation operations. In general, it would be necessary for DOE or another management and disposal organization to determine its transportation resource needs and assemble the organizational elements needed to be capable of transporting used nuclear fuel from each shutdown site and to conduct efficient campaigns of shipments from the sites. To ensure effective coordination of planning, preparatory, and operational activities for shipping used nuclear fuel from the shutdown sites, the resulting organization would establish communications and working interfaces with the organizations responsible for each of the shutdown sites.

4.1.2 Task 2 – Acquire Casks, Railcars, Ancillary Equipment, and Transport Services

It would be necessary to acquire a fleet of transportation casks, ancillary equipment and railcars to conduct the shipping campaigns from the shutdown sites. In the acquisition of transportation casks from cask vendors, transportation certificates of compliance would be updated, as is necessary, to accommodate all used nuclear fuel to be shipped from the shutdown sites (including damaged fuel assemblies in fuel control dry shielded canisters in storage at the Rancho Seco site) and GTCC low-level radioactive waste that is stored in canisters at the shutdown sites.

Technical specifications would need to be developed for each kind of transportation cask and for major separable components (e.g., impact limiters) as well as the cask's associated ancillary equipment and consumables. There would be a minimum of eight procurement specifications for the eight kinds of transportation casks, components, ancillary equipment, and consumables that would need to be procured.

In addition, specifications would be developed for railcars that would be needed to transport the transportation casks. Three kinds of railcars would need to be procured: railcars for transportation casks, buffer cars, and escort cars. Based on previous transportation planning conducted for used nuclear fuel shipments (DOE 2009), all three types of railcars would be specially designed cars that would need to be tested to verify their conformance to AAR Standard S-2043 (AAR 2008); however, it may be possible to use empty cask cars as buffer cars, reducing the types of railcars that would need to be procured. Testing services would need to be procured for the railcars.

Because the transportation casks that would be used to transport used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites would be similar in size and weight, it is possible that only one design for a cask railcar would be needed. It may also be possible to use, with only minor modifications, the design and specification developed and qualified by the

U.S. Navy for railcars it is procuring for the shipment of M-290 transportation casks for naval used nuclear fuel. In addition, it may be possible to adopt the design and specification being developed by the U.S. Navy for escort railcars. A buffer railcar design may be jointly developed with the Navy.

To obtain AAR's full approval that the three types of railcars perform in accordance with the provisions of the AAR Standard, it would be necessary to conduct tests which demonstrate that all car types in the consist comply with the requirements of AAR Standard S-2043; 100,000 miles of in-service use is also required.

Last, it would be necessary to procure transportation services for the off-site transportation of casks that contain used nuclear fuel and GTCC low-level radioactive waste and for unloaded casks that would be returned to shutdown sites for loading. These services will include long-haul transport services provided by Class I (Mainline), Class II (Regional), and Class III (Short Line) railroads as well as services provided by operators of heavy haul trucks, barge and port operators, and heavy lift equipment operators for transloading operations. The services of private security companies for physical security services in all stages of transit from departure from the shutdown sites to delivery to a destination site may also be procured. In-transit security personnel may also be accompanied by health physics support personnel if it is determined that this is required.

4.1.3 Task 3 – Conduct Preliminary Logistics Analysis and Planning

In this task, the information needed to estimate the amount of time that would be required to load and ship casks containing used nuclear fuel and GTCC low-level radioactive waste from each of the shutdown sites would be collected. It would also be necessary to estimate the time that would be required at the destination facility to receive, unload, inspect, and maintain, and return casks for their next shipments.

The time required for loading and preparing a cask for transportation is expected to be unique for each of the shutdown sites. The differences would arise because of differences in the resources that the sites may deploy and differences in the transportation casks that would be used. Examples of such differences include the number of transfer casks that could be used to transfer canisters from storage modules to transportation casks that are available at a site, and whether it would be necessary to move the loaded transportation casks from the loading station to the transport vehicle, e.g., on-site transfer onto a barge such as may occur at the Connecticut Yankee site versus directly onto a railcar, which would be expected to occur at the Maine Yankee, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, San Onofre, and Vermont Yankee sites. In addition, at the Humboldt Bay site the canisters that contain used nuclear fuel and GTCC low-level radioactive waste are stored in HI-STAR HB transportable overpacks, thereby making transfers from storage modules to transportation casks unnecessary. It would still be necessary to conduct inspections and tests to verify that the HI-STAR HB casks comply with the requirements of their certificates of compliance before shipments can be made. In addition, it would be necessary to install impact limiters on the HI-STAR HB casks, place the casks onto transport skids, and load the assembled transport packages onto a transport vehicle at the site.

The amount of time that would be required to transport loaded and unloaded casks from and to the shutdown sites, and to and from a destination site would also vary among the shutdown sites. Some of the differences would be because the travel distances to a destination site from the shutdown sites would be different. Other differences among the shutdown sites could have a greater influence on time in transit for shipments than the distance from the destination site. For example, if it is necessary to use heavy haul trucks to transport HI-STAR HB casks 160 to 280 miles from the Humboldt Bay site to a nearby rail siding or spur and then transfer the casks to railcars to complete the transport to a destination site, the time in transit would be significantly different than that for shipments from the Trojan or Rancho Seco sites in the western states region of the United States. The Trojan and Rancho Seco sites have direct access to a railroad and thus would be able to load casks onto railcars at the sites.

Conversely, shipments from the Humboldt Bay site would be one-way movements with no return of the transportation casks to the site for reloading whereas shipments of transportation casks from all eleven of the remaining sites would require returns of unloaded transportation casks for reloading. At the Connecticut Yankee, Yankee Rowe, Big Rock Point, and Kewaunee sites outbound loaded shipments would involve heavy haul truck or barge shipments to nearby rail sidings or spurs and transfers of casks from the heavy haul trucks, or possibly from barges, to railcars. Returning shipments of unloaded casks would require the reverse of the sequence for the outbound shipments. Barges could also be used to ship transportation casks to nearby rail sidings or spurs or ports from the Maine Yankee, La Crosse, and Trojan sites.

The above factors that would affect the time required to make shipments would also affect the transportation resource requirements and the resource requirements at the shutdown sites. The factors would also affect the durations of activities to remove used nuclear fuel and GTCC low-level radioactive waste from each of the sites and collectively from all of the shutdown sites. These factors along with the funding resources would be analyzed to assess the efficacy of alternative orders for shipments to be made from the shutdown sites and the numbers of each type of transportation cask (and components) and the number of cask cars, buffer cars, and escort cars to procure for each alternative set of assumptions. This information would be used to inform managers to support decisions regarding modes of transport, acquisition decisions, staffing decisions, and allocations of resources.

4.1.4 Task 4 – Coordinate with Stakeholders

Coordination with stakeholders on transport modes, routes, and training and preparedness of emergency response personnel would be an essential activity. It would build on similar coordination efforts currently supported by the DOE through the National Transportation Stakeholders Forum and through cooperative agreements with the four state regional groups (the Southern States Energy Board, the Western Interstate Energy Board, the Council of State Governments – Midwest , and the Council of State Governments – Eastern Regional Conference) and the National Conference of State Legislatures, which supports tribal engagement with DOE.

A key activity would be to develop and implement policy and procedures to provide technical and funding assistance to states and tribes that would be affected by the transport of used nuclear fuel through and near to their jurisdictions. In addition to developing and implementing procedures for technical and funding support to states and tribes for safe routine transportation and emergency response for transportation accidents, it is expected that the transportation operations organization would work with the affected states and tribes to determine the modes of transportation that could be used to move used nuclear fuel from the shutdown sites as well as the routes that would be used. This is expected to be a collaborative effort in which the transportation operations organization, transportation carriers, and the states and tribes would identify and weigh factors that would influence the selections to be made. Identification of the modes and routes to be used for the shipments, as well as procedures to be implemented to ensure and provide confidence that the shipments would be made safely, would be the objective of this activity.

4.1.5 Task 5 – Develop Campaign Plans

As activities progress to procure resources needed to conduct shipping campaigns from the shutdown sites, it would be necessary to plan for and assemble staff who would conduct shipment operations. This planning effort would include determining the structure and organization of the work to be performed to conduct shipment operations, acquiring and training the staff who would conduct operations, developing operational procedures, and establishing the necessary supporting organizational infrastructure.

The major elements of the work structure for the transport operations activities would include transportation fleet management, shipping campaign management, and in-transit operations management. Sub-elements within these three management elements would include:

- transportation cask, ancillary equipment, and railcar maintenance and servicing
- campaign kit assembly and distribution[30]
- scheduling and expediting of shipping campaigns including shipments (loaded and unloaded casks), equipment, field personnel, and in-transit security and safety escort personnel
- coordination of shipment notifications, in-transit tracking, in-transit physical security, and emergency response operations
- field services including technical support as required.

In addition to training that would be conducted to prepare for operations, activities for the operations staff before the transport operations begin would include:

- developing operations procedures
- establishing operational interfaces with the operations organizations at each of the shutdown sites
- establishing operational interfaces with officials of state, tribal, and local governments whose jurisdictions would be affected by transportation of used nuclear fuel from the shutdown sites
- establishing operational interfaces with transportation carriers and providers of special transportation services that may be needed

[30] Campaign kits are collections of special tools and equipment that would be needed at shipping sites to load and prepare casks for transport and at transload locations where casks would be transferred to and from railcars from and to another mode of transportation.

- establishing operational interfaces with the operator of the destination facility.

Establishing organizations (or elements matrixed from other organizations) that would support shipment operations activities would also be necessary. The support organizations would include: quality assurance, licensing and regulatory compliance (to ensure that certificates of compliance are current and encompass the used nuclear fuel that would be shipped), training, procurement, public information, and field engineering. Each of these supporting organizational elements would need to acquire its own staff and resources and develop its own policies, plans, and procedures that would be tailored to meet their unique needs.

4.2 Operational Activities to Prepare, Accept, and Transport from a Shutdown Site

The activities to prepare, accept, and transport used nuclear fuel from each of the shutdown sites are rolled up into the four major groups of activities listed in the second half of Table 4-1. These are expected to include tabletop exercises that would support training for shipments and dry run activities at shipping sites and at transload locations. These readiness activities would be followed by loading of casks at the shutdown sites, acceptance of the casks loaded and prepared for transport, shipment of the casks to the destination facility, inspection and maintenance of casks following shipment, and return of unloaded casks to shipping sites.

4.2.1 Task 6 – Conduct Readiness Activities

Tabletop exercises would involve the transportation operations organization and the shutdown site operations organization along with participation by state, tribal, and local officials. It is also anticipated that in-transit tabletop exercises would involve participation by transportation planning and operations organizations and officials from affected states, tribes, and local governments. The tabletop exercises would be in-office drills designed to identify gaps in planning, procedures, and training for the full sequence of operations that would be involved in making shipments of used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites to a destination facility. These exercises would be developed jointly by the operations, training, and quality assurance organizations.

Following the tabletop exercises, the transportation and shutdown site operations organizations would conduct dry run operations to establish the operational basis for determining readiness to make shipments. The dry run operations would not involve removal of canisters containing used nuclear fuel from storage systems but would otherwise involve the full sequence of operational steps. These steps would include handling, loading, and preparation of casks for shipment; loading of the casks onto transport vehicles; and transloading of casks from heavy haul trucks or barges to railcars and the reverse operation.

Readiness reviews would be conducted jointly by the transportation operations organization, the shutdown site operations organization, and transportation service operators to review the results of tabletop and dry run activities and to verify that open issues identified in these exercises have been appropriately resolved. Readiness reviews would also be conducted with state, tribal, and local officials to ensure that there are no outstanding issues that would need to be addressed to ensure effectiveness of emergency response and in-transit security operations that the transited jurisdictions may provide.

4.2.2 Task 7 – Load for Off-site Transport

Shutdown site operations organizations would remove the transportable dry storage canisters containing used nuclear fuel or GTCC low-level radioactive waste from on-site storage systems, load the canisters into transportation casks, prepare the loaded casks for shipment, and load the prepared casks onto transport vehicles.[31] Unloaded casks would be delivered to each of the shutdown sites either on railcars, heavy haul trucks, or barges. Following delivery of unloaded casks, it is assumed that each shutdown site operations organization

- receives casks at its site, prepares the casks to be loaded and verifies the casks are suitable for loading with canisters that contain the site's used nuclear fuel
- is registered with the NRC as a user of the transportation cask that would be loaded at the site
- uses equipment designed by the vendor of the storage system and transportation cask and follows on-site procedures to transfer canisters containing used nuclear fuel or GTCC low-level radioactive waste from its on-site storage system into the transportation cask body
- prepares the transportation cask for shipment including assembly of all components and conduct of tests to verify proper assembly for shipment specified by the cask's certificate of compliance
- places the transportation cask on a shipping skid/cradle, load the cask-on-cradle unit onto the transport vehicle, and provides the documentation required to verify that the shipment has been properly packaged for off-site transportation
- takes an average of up to one calendar week to complete the sequence of operations from receipt of an unloaded cask through to delivery of the cask for off-site transportation.

Used nuclear fuel at the Humboldt Bay site is stored in storage/transport canisters in HI-STAR HB cask bodies. The HI-STAR HB cask, when impact limiters are attached, is certified by NRC to transport the used nuclear fuel from the Humboldt Bay site. Thus, the site's operator would not have to transfer canisters from a storage system to a transportation cask. Nonetheless, the shutdown site operations organization would be required to remove the already-loaded HI-STAR HB casks from their sub-grade storage locations, complete assembly of the casks for transport including installing impact limiters, conduct pre-shipment tests that are specified in the cask's certificate of compliance, load the casks onto transport vehicles, and provide the documentation required to verify that the shipment of used nuclear fuel has been properly packaged for off-site transportation.

4.2.3 Task 8 – Accept for Off-site Transportation

At each of the shutdown sites and for each cask shipped from the sites, the transportation operations organization would accept loaded casks that have been prepared for shipment and

[31] Under the Standard Contract (10 CFR 961.11), DOE is obligated to accept only bare used nuclear fuel. Acceptance of canistered used nuclear fuel would require an amendment to the Standard Contract.

placed onto transport vehicles. The transportation operations organization would also take possession of and title to the used nuclear fuel or GTCC low-level radioactive waste that is contained in the casks at the same time it accepts the loaded cask for shipment.[32] For each such shipment, preparation would be made in advance to ensure that the contents of the shipment are verified and that the requirements of the transportation certificate of compliance have been met. The transportation operations organization field operations staff would inspect documentation for each shipment that has been prepared and provided by the owner of the shutdown site and, as appropriate, conduct physical inspections of the loaded transportation cask on its transport vehicle.

4.2.4 Task 9 – Transport

The complexity of off-site transportation of casks containing used nuclear fuel or GTCC low-level radioactive waste from the shutdown sites would vary among the sites. Shipment operations from sites that would require use of heavy haul trucks or barges to move casks to nearby rail sidings or spurs would be significantly more complex than those from sites where the casks could be directly loaded onto railcars for off-site shipment. In addition, sites where there is a practical limit of one or two casks that can be placed on railcars for shipment in a single train would require a greater application of resources than would be the case for sites that have on-site rail spurs that can accommodate many railcars and connect to a railroad that can accommodate trains hauling five or more of the heavily loaded cask cars.

Shipment operations would involve advance scheduling and notification of state and tribal governments; coordination among the transportation physical security force and state, tribal, and local security officials; coordination between transportation companies and the transportation operations organization for shipments that involve intermodal operations; and cross-country coordination among the rail carriers and the transportation operations organization to ensure that shipment schedules are known and maintained. The transportation operations organization would use satellite tracking to monitor the progress of each shipment containing used nuclear fuel or GTCC low-level radioactive waste en route. The transportation operations organization may also use satellite tracking along with expediting services to expedite return shipments of unloaded casks to shutdown sites.

In-transit operations for shipments of used nuclear fuel and GTCC low-level radioactive waste would principally involve real-time tracking of shipment locations and deployment of physical security personnel, and possibly radiological safety technicians, who would observe shipments from the escort railcars that would be included in each used nuclear fuel rail shipment.

The transportation operations organization would maintain an emergency operations center that would maintain readiness to direct resources to respond to any in-transportation event that may occur during shipment of used nuclear fuel or GTCC low-level radioactive waste from the shutdown sites. The emergency operations center would coordinate U.S. Government response efforts with those of state, tribal, and local officials in a jurisdiction that may be involved.

[32] Before such acceptance, the shutdown site operations organization would need to have an amendment to the Standard Contract permitting it to present canistered rather than bare used nuclear fuel for acceptance for transportation and an interim storage facility would have to be operational.

A typical shipment of loaded casks containing used nuclear fuel or GTCC low-level radioactive waste would require 1 to 2 weeks of transit time to complete. Shipments over distances of 500 to 1,000 miles and where railcars are loaded at shipping sites would generally be completed in about 1 week. Shipments over distances that exceed 1,000 miles and that require use of intermodal transportation would generally require about 2 weeks. Based on the experience of the U.S. Navy, shipments of unloaded casks returning to a site for reloading, if not expedited, can require up to a month.

4.3 Results

In this section, representative time sequences of activities listed in Table 4-1 and their durations were developed for scenarios involving removing used nuclear fuel from one shutdown site and for removing used nuclear fuel and GTCC low-level radioactive waste from the Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion sites.[33]

4.3.1 Removal of Used Nuclear Fuel from One Shutdown Site

In this section, representative time sequences of activities listed in Table 4-1 and their durations were first developed for four scenarios involving a single site that was assumed to be served by a railroad. For the purposes of this analysis, Maine Yankee was assumed to be representative, where 60 canisters of used nuclear fuel and 4 canisters of GTCC low-level radioactive waste are stored. The Maine Yankee site was used in constructing this scenario only for the purposes of analysis. DOE has not made any decisions regarding the priority or preference for removing used nuclear fuel from shutdown sites.

The four scenarios are described as follows:

In the first scenario used nuclear fuel was removed from one shutdown site. The time sequence presented in this scenario provides an initial estimate of the duration for key activities and the total duration for removing used nuclear fuel and GTCC low-level radioactive waste from a single site that is served by a railroad. For the purposes of the scenario, the analysis assumed that DOE would procure five transportation casks that would be dedicated to shipping used nuclear fuel and GTCC low-level radioactive waste from the site. The time durations used for the scenario were based on conservative estimates of the time durations for tasks. Figure 4-1 illustrates the time sequence of activities and their estimated durations for this scenario.

The second scenario was similar to the first scenario, but optimistic estimates of the time durations for tasks were used. Figure 4-2 illustrates the time sequence of activities and their estimated durations for this scenario.

The third scenario that assumed that DOE would procure 10 casks that would be dedicated to shipping used nuclear fuel and GTCC low-level radioactive waste from the site, and that would be operated in two, five-cask trains. The time durations used for the scenario were based on

[33] These representative time sequences are to be used for planning purposes only and shall not be construed as binding in any way on DOE.

conservative estimates of the time durations for tasks. The fourth scenario was similar to the third scenario, but optimistic estimates of the time durations for tasks were used.

Figure 4-3 presents the total time durations for the four scenarios for comparison. The estimated time from the start of the project to the completion of the last shipment of used nuclear fuel and GTCC low-level radioactive waste from this single site was shown to range from 6.2 years to 11.2 years. The estimated durations were most affected by the time required to procure casks, components, and campaign kits, and the time required to develop and procure railcars that meet AAR Standard S-2043 (AAR 2008). For procuring casks, components, and campaign kits, the estimated time durations ranged from 36 to 48 months. For procuring railcars that meet AAR Standard S-2043, the estimated time durations ranged from 36 to 66 months.

As illustrated in Figure 4-1 and Figure 4-2 the tasks to procure casks and railcars were assumed to take place in parallel. The Humboldt Bay site does not require the procurement of casks, although procurement of impact limiters and S-2043 compliant railcars would be required. Because the amount of time required to obtain AAR approved railcars would be independent of the site from which shipments were made, and because obtaining AAR-approved railcars is a critical path activity, the total time required for a project to remove used nuclear fuel and GTCC low-level radioactive waste from the Humboldt Bay site would not be significantly shorter than that for the single site example and would range from about 5 to 6 years.

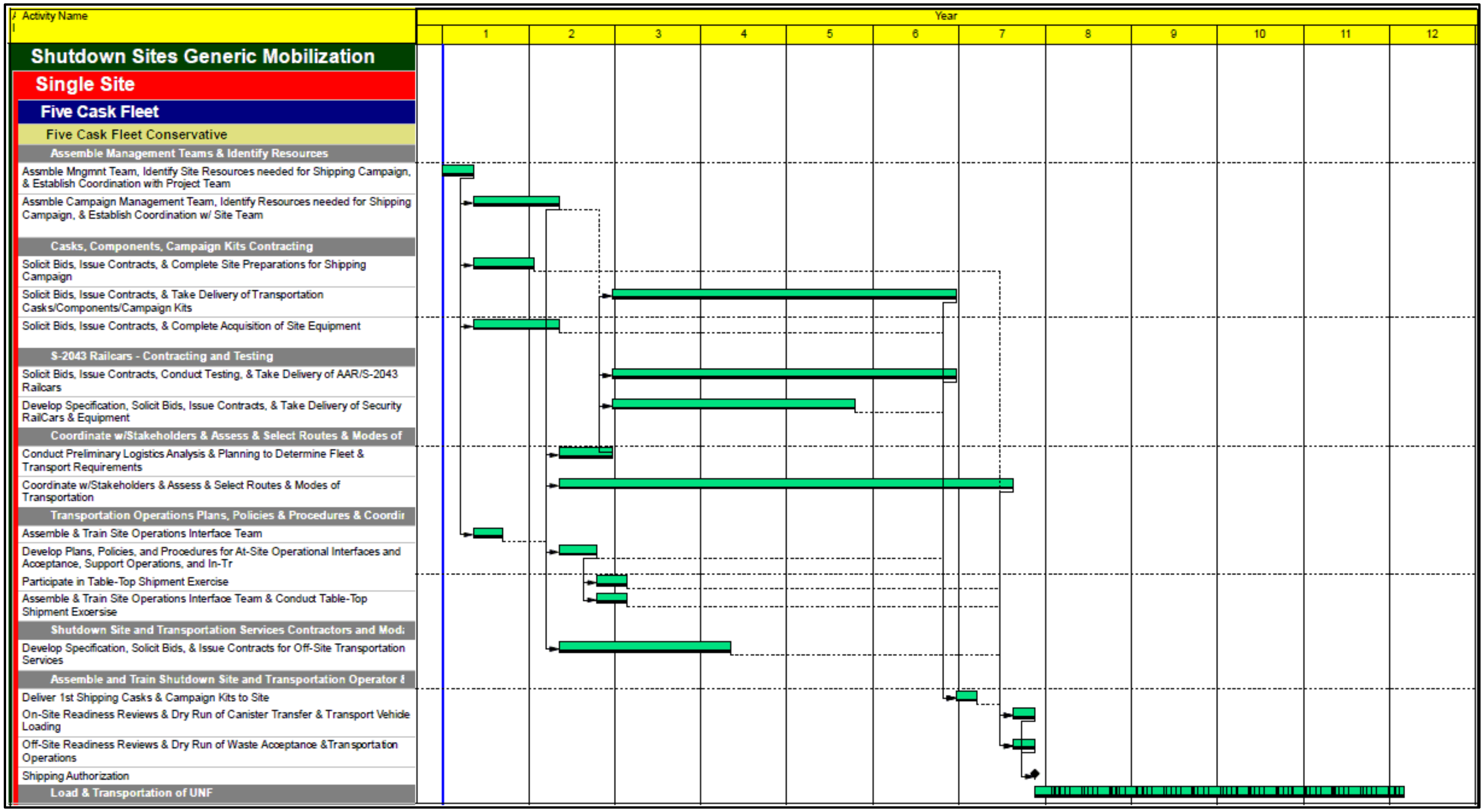


Figure 4-1. Time Sequences of Activities and Estimated Durations to Prepare for and Remove Used Nuclear Fuel from a Single Shutdown Site Based on Five Casks and Conservative Task Durations

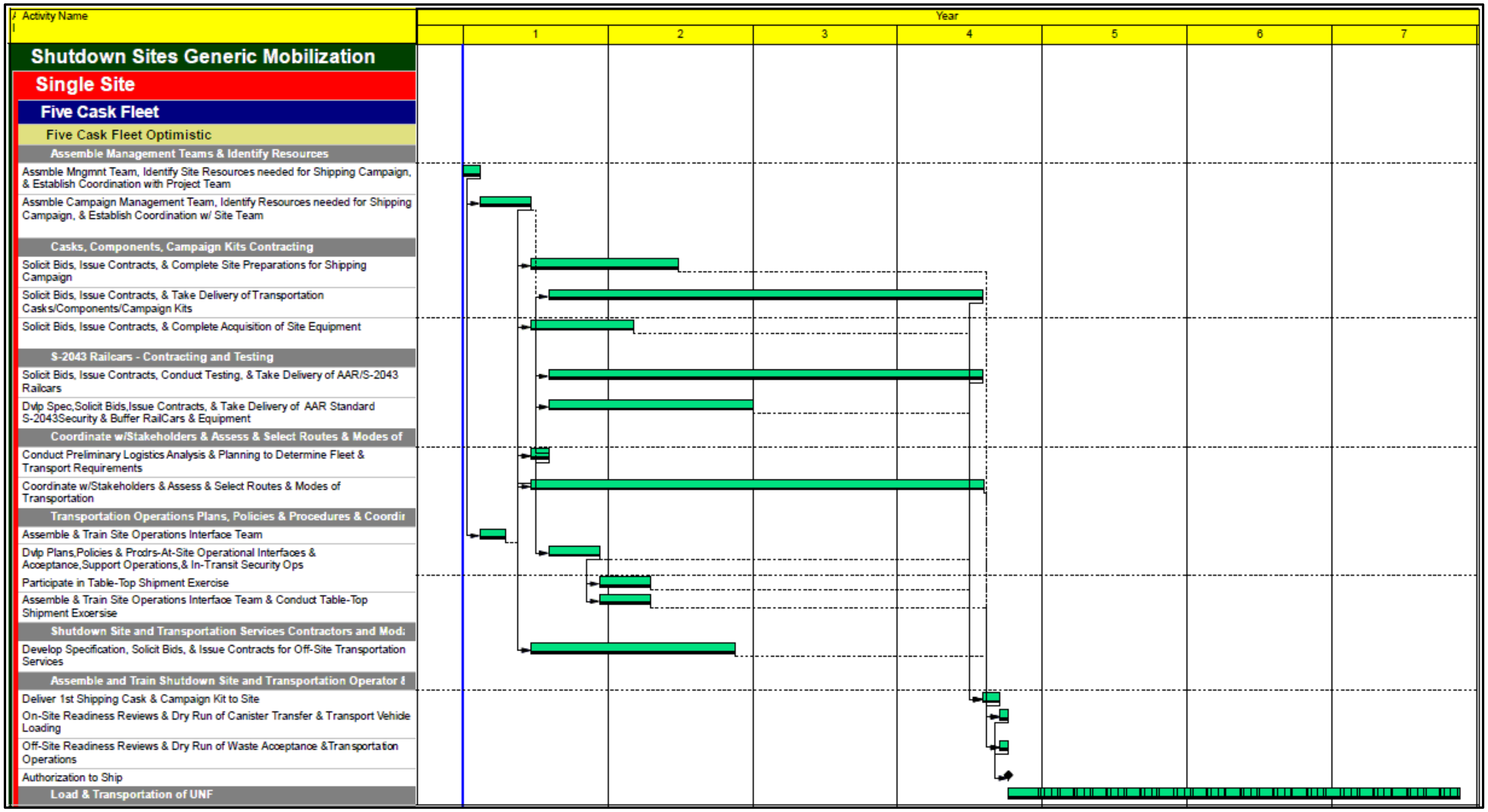


Figure 4-2. Time Sequences of Activities and Estimated Durations to Prepare for and Remove Used Nuclear Fuel from a Single Shutdown Site Based on Five Casks and Optimistic Task Durations

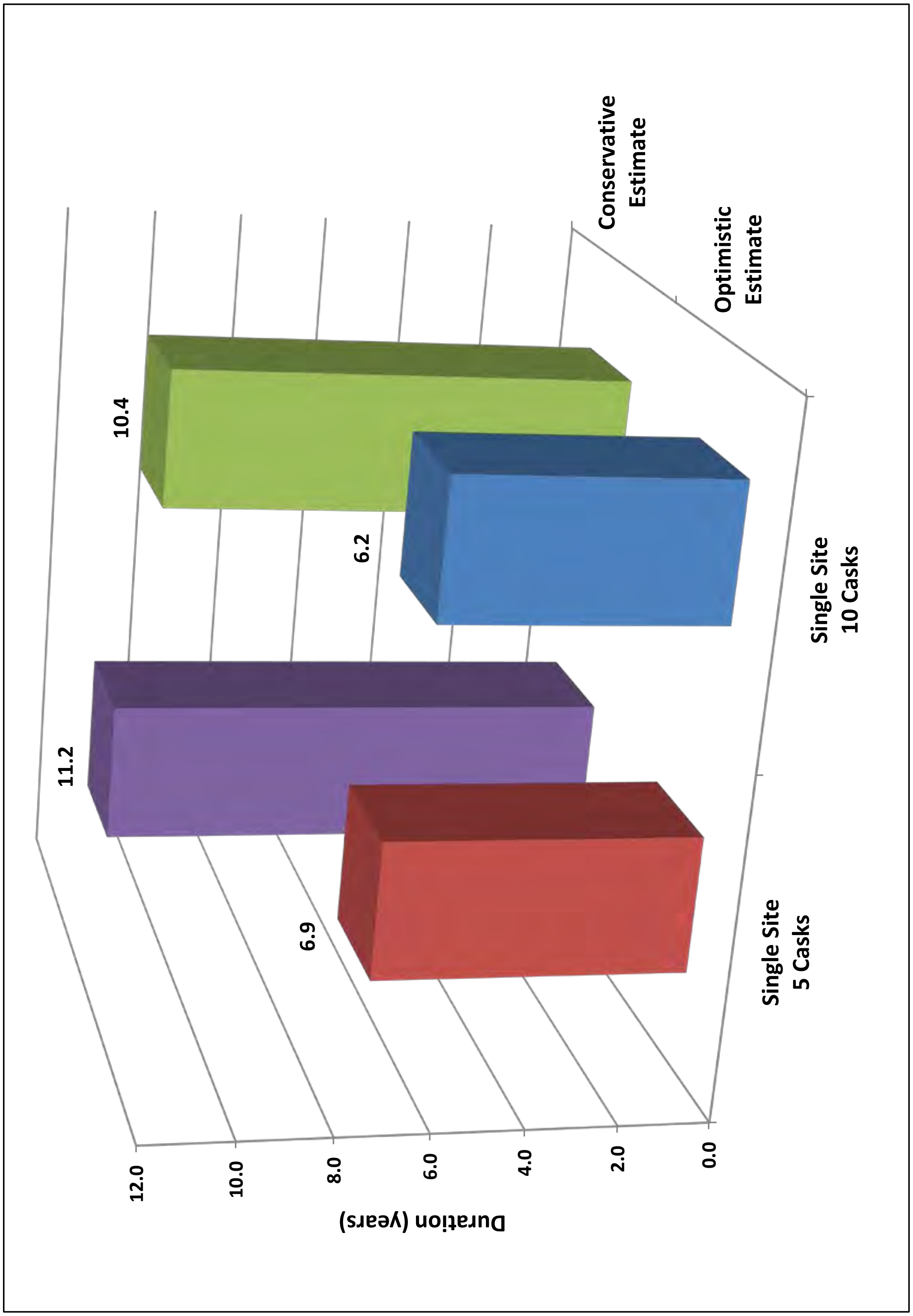


Figure 4-3. Estimated Time Durations for Four Scenarios to Prepare for and Remove Used Nuclear Fuel from a Single Shutdown Site

4.3.2 Removal of Used Nuclear Fuel and GTCC Low-Level Radioactive Waste from Nine Shutdown Sites

Figure 4-4 shows the representative durations and sequence of activities to prepare for and remove all used nuclear fuel and GTCC low-level radioactive waste from the Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion sites. The cumulative duration of 11.5 to 14.5 years shown in Figure 4-4 for the project to prepare for and remove all used nuclear fuel and GTCC low-level radioactive waste from the sites includes the schedule uncertainty associated with procurement of casks (4.5 to 5.5 years) and railcars (4 to 5 years) and coordination of shipping campaigns (7 to 10 years). The representative durations and sequence of activities shown in Figure 4-4 do not include Crystal River, Kewaunee, San Onofre, and Vermont Yankee because these sites only recently shut down, are at the beginning stages of the decommissioning process, and generally do not have fully developed irradiated fuel management plans or post-shutdown decommissioning activities reports. These factors make estimates of time durations for removing the used nuclear fuel and GTCC low-level radioactive waste from these sites less certain.

Project activities that would precede shipments from all shutdown sites would require only a slightly greater amount of time than that which would be required for one shutdown site. This assumes that project resources (personnel, funding, and functions such as procurement and quality assurance) would be adequate to support concurrent acquisitions of transportation casks and associated components that would include several units of each of the eight transportation casks that would be used at the shutdown sites—the NAC-STC, NAC-UMS UTC, MP187, MP197HB, TS125, HI-STAR 100, HI-STAR HB, and MAGNATRAN; and to acquire and certify the fleet of AAR Standard S-2043 compliant railcars that would be needed. It also assumes that there would be flexibility in making acquisitions such as limited constraints on procuring casks and associated components from non-domestic suppliers.

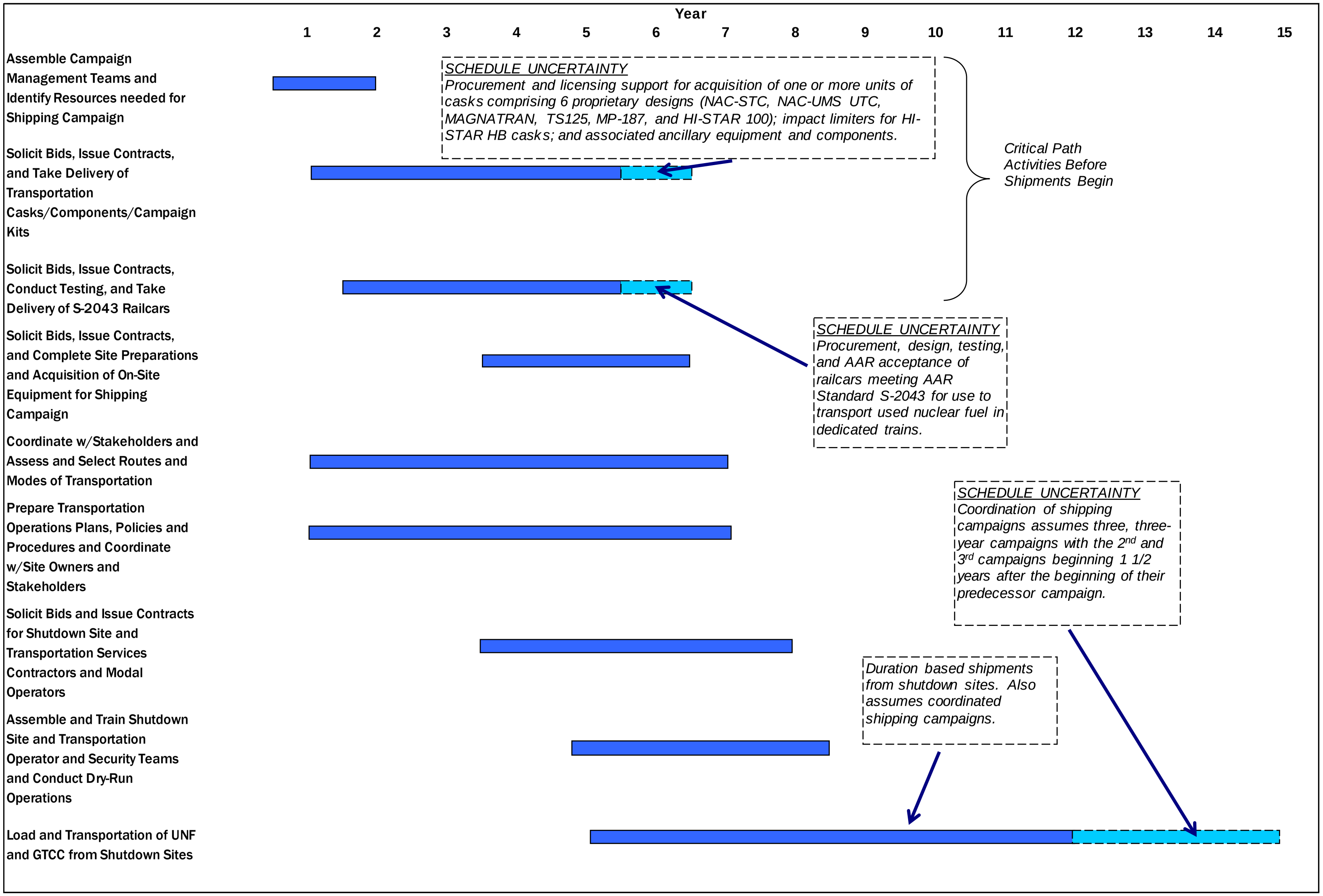


Figure 4-4. Estimated Durations of Key Activities to Prepare for and Remove Used Nuclear Fuel from Nine Shutdown Sites

5. CONCLUSIONS AND RECOMMENDATIONS

In this report, a preliminary evaluation of removing used nuclear fuel from 13 shutdown sites was conducted. The evaluation was divided into four components:

- characterization of the used nuclear fuel and GTCC low-level radioactive waste inventory
- a description of the on-site infrastructure and conditions relevant to transportation activities
- an evaluation of the near-site transportation infrastructure and experience relevant to shipping transportation casks containing used nuclear fuel from the shutdown sites, including gaps in information
- an evaluation of the actions necessary to prepare for and remove used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

From the evaluations, time sequences of activities and time durations were developed for preparing for and removing the used nuclear fuel and GTCC low-level radioactive waste from a single shutdown site and for the Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion sites. Crystal River, Kewaunee, San Onofre, and Vermont Yankee were not included because these sites only recently shut down, are at the beginning stages of the decommissioning process, and generally do not have fully developed irradiated fuel management plans or post-shutdown decommissioning activities reports, which makes estimates of time durations for removing the used nuclear fuel and GTCC low-level radioactive waste from these sites less certain.

The 13 shutdown sites use designs from 4 different suppliers, including 11 different (horizontal and vertical) storage systems that would require 9 different transportation cask designs. Several issues were identified with the used nuclear fuel and GTCC low-level radioactive waste inventory at the shutdown sites. The most important of the issues was that there are six damaged fuel assemblies in five of the storage canisters at Rancho Seco that were not placed in failed fuel dry shielded canisters. Further evaluation would be needed to determine if the canisters containing this damaged fuel can be shipped in the MP187 transportation cask without repackaging. In addition, the transportation certificate of compliance for the HI-STAR HB cask would need to be revised to allow transport of 44 used nuclear fuel assemblies at the Humboldt Bay site with initial enrichments of 2.08 weight percent, which is less than the minimum initial enrichment of 2.09 weight percent authorized by the transportation certificate of compliance for the HI-STAR HB cask.

The lists of approved contents in the certificates of compliance for the TS125, HI-STAR HB, HI-STAR 100, and MP187 transportation casks do not include GTCC low-level radioactive waste. For GTCC low-level radioactive waste to be shipped from the Humboldt Bay, Rancho Seco, San Onofre, and Vermont Yankee sites in these transportation casks, changes to the transportation certificates of compliance would be required. Also, the certificates of compliance for the TS125 and MP187 transportation casks would also need to be updated from a -85 to a -96 designation before the casks or impact limiters could be fabricated. In addition, the used nuclear fuel or GTCC low-level radioactive waste that may be stored in 32PTH2 canisters at San Onofre would not be transportable without changes to the list of approved contents in the certificate of compliance for MP197HB transportation cask.

Six of the sites, Maine Yankee, Zion, Crystal River, Kewaunee, San Onofre, and Vermont Yankee, have high burnup used nuclear fuel in storage. The 90 high burnup used nuclear fuel assemblies at Maine Yankee are packaged in Maine Yankee Fuel Cans (i.e., damaged fuel cans). This option for transporting high burnup used nuclear fuel is allowed by the certificate of compliance for the NAC-UMS UTC transportation cask (Docket No. 71-9270), and eliminates the concern over its transportability. For the Zion site, all high burnup fuel was packaged in damaged fuel cans. This also eliminates the concern over transportability of the 36 high burnup used nuclear fuel assemblies at Zion. High burnup used nuclear fuel stored in 32PTH1 canisters at Crystal River and 24PT4 canisters at San Onofre would be transportable in the MP197HB transportation cask. High burnup used nuclear fuel that will be stored in MPC-68 canisters at Vermont Yankee would not be transportable without changes to the list of approved contents in the certificate of compliance for the HI-STAR 100 transportation cask. An application for a certificate of compliance for the HI-STAR 190 transportation cask has been submitted to the NRC; high burnup used nuclear fuel that will be stored in MPC-37 canisters at San Onofre would be transportable if it is included in the list of approved contents in the certificate of compliance for the HI-STAR 190 transportation cask.

The used nuclear fuel at the shutdown sites was loaded into canisters and placed in ISFSIs as early as 2001. The initial storage licenses granted under 10 CFR Part 72 were for a period of 20 years, so renewals will need to occur starting in about 2018 to 2020. It is likely that the NRC will have questions about the condition of the stored used nuclear fuel during the storage license renewal process. In addition, transportation cask certificates of compliance are for 5-year periods, so these certificates will also need to be renewed on a regular basis. This will require a long-term commitment by the owners of the certificates of compliance to maintain these certificates.

Table 5-1 summarizes the mode options for transporting used nuclear fuel and GTCC low-level radioactive waste from the 13 shutdown sites. The modes listed in Table 5-1 were based on the evaluations of on-site transportation conditions, the near-site transportation infrastructure, and off-site transportation experience at the shutdown sites, particularly during large component removals during reactor decommissioning. An important observation regarding Table 5-1 is that all shutdown sites have at least one off-site transportation mode option for removing their used nuclear fuel and GTCC low-level radioactive waste, and some shutdown sites have multiple options. In addition, it is assumed that any refurbishment or upgrade of on-site infrastructure required prior to receipt of equipment for loading and transportation will be performed by the shutdown site organization to facilitate timely shipping of used nuclear fuel and GTCC low-level radioactive waste from the site.

Based on the activities and task durations presented in Section 4 of this report, preparing for and removing the used nuclear fuel and GTCC low-level radioactive waste from nine of the shutdown sites could be accomplished in 11.5 to 14.5 years (see Figure 4-4). This estimate did not include removing used nuclear fuel and GTCC low-level radioactive waste from Crystal River, Kewaunee, San Onofre, and Vermont Yankee. This time period was largely driven by the time required to load and transport the used nuclear fuel and GTCC low-level radioactive waste; procure casks, components, and campaign kits; and the time required to procure railcars that meet AAR Standard S-2043. While the latter two activities could take place in parallel, they still represent a significant fraction of the time it would take to prepare for and remove the used nuclear fuel and GTCC low-level radioactive waste from the shutdown sites.

Table 5-1. Summary of Transportation Mode Options for Shipments from Shutdown Sites

Site	Transportation Mode Options		Comments
Maine Yankee	Direct rail	Barge to rail	The on-site rail spur is not being maintained. The condition of the Maine Eastern Railroad would need to be verified
Yankee Rowe	Heavy haul truck to rail	–	The shortest heavy haul would be 7.5 miles to the east portal of the Hoosac Tunnel.
Connecticut Yankee	Barge to rail	Heavy haul truck to rail	The on-site barge slip has not been used since decommissioning but remains intact. It is uncertain whether the cooling water discharge canal is deep enough to accommodate barges without dredging. The shortest heavy haul would be about 12.5 miles to the end of the Portland rail spur. The rail infrastructure at the end of the Portland rail spur would need to be evaluated.
Humboldt Bay	Heavy haul truck to rail	Heavy haul truck to barge to rail	The heavy haul distance to a rail spur or siding would be in the range of 160 to 280 miles. The condition of the Fields Landing Terminal located two miles from the Humboldt Bay site would need to be verified for barge transport.
Big Rock Point	Heavy haul truck to rail	Barge to rail	The heavy haul would probably be about 52 miles to Gaylord, Michigan. A shorter heavy haul of 13 miles to Petoskey, Michigan may be possible. The rail infrastructure at these locations would need to be evaluated.
Rancho Seco	Direct rail	–	The rail spur is not being maintained. Weight restrictions on the Ione Industrial Lead would require route clearance by the railroad or a track upgrade.
Trojan	Direct rail	Barge to rail	The on-site rail spur was removed.
La Crosse	Direct rail	Barge to rail	The on-site rail spur was used to ship the reactor pressure vessel. The location and method for loading the transportation cask and moving the transportation cask to a rail spur is uncertain.
Zion	Direct rail	Barge to rail	The rail spur was recently refurbished to support reactor decommissioning waste shipments.
Crystal River	Direct rail	Barge to rail	Extensive on-site rail system serves co-located fossil fuel plants.
Kewaunee	Heavy haul truck to rail	Heavy haul truck to barge to rail	Condition of potential heavy haul truck routes, transload locations, and rail infrastructure would need to be evaluated.
San Onofre	Direct rail	Heavy haul truck to barge to rail	The rail spur was recently refurbished to support reactor decommissioning shipments for San Onofre-1.
Vermont Yankee	Direct Rail	–	On-site rail spur will be reactivated to support decommissioning.

As part of this preliminary evaluation, twelve shutdown sites have been visited: Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, and San Onofre. In order to confirm the information in this report and to refine the estimates of activities and task durations, it is recommended that the one remaining shutdown site (Vermont Yankee) be visited. As additional nuclear power reactor sites such as FitzPatrick, Pilgrim, and Oyster Creek shut down, these sites should be included in updates to the report.

The estimates of durations for project tasks presented here are preliminary and depend on the many identified assumptions. Consequently, in preparing a comprehensive project plan to prepare for and remove used nuclear fuel from the shutdown sites it will be necessary to refine the estimates using improved information regarding each of the sites and their near-site transportation infrastructure and using methods that will allow managers to gauge the importance of assumptions and project considerations. In this regard, it is recommended that DOE or another management and disposal organization use a quantitative risk analysis tool to provide estimates of project risks and opportunities. Such quantitative analyses would support estimating, managing, and funding of contingencies, and would increase confidence that the project would be successfully executed. Risk-informed estimates would also allow the project's managers to anticipate time and funding resources, and alternative courses of action that might be needed to effectively respond to changing circumstances.

DOE or another management and disposal organization should also take advantage of improved information regarding loading and transportation of used nuclear fuel from the shutdown sites to refine the data used by the DOE Transportation Operations Model (TOM) to evaluate optimizations that may be possible in acquiring and using transportation resources. TOM could also be used to conduct sensitivity analyses and identify important gaps in information that could be filled with additional data collected from the shutdown sites. Information developed using TOM could also be used in case studies conducted using the quantitative analysis tools discussed above.

6. REFERENCES

10 CFR Part 71. 2015. "Packaging and Transportation of Radioactive Material." *Code of Federal Regulations*, U.S. Nuclear Regulatory Commission. Available at http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR

10 CFR Part 72. 2015. "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." *Code of Federal Regulations*, U.S. Nuclear Regulatory Commission. Available at http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR

10 CFR Part 961. 2015. "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste." *Code of Federal Regulations*, U.S. Department of Energy. Available at http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR

49 CFR Part 213. 2014. "Track Safety Standards." *Code of Federal Regulations*, Federal Railroad Administration. Available at http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR

63 FR 67976-67979. December 9, 1998. "Northwestern Pacific Railroad; Emergency Order to Prevent Operation of Trains on Northwestern Pacific Railroad's Trackage from Arcata, California, to Mile Post 63.4 Between Schellville and Napa Junction, California." *Federal Register*, Federal Railroad Administration, FRA Emergency Order No. 21, Notice No. 1.

76 FR 27171-27172. May 10, 2011. "Northwestern Pacific Railroad Co.; Notice of Partial Relief from Emergency Order No. 21." *Federal Register*, Federal Railroad Administration, FRA Emergency Order No. 21, Notice No. 4.

AAR (Association of American Railroads). 2008. "Performance Specification for Trains Used to Carry High-Level Radioactive Material." Standard S-2043, *AAR Manual of Standards and Recommended Practices, Section C, Car Construction Fundamentals and Details.* Association of American Railroads, Washington, D.C. Amended by AAR Circular Letter C-10914, December 18, 2008; AAR Circular Letter C-11084, August 18, 2009; and AAR Circular Letter C-11113, October 23, 2009.

AC&T (American Cranes & Transport). 2011. *Site Report: Transport*. Vol. 7, Issue 7, pp. 38-39.

BRC. 2012. *Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy.* Prepared by the Blue Ribbon Commission on America's Nuclear Future for the U.S. Department of Energy, Washington, D.C.

Connecticut Yankee. 2012. "CY Snapshots." Accessed October 20, 2012 at http://www.connyankee.com/html/transformer.html.

Dempsey S and M Snyder. 2005. "Dispositioning Once-Through Steam Generators, An Engineering Solution Developed with Rancho Seco." WM'05 Conference Proceedings. February 27-March 3, 2005, Tucson, Arizona. Available at http://www.wmsym.org/archives/pdfs/5017.pdf.

Dietrich PT. 2013a. Letter from Peter T. Dietrich (Senior Vice President, Southern California Edison) to U.S. Nuclear Regulatory Commission. "Subject: Docket Nos. 50-361 and 50-362, Certification of Permanent of Power Operations, San Onofre Nuclear Generating Station Units 2 and 3." June 12, 2013. ADAMS Accession Number ML131640201.

Dietrich PT. 2013b. Letter from Peter T. Dietrich (Senior Vice President, Southern California Edison) to U.S. Nuclear Regulatory Commission. "Subject: Docket No. 50-361, Permanent Removal of Fuel from the Reactor Vessel, San Onofre Nuclear Generating Station Unit 2." July 22, 2013. ADAMS Accession Number ML13204A304.

Dietrich PT. 2013c. Letter from Peter T. Dietrich (Senior Vice President, Southern California Edison) to U.S. Nuclear Regulatory Commission. "Subject: Docket No. 50-362, Permanent Removal of Fuel from the Reactor Vessel, San Onofre Nuclear Generating Station Unit 3." June 28, 2013. ADAMS Accession Number ML13183A391.

DOE (U.S. Department of Energy). 2009. *National Transportation Plan*. Report No. DOE/RW-0603, Revision 0. Office of Civilian Radioactive Waste Management, Washington, D.C.

DOE (U.S. Department of Energy). 2013. *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*. Washington, D.C.

DSI (DeskMap Systems, Inc.). 2004. *Professional Railroad Atlas of North America*. Third Edition. Railroad Information Services. Austin, Texas.

EIA (Energy Information Agency). 2002. "2002 Form RW-859 Nuclear Fuel Data Survey Database." Energy Information Agency, Washington, D.C.

Elnitsky J. 2013. Letter from John Elnitsky (Vice President, Duke Energy) to U.S. Nuclear Regulatory Commission. "Subject: Crystal River Unit 3 – Post-Shutdown Decommissioning Activities Report." December 2, 2013. ADAMS Accession Numbers ML13340A009 and ML13343A178.

Entergy. 2014. *Vermont Yankee Site Assessment Study*. Available at http://vydecommissioning.com/document-library/

EPRI (Electric Power Research Institute). 1997a. *Yankee Rowe Decommissioning Experience Record: Volume 1*. EPRI Report Number TR-107917-V1, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 1997b. *Trojan PWR Decommissioning: Large Component Removal Project*. EPRI Report Number TR-107916, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 1998. *Yankee Rowe Decommissioning Experience Record: Volume 2*. EPRI Report Number TR-107917-V2, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2000. *Trojan Nuclear Power Plant Reactor Vessel and Internals Removal.* EPRI Report Number 1000920, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2005. *Maine Yankee Decommissioning – Experience Report: Detailed Experiences 1997-2004.* EPRI Report Number 1011734, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2005. *Decommissioning San Onofre Nuclear Generating Station Unit 1 (SONGS-1): Reactor Vessel Internals Segmentation*. EPRI Report Number 1011733, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2006. *Connecticut Yankee Decommissioning Experience Report: Detailed Experiences 1996-2006*. EPRI Report Number 1013511, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2007. *Rancho Seco Nuclear Generating Station Decommissioning Experience Report: Detailed Experiences 1989-2007*. EPRI Report Number 1015121, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2008a. *Rancho Seco Reactor Vessel Segmentation Experience Report*. EPRI Report Number 1015501, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2008b. *San Onofre Nuclear Generating Station – Unit 1 Decommissioning Experience Report: Detailed Experiences 1999-2008*. EPRI Report Number 1016773, Electric Power Research Institute, Palo Alto, California.

EPRI (Electric Power Research Institute). 2010. *Industry Spent Fuel Storage Handbook*. EPRI Report Number 1021048, Electric Power Research Institute, Palo Alto, California.

Fed. Cir. 2008a. *Yankee Atomic Electric Co. v. U.S.*, 536 F.3d 1268 (Fed. Cir. 2008)

Fed. Cir. 2008b. *Pacific Gas & Electric Co. v. U.S.*, 536 F.3d 1282 (Fed. Cir. 2008)

Feigenbaum T. 2005. "Maine Yankee Reactor Vessel Removal and Barge Transport." Presentation to the U.S. Department of Energy TEC Working Group, April 4-5, 2005, Phoenix, Arizona.

Franke JA. 2013. Letter from Jon A. Franke (Vice President, Crystal River Nuclear Plant, Duke Energy) to U.S. Nuclear Regulatory Commission. "Subject: Crystal River Unit 3 – Certification of Permanent Cessation of Power Operations and that Fuel Has Been Permanently Removed from the Reactor." February 20, 2013. ADAMS Accession Number ML13056A005.

Gilson D. 2005. "Old Rail Spur Reactivated, Railroad Moves Radioactive Materials from San Onofre." *Radwaste Solutions*, 12(2):20-26.

Gilson D and T Blythe. 2005. "Experiences in Rail Transportation of Radioactive Materials from San Onofre Nuclear Generating Station – Unit 1." In P*roceedings: 2004 EPRI International Low-Level Waste Conference and Exhibit Show*. EPRI Report Number 1011410, pp. 807-824. Electric Power Research Institute, Palo Alto, California.

Google, Inc. 2015. Google Earth (Version 7.1.5.1557). Available at http://www.google.com/earth/index.html.

Gretzner D. 2006. "Bye-Bye Big Rock." *Radwaste Solutions*, 13(6):12-16.

HBHRCD (Humboldt Bay Harbor, Recreation & Conservation District). 2012. Humboldt Bay Shipping Terminals. Accessed October 24, 2012 at http://www.humboldtbay.org/portofhumboldtbay/terminals/.

Herron JT. 2010. Statement of John T. Herron. Blue Ribbon Commission on America's Nuclear Future, Transportation and Storage Subcommittee Meeting, November 2, 2010, Chicago, Illinois.

IAEA (International Atomic Energy Agency). 2012. Power Reactor Information System (PRIS). Available at www.iaea.org/pris.

Johnson K. 2006. "Segmenting and Disposing of the Rancho Seco Reactor Vessel Internals." *Radwaste Solutions*, 13(5):37-50.

Lackey MB and ML Kelly. 1996. "The Trojan Large Component Removal Project." In *Proceedings of the ASME-JSME 4th International Conference on Nuclear Engineering 1996 (ICONE-4), New Orleans, Louisiana, March 10-14, 1996*, pp. 89-94.

Lackey MB and ML Kelly. 1997. "The Trojan Large-Component Removal Project." *Radwaste Magazine*, 4(1):11-17.

Leduc DR. 2012. *Dry Storage of Used Fuel Transition to Transport*. Report No. FCRD-UFD-2012-000253. U.S. Department of Energy, Washington, D.C.

Lessard L. 2000. "Safe from Start to Finish, The 1100-Mile Journey of the Yankee Rowe Reactor Pressure Vessel." *Radwaste Solutions*, 7(2):44-49.

Manzione K. 2015. Letter from Kimberly Manzione (Licensing Manager, Holtec International) to Mark Lombard (Director, Division of Spent Fuel Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission), "Application Request for a Certificate of Compliance (CoC) for Holtec's Model No. HI-STAR 190 Type B(U)F Transportation Package," August 7, 2015. ADAMS Accession Numbers ML15219A588, ML15219A589, ML15219A585, and ML15219A586.

Morgan R. 2015. "The Challenges Faced Moving Dimensional and Heavy Shipments." Presentation at Waste Management 2015, Session 73: US Motor Carrier Challenges in Transporting Radioactive Material, March 15-19, 2015, Phoenix, Arizona.

NAC. 1990. Facility *Interface Capability Assessment (FICA) Project Cask-Handling Assessment Big Rock Point Nuclear Plant*. DOE Records Information System Accession Number MOV.19980306.0048. NAC International, Norcross, Georgia.

NAC. 1991a. *Near-Site Transportation Infrastructure Project Draft Report and Assessment, Rancho Seco Nuclear Generating Station*. DOE Records Information System Accession Numbers MOV.20000107.0010, MOV.20000107.0011, MOV.20000107.0012, MOV.20000107.0013, MOV.20000107.0014, MOV.20000107.0015, MOV.20000107.0016, and MOV.20000107.0017. NAC International, Norcross, Georgia.

NAC. 1991b. *Near-Site Transportation Infrastructure Project Draft Report and Assessment, Trojan Nuclear Plant*. DOE Records Information System Accession Number MOV.20030710.0010. NAC International, Norcross, Georgia.

NAC. 2006. *NAC-STC Safety Analysis Report*. Volumes 1 and 2, Docket No. 71-9235, Revision 16, NAC International, Norcross, Georgia.

NRC (U.S. Nuclear Regulatory Commission). 2007a. *Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function*. Division of Spent Fuel Storage and Transportation Interim Staff Guidance – 1, Revision 2, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML071420268.

NRC (U.S. Nuclear Regulatory Commission). 2007b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 30, Regarding Vermont Yankee Nuclear Power Station, Final Report – Main Report*. NUREG-1437, Supplement 30. U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission). 2009. *Safety Evaluation Report*, Docket No. 72-11, Sacramento Municipal Utility District, Rancho Seco Independent Spent Fuel Storage Installation, License No. SNM-2510, Amendment No. 3. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML092240439.

NRC (U.S. Nuclear Regulatory Commission). 2011. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 44, Regarding Crystal River Unit 3 Nuclear Generating Plant, Draft Report for Comment*. NUREG-1437, Supplement 44. U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission). 2013. *2013-2014 Information Digest*. NUREG-1350, Volume 25. U.S. Nuclear Regulatory Commission, Office of Public Affairs, Washington, D.C.

Nutt M, E Morris, F Puig, S Gillespie, and E Kalinina. 2012. *Transportation-Storage Logistics Model – CALVIN (TSL-CALVIN): Users Manual*. Report No. FCRD- NFST-2013-000424. U.S. Department of Energy, Washington, D.C.

Petrosky T. 2004. "The Big Rock Vessel Goes to Barnwell." *Radwaste Solutions*, 11(1):15-18.

Radwaste Magazine. 1999. "Cruisin' Up the River, The Final Journey of the Trojan Reactor Vessel." *Radwaste Magazine*, 6(6):48-53.

Radwaste Solutions. 2000. "Moving to Another Stage of Life, Shipping, Decontaminating, and Final Disposition of the Maine Yankee Large Components." *Radwaste Solutions*, 7(5):50-55.

Radwaste Solutions. 2007. "La Crosse BWR Reactor Vessel Shipped to Barnwell." *Radwaste Solutions*, 14(5):30-32.

Redeker S. 2006. Letter from Steve Redeker (Manager, Plant Closure & Decommissioning, Rancho Seco Nuclear Plant, Sacramento Municipal Utility District) to Randy Hall (U.S. Nuclear Regulatory Commission). "Subject: Docket No. 72-11, Rancho Seco Independent Spent Fuel Storage Installation, License No. SNM-2510, Special Report Regarding a Violation of 10 CFR Part 72 Technical Specification 2.1.1." December 6, 2006. ADAMS Accession Number ML063470045.

SAIC (Science Applications International Corporation). 1991. *Historical Review of Domestic Spent Fuel Shipments–Update*. ORNL/Sub-88-997962/1. Oak Ridge, Tennessee.

Sampson, M. 2013. Letter from Michele Sampson (Chief, Licensing Branch, Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission) to Paul Triska (Transnuclear, Inc.), "Subject: Renewal of Certificate of Compliance No. 9255 for the Model No. NUHOMS MP187 Transportation Cask." August 9, 2013. Docket No. 71-9255, TAC No. L24774. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML13224A092.

Sampson, M. 2014. Letter from Michele Sampson (Chief, Licensing Branch, Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission) to Michael V. McMahon (AREVA, Inc.), "Subject: Revision No. 12 of Certificate of Compliance No. 9255, Docket No. 71-9255." March 7, 2014. Docket No. 71-9255, TAC No. L24890. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML14069A373.

Sartain MD. 2014a. Letter from Mark D. Sartain (Vice President-Nuclear Engineering, Dominion Energy Kewaunee, Inc.) to U.S. Nuclear Regulatory Commission. "Subject: Dominion Energy Kewaunee, Inc., Kewaunee Power Station, Update to Irradiated Fuel Management Plan Pursuant to 10 CFR 50.54(bb)." April 25, 2014. ADAMS Accession Number ML14119A120.

Sartain MD. 2014b. Letter from Mark D. Sartain (Vice President-Nuclear Engineering, Dominion Energy Kewaunee, Inc.) to U.S. Nuclear Regulatory Commission. "Subject: Dominion Energy Kewaunee, Inc., Kewaunee Power Station, Revision to Post-Shutdown Decommissioning Activities Report." April 25, 2014. ADAMS Accession Number ML14118A382.

Slimp B, M Papp, and PH Hoang. 2014. "Design and Analysis of Shipping Container for Big Rock Decommissioned Reactor Vessel." Proceedings of the ASME 2014 Pressure Vessels and Piping Conference, July 20-2014, Anaheim, California.

Stoddard DG. 2013a. Letter from Daniel G. Stoddard (Senior Vice President-Nuclear Operations, Dominion Energy Kewaunee, Inc.) to U.S. Nuclear Regulatory Commission. "Subject: Dominion Energy Kewaunee, Inc., Kewaunee Power Station, Certification of Permanent Cessation of Power Operations." February 25, 2013. ADAMS Accession Number ML13058A065.

Stoddard DG. 2013b. Letter from Daniel G. Stoddard (Senior Vice President-Nuclear Operations, Dominion Energy Kewaunee, Inc.) to U.S. Nuclear Regulatory Commission. "Subject: Dominion Energy Kewaunee, Inc., Kewaunee Power Station, Certification of Permanent Removal of Fuel from the Reactor Vessel." May 14, 2013. ADAMS Accession Number ML13135A209.

STB (Surface Transportation Board). 2012. "FAQs." Surface Transportation Board, U.S. Department of Transportation. Accessed October 20, 2012 at http://stb.dot.gov/stb/faqs.html.

Tompkins B. 2006. "Big Rock Point: From Groundbreaking to Greenfield." *Nuclear News*, 49(12):36-43.

TOPO (Transportation Operations Project Office). 1993a. *Maine Yankee Atomic Power Station, Maine Yankee Atomic Power Company, Site and Facility Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19940228.0020. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1993b. *Yankee-Rowe Atomic Power Station, Yankee Atomic Electric Company, Site and Facility Transportation Services Planning Document.* DOE Records Information System Accession Number HQV.19931215.0018. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1993c. *Haddam Neck Nuclear Generating Station, Connecticut Yankee Atomic Power Company, Northeast Utilities Company, Site and Facility Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19931101.0004. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1993d. *Humboldt Bay Power Plant Unit 3, Pacific Gas and Electric Company, Site and Facility Transportation Services Planning Document.* DOE Records Information System Accession Number HQV.19931101.0005. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1993e. *La Crosse Nuclear Power Station, Dairyland Power Cooperative, Site and Facility Transportation Services Planning Document.* DOE Records Information System Accession Number HQV.19931101.0007. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1993f. *San Onofre Nuclear Generating Station Units 2 and 3, Southern California Edison Company, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19931215.0011. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994a. *Big Rock Point Nuclear Station, Consumers Power Company, Site and Facility Transportation Services Planning Document.* Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994b. *Zion Nuclear Power Station Units 1 and 2, Commonwealth Edison Company, Site and Facility Transportation Services Planning Document*. DOE Records Information System Accession Number MOV.19940919.0002. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994c. *Crystal River Unit 3, Florida Power Company, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19940510.0027. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994d. *Kewaunee Nuclear Station, Wisconsin Public Service Corporation, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19940404.0007. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994e. *San Onofre Nuclear Generating Station Unit 1, Southern California Edison Company, Site and Facility Transportation Services Planning Document.* Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994f. *Vermont Yankee Nuclear Power Station, Vermont Yankee Nuclear Corporation, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number MOL.19990719.0315. Oak Ridge, Tennessee.

Transnuclear. 2008. *Thermal Evaluation of FC DSC Loaded with Damaged Fuel Assemblies*. Calculation No. 13302.0404, Revision 0. ADAMS Accession Number ML092220206.

TriVis Incorporated. 2005. *Facility Interface Review and Update, Final Report on Facility Interfaces for the Office of Civilian Radioactive Waste Management.* DOE Records Information System Accession Number MOL.20060121.0173. TriVis Incorporated, Pelham, Alabama.

Troher K. 2011. "Reactor Head Goes Through Kenosha County On Way to Utah." *Kenosha News*. December 2, 2011.

USACE (U.S. Army Corps of Engineers). 2012. *Five-Year Programmatic Assessment and 404(b)(1) Analysis, Humboldt Harbor and Bay Operations and Maintenance Dredging (FY 2012-FY 2016), Humboldt Bay, Humboldt County, California*. U.S. Army Corps of Engineers, San Francisco Bay District.

USACE (U.S. Army Corps of Engineers). 2014. "Harbor Infrastructure Inventories, Kewaunee Harbor, Wisconsin." U.S. Army Corps of Engineers, Detroit District. Accessed May 28, 2014 at http://www.lre.usace.army.mil/Missions/GreatLakesNavigation/GreatLakesHarborFactSheets.aspx.

Ux Consulting. 2015a. Table 13. Dry Cask Storage in the US by Vendor (as of September 1, 2015). *StoreFUEL and Decommissioning Report*. 16(205):89. September 1.

Ux Consulting. 2015b. Shutdown Reactor Loading Briefs. *StoreFUEL and Decommissioning Report*. 16(205):62. September 1.

Vanderniet C. 2012. Letter from Clark Vanderniet (Transnuclear) to Document Control Desk, Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, "Subject: Notification for Fabrication of the First Packaging under CoC 9302 (Docket No. 71-9302)." November 7, 2012. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML12314A378.

Washington Nuclear Corporation. 2003. Newsbriefs. *SpentFUEL*. 10(483):4.

Wamser, CJ. 2014. Letter from Christopher J. Wamser (Site Vice President, Entergy Nuclear Operations, Inc., Vermont Yankee) to U.S. Nuclear Regulatory Commission. "Subject: Update to Irradiated Fuel Management Program Pursuant to 10 CFR 50.54(bb), Vermont Yankee Nuclear Power Station, Docket No. 50-271, License No. DPR-28." December 19, 2014. ADAMS Accession Number ML14358A251.

Wamser, CJ. 2015. Letter from Christopher J. Wamser (Site Vice President, Entergy Nuclear Operations, Inc., Vermont Yankee) to U.S. Nuclear Regulatory Commission. "Subject: Certifications of Permanent Cessation of Power Operations and Permanent Removal of Fuel from the Reactor Vessel, Vermont Yankee Nuclear Power Station, Docket No. 50-271, License No. DPR-28." January 12, 2015. ADAMS Accession Number ML15013A426.

Waters, MD. 2012. Letter from Michael D. Waters (Chief, Licensing Branch, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission) to Steven E. Sisley (EnergySolutions), "Subject: Certificate of Compliance No. 9276, Revision No. 4, For the Model FuelSolutions™ TS125 Transportation Package." October 26, 2012. Docket No. 71-9276, TAC No. L24684. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession Number ML12306A387.

Wheeler DM. 2002. "Large Component Removal/Disposal." WM'02 Conference Proceedings. February 24-28, 2002, Tucson, Arizona. Available at http://www.wmsym.org/archives/2002/Proceedings/44/573.pdf.

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Appendix A:

U.S. Nuclear Regulatory Commission Certificates of Compliance

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Appendix A
U.S. Nuclear Regulatory Commission Certificates of Compliance and Site-Specific Licenses

Table A-1 lists the docket number, package identification number, revision number, certificate of compliance expiration date, and ADAMS accession number for the transportation casks certified to transport used nuclear fuel from the shutdown sites. Table A-2 lists the docket number, certificate of compliance number issue date, certificate of compliance expiration date, amendment number, amendment effective date, and ADAMS accession number for the general certified storage systems used at the shutdown sites. Table A-3 lists the license number, docket number, license issue date, license expiration date, amendment number, amendment date, and ADAMS accession number for the Humboldt Bay, Rancho Seco, and Trojan site-specific licenses.

Table A-1. Transportation Casks Certified to Transport Used Nuclear Fuel from the Shutdown Sites

Transportation Cask	Docket	Package Identification Number	Revision	Certificate of Compliance Expiration Date	ADAMS Accession Number
NAC-STC	71-9235	USA/9235/B(U)F-96	13	05/31/2019	ML14148A289
MP187	71-9255	USA/9255/B(U)F-85	12	11/30/2018	ML14069A254
HI-STAR 100 and HI-STAR HB	71-9261	USA/9261/B(U)F-96	9	04/30/2019	ML14099A546
NAC-UMS UTC	71-9270	USA/9270/B(U)F-96	4	10/31/2017	ML12306A440
TS125	71-9276	USA/9276/B(U)F-85	4	10/31/2017	ML12306A387
MP197 and MP197HB	71-9302	USA/9302/B(U)F-96	7	08/31/2017	ML14114A049
MAGNATRAN	71-9356	--	--	--	--
HI-STAR 190	71-9373	--	--	--	--

ADAMS= U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams.html)

Table A-2. General Licensed Storage Systems Used at the Shutdown Sites

Storage System	Docket	Certificate of Compliance Issue Date	Certificate of Compliance Expiration Date	Amendment	Amendment Effective Date	ADAMS Accession Number
Standardized NUHOMS	72-1004	01/23/1995	01/23/2015	13	05/24/2014	ML14153A573
HI-STORM 100	72-1014	05/31/2000	05/31/2020	9	03/11/2014	ML14071A188
NAC-UMS	72-1015	11/20/2000	11/20/2020	5	01/12/2009	ML090120408
NAC-MPC	72-1025	04/10/2000	04/10/2020	6	10/04/2010	ML102920618
Fuel Solutions Storage System	72-1026	02/15/2001	02/15/2021	4	07/03/2006	ML061910527
Standardized Advanced NUHOMS	72-1029	02/05/2003	02/05/2023	3	02/23/2015	ML15054A415
MAGNASTOR	72-1031	02/04/2009	02/04/2029	5	06/29/2015	ML15180A364
HI-STORM UMAX	72-1040	04/06/2015	04/06/2035	1	09/08/2015	ML15252A426

ADAMS= U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams.html)

Table A-3. Site-Specific Licenses at the Shutdown Sites

Site	License	Docket	License Issue Date	License Expiration Date	Amendment	Amendment Date	ADAMS Accession Number
Trojan	SNM-2509	72-17	03/31/1999	03/31/2019	6	03/17/2006	ML060790069
Rancho Seco	SNM-2510	72-11	06/30/2000	06/30/2020	3	08/11/2009	ML092240338
Humboldt Bay	SNM-2514	72-27	11/17/2005	11/17/2025	3	09/17/2013	ML13196A466

ADAMS= U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams.html)

Appendix B:

Rail Infrastructure Assessments of Shutdown Sites

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Appendix B
Rail Infrastructure Assessments of Shutdown Sites

This appendix contains the rail infrastructure assessments conducted during site visits to Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, and Zion. The assessments consisted of an existing site overview and railroad operational overview.

B.1 Humboldt Bay

The Humboldt Bay site visit was conducted on July 17, 2013.

B.1.1 Existing Site Overview

The Humboldt Bay site has no rail infrastructure. Figure B-1 is a satellite view of the Humboldt Bay site.

B.1.2 Railroad Operational Overview

The Northwestern Pacific Railway (NWPY) is a regional railroad that served the north coast of California. Its main line ran from Schellville to Eureka, California, a distance of 260.1 miles. The railroad began at milepost 40.4 (Schellville) and ended at milepost 300.5 (Samoa). The rail line has 30 tunnels, 1 over-highway bridge and 52 over-water bridges from Eureka to Schellville.

In 1998 the Federal Railroad Administration issued an Emergency Order that closed the line from Arcata (milepost 295.5) to milepost 63.4 between Schellville and Napa Junction, California. In May 2011, the Federal Railroad Administration lifted the Emergency Order allowing freight trains to operate as far north as milepost 62.9 near Windsor, California. Currently, the northern section from Windsor to Arcata is not operating. There are five locomotives stored in out-of-service status on the non-operating northern section in Eureka.

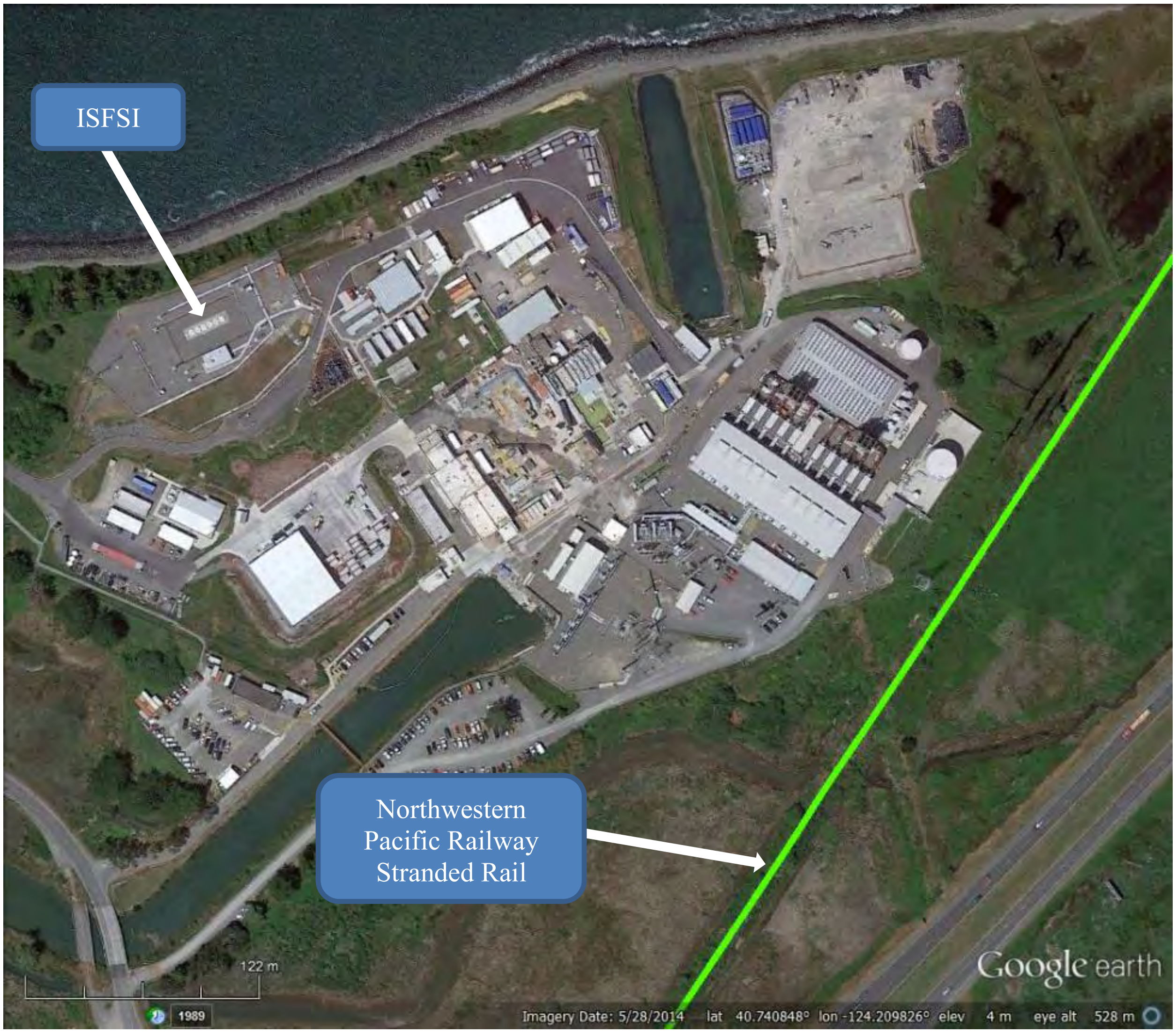

Figure B-1. Satellite View of Humboldt Bay Site (Google 2015)

B.2 Big Rock Point

The Big Rock Point site visit was conducted on July 25, 2013.

B.2.1 Existing Site Overview

The Big Rock Point site has no existing rail service. The rail line was abandoned and removed in May 1986. Figures B-2 and B-3 are satellite views of the Big Rock Point site.

Figure B-2. Satellite View of the Big Rock Point Site (Google 2015)

Figure B-3. Closer Satellite View of the Independent Spent Fuel Storage Installation Pad and the Main Office Building at Big Rock Point (Google 2015)

B.2.2 Railroad Operational Overview

Because direct rail access to the Big Rock Point site is not available, the shipment of used nuclear fuel from Big Rock Point by rail would involve heavy haul truck transport to a rail siding or spur and transloading from heavy haul truck to rail. Previously, two locations have been used for transloading of large components during decommissioning, a siding on the Great Lakes Central Railroad located in Petoskey, Michigan and a spur on the Lake State Railway located in Gaylord, Michigan. Figures B-4, B-5, and B-6 show features of the Petoskey location. Figures B-7, B-8, and B-9 show features of the Gaylord location.

The Great Lakes Central Railroad siding is located in Petoskey, Michigan and is currently used to transload plastic pellets from railcars and deliver them to a local factory. The rail line in the vicinity of the siding appears to be in track class 1 condition. The use of this location during decommissioning of the Big Rock Point site required heavy haul truck transport for approximately 13 miles from the Big Rock Point site. The siding is approximately 1,000 feet long, has electrical power available, and there is sufficient space to perform transloads of used nuclear fuel transportation casks.

The Lake State Railway's spur is located near the intersection of North Otsego Lake Drive and Highland Avenue in Gaylord, Michigan. The use of this location during decommissioning of the Big Rock Point site required heavy haul truck transport for approximately 50 miles from the Big Rock Point site. The rail line in the vicinity of the spur appears to be in "Excepted Track" condition. Approximately 1000 feet south the track appears to have been rehabilitated to track class 2 condition.

Figure B-4. Transload Location Near Petoskey, Michigan (Google 2015)

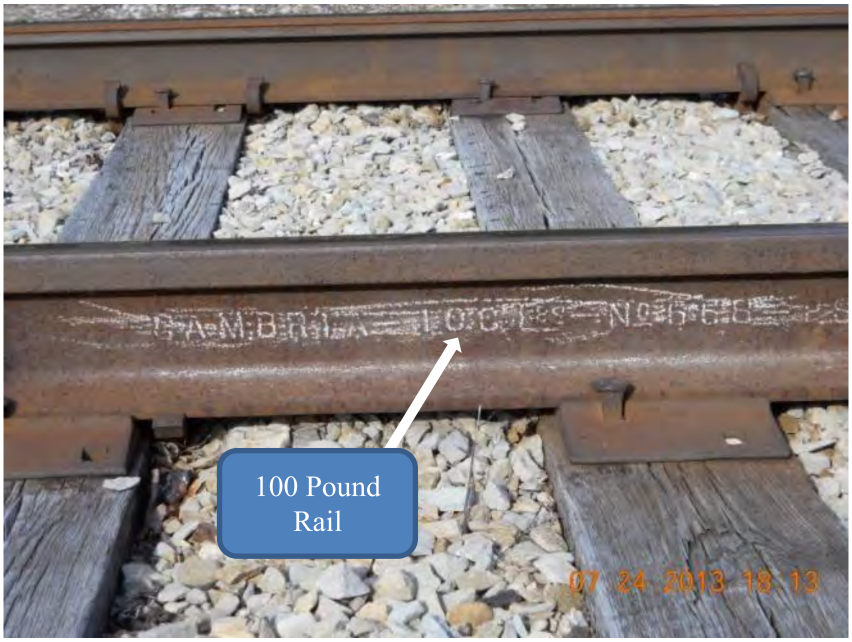

Figure B-5. Railroad Track Located Near Petoskey, Michigan Transload Location (2013)

Figure B-6. Petoskey Transload Location Railroad Siding (2013)

Figure B-7. Transload Location Near Gaylord, Michigan (Google 2015)

Figure B-8. Track Condition in the Vicinity of Gaylord Transload Location (Looking North) (2013)

Figure B-9. Track Condition in the Vicinity of Gaylord Transload Location (Looking South) (2013)

B.3 Rancho Seco

The Rancho Seco site visit was conducted on July 16, 2013.

B.3.1 Existing Site Overview

Figure B-10 is a satellite view of the Rancho Seco site and Figure B-11 shows Union Pacific Railroad track and switch locations. Plant site rail infrastructure is intact but not maintained to operating condition. The Rancho Seco site rail system has a section of rail removed inside the perimeter gate to prevent entry of rail rolling stock.

B.3.2 Railroad Operational Overview

The serving railroad is the Union Pacific Railroad. The plant lead is approximately 3,500 to 4,000 feet from the facility perimeter fence. The plant lead is 90-lb. rail from the Union Pacific switch to the interplant switch inside the fence. The plant lead has a split rail derailer near the Union Pacific switch preventing rolling stock entry onto the Union Pacific railroad. The plant has a flop derailer approximately 30 feet inside the facility's perimeter fence preventing rolling stock from entering the Rancho Seco site by rail. Approximately 150 feet from the fence, the facility has a switch; the rail from the switch inside the facility is 112-lb. rail. The switch leads to the ISFSI stub track. The ISFSI stub track is approximately 400 feet long and parallels the ISFSI pad ending at the south end of the pad.

The Ione Industrial Lead serves the Rancho Seco site. This lead connects to the Union Pacific mainline in Galt, California. The lead is track class 2 with a maximum speed limit of 20 mph. Six-axle locomotives are prohibited from the lead and the maximum gross weight for a railcar on the lead between Rancho Seco and Galt is 158 tons. To exceed these provisions, it would be necessary to obtain route clearance from the Union Pacific Railroad or to upgrade the track.

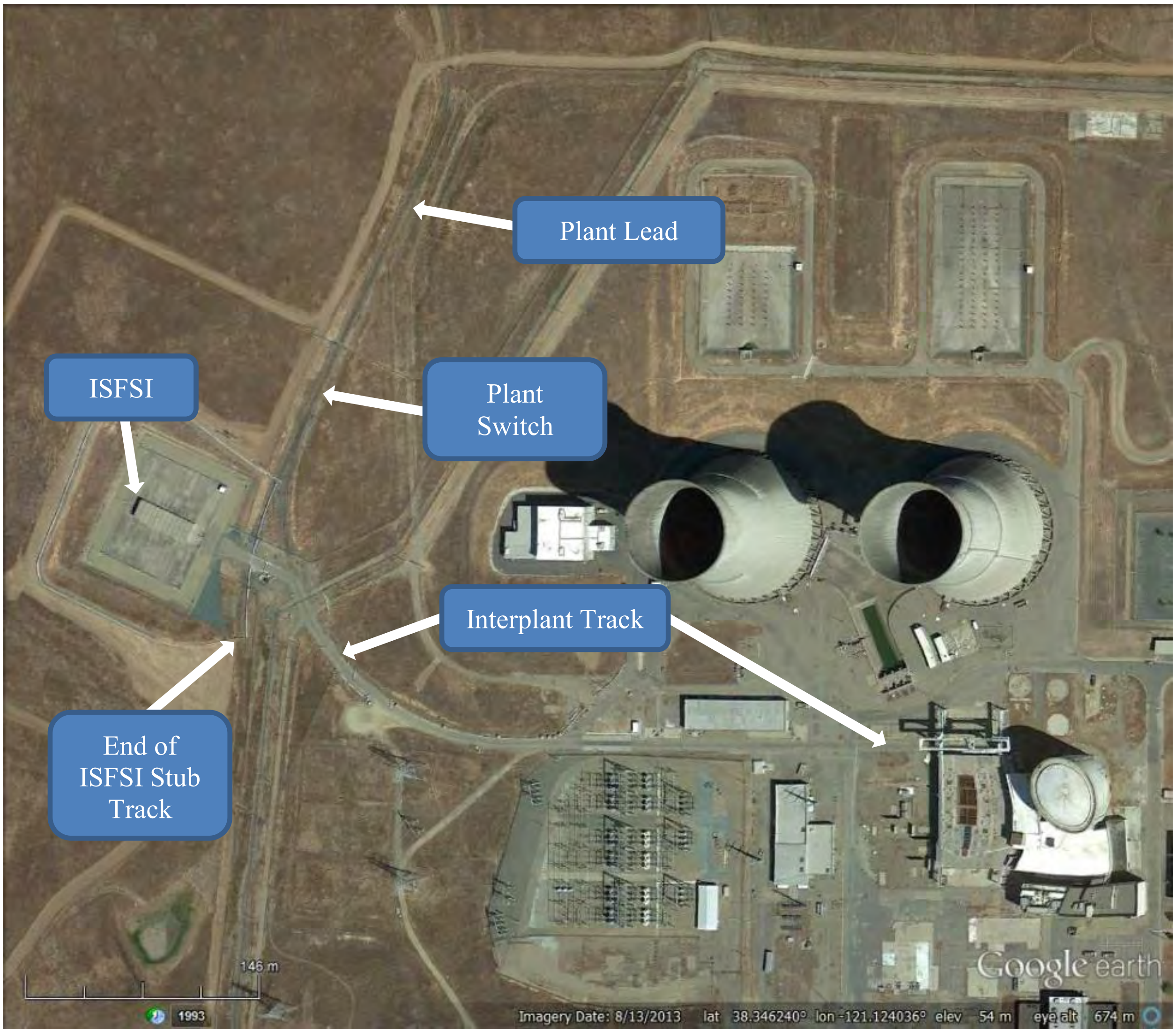

Figure B-10. Satellite View of the Rancho Seco Plant (Google 2015)

Figure B-11. Union Pacific Railroad Track and Switch Locations (Google 2015)

B.4 Trojan

The Trojan site visit was conducted on July 15, 2013.

B.4.1 Existing Site Overview

The Trojan site has sections of rail that are intact but not maintained. Figure B-12 is a satellite view of the site. The existing track runs parallel to the access road to the ISFSI pad. The rail is approximately 170 feet from the ISFSI pad gate. The existing on-site rail terminates laterally across from the gate. A stub track off of the west side of the Portland and Western Railroad's (PNWR), track was last used to load and ship low-level waste in 2002-2004. The stub track and switch were removed shortly after the last shipment. The plant lead and switch off of the PNWR was removed in approximately 1989 and the Access Control building was built on the curve from the lead into the plant facility.

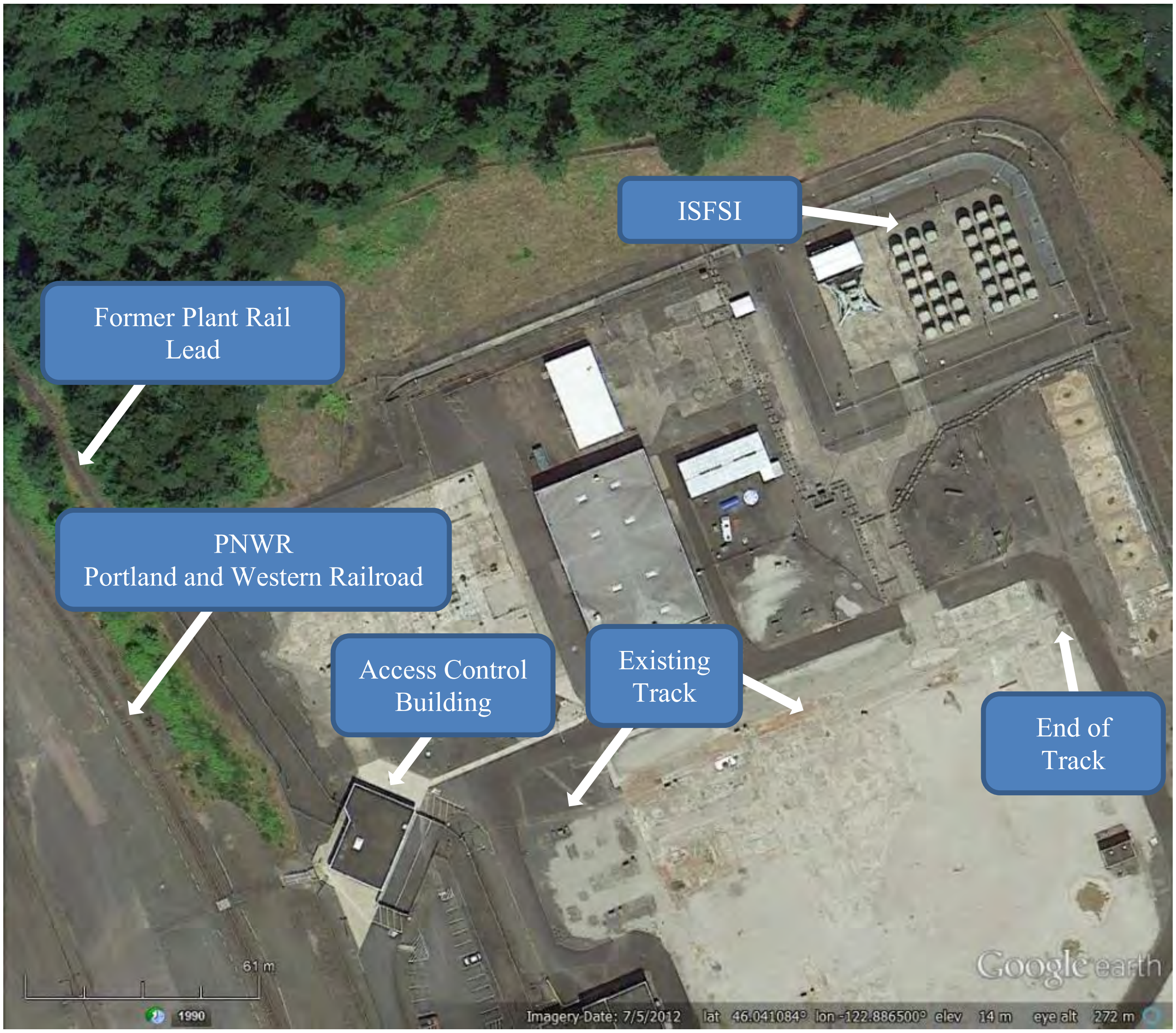

Figure B-12. Satellite View of Trojan Site (Google 2015)

B.4.2 Railroad Operational Overview

The PNWR is a 520-mile short line railroad that interchanges with the Albany and Eastern Railroad, BNSF Railroad, Central Oregon and Pacific Railroad, Coos Bay Rail Link, Hampton Railway, Port of Tillamook, and Union Pacific Railroad. Commodities transported include aggregates, brick and cement, chemicals, construction and demolition debris, food and feed products, forest products, metallic ores and minerals, steel, and scrap. The PNWR was acquired by the Genesee and Wyoming in 1995. The Genesee and Wyoming operates 63 short line and regional railroads in the United States, Canada, Bolivia, Australia, Mexico, and the Netherlands.

The PNWR was the serving railroad for the Trojan site until 2004 after completing the low-level radioactive waste shipments from the site. At that time the west stub track and switch were removed.

PNWR's Astoria District rail line would serve the Trojan site. From the Trojan site south to the BNSF interchange at Willbridge is approximately 36.5 miles. Approximately 5 miles south of Willbridge, the PNWR interchanges with the Union Pacific, which is a part of the Strategic Rail Corridor Network (STRACNET). An interchange with the Union Pacific may be possible through a waiver process. The Astoria District Rail Line is track class 2. The railroad milepost at Trojan is 40.8 and the milepost at Willbridge is 4.3. The maximum authorized timetable speed from Gasco (milepost 5.6) to Astoria (milepost 99.7) is 25 mph.

B.5 La Crosse

The La Crosse site visit was conducted on July 23, 2013.

B.5.1 Existing Site Overview

Currently there is a spur off of the BNSF double track mainline that will hold two railcars inside the La Crosse site (Figures B-13 through B-15). Sections of the facility rail system are intact but in unusable condition. The interplant rail system had two switches that had spurs that ran to the reactor building and the adjacent Genoa #3 coal-fired power plant.

B.5.2 Railroad Operational Overview

The BNSF Railroad is the serving railroad for the La Crosse site at Genoa. The track is a mainline and is part of the BNSF's Aurora Subdivision and the Chicago Division. The line is not an Amtrak Route. The line primarily is for intermodal and freight trains.

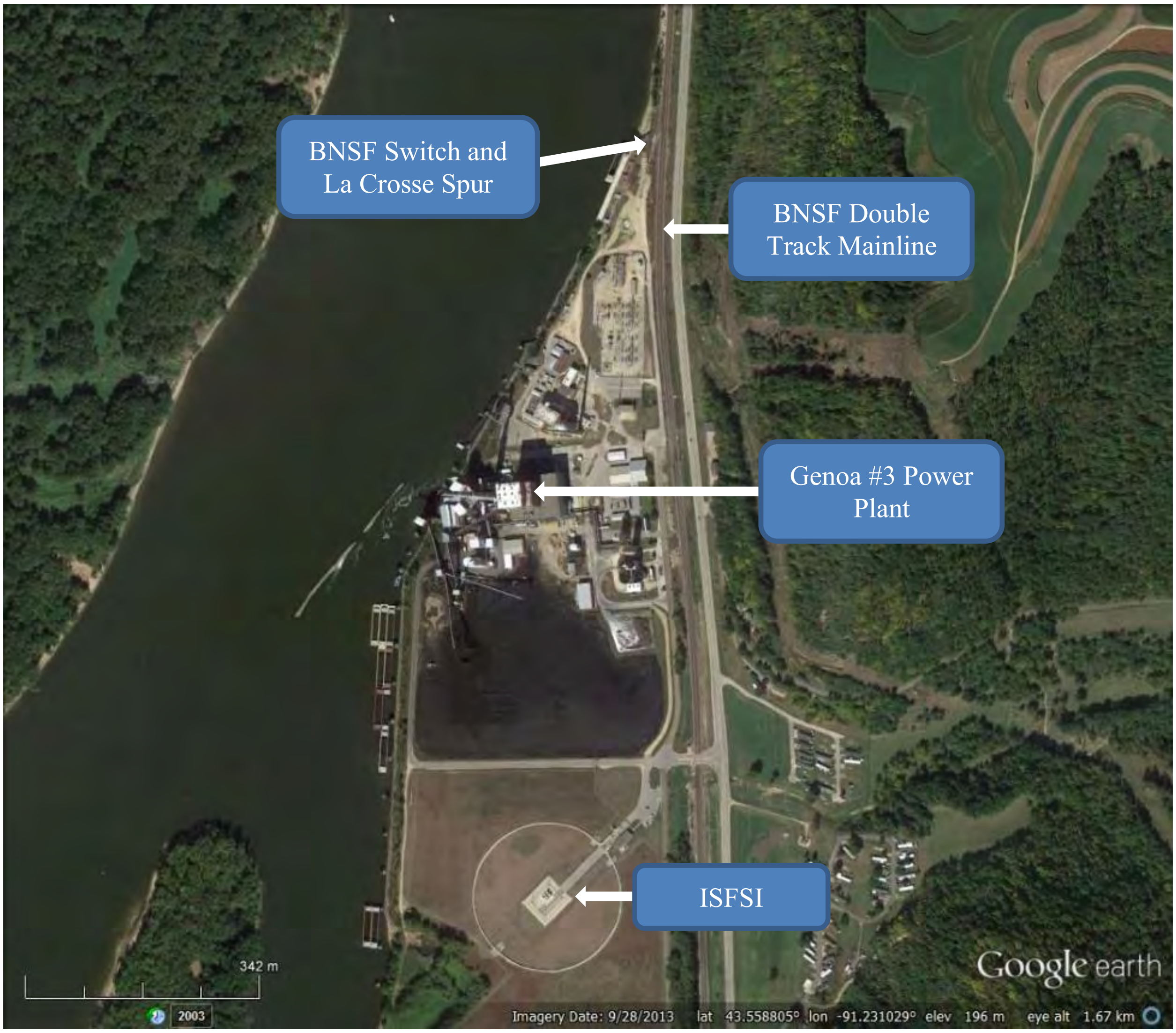

Figure B-13. Satellite View of the La Crosse Site with Switch, Spur, Mainline, and Independent Spent Fuel Storage Installation (Google 2015)

Figure B-14. Satellite View of the La Crosse Site with Switch, Spur, and Mainline (Google 2015)

Figure B-15. Satellite View of the La Crosse Site with Turbine and Reactor Buildings (Google 2015)

B.6 Zion

The Zion site visit was conducted on July 22, 2013.

B.6.1 Existing Site Overview

The Zion site is serviced by the Union Pacific Railroad. In 2012 Zion Solutions completed the interplant rail system upgrade. Figures B-16 through B-20 show the rehabilitated rail infrastructure. The installation of two switches on the Union Pacific double track mainline, a plant lead, and a crossover switch allow access from either track to the Zion facility. The rebuilt lead from the Union Pacific's mainline into the plant includes 100-lb. rail, specialty equipment, negotiable 12 degree curves, cement crossties on the two curves, and a unidirectional derailer that protects the railroad. The lead also includes two private crossings that afford access to the beach area. The lead has three switches for three plant tracks that are approximately 1200 to 1400 feet inside the perimeter fence that has an 11-degree, 39-minute curve in it. There are unidirectional derailers outside of the perimeter fence that protect the plant from incoming rolling stock. The east track has two switches that lead to the Fuel Building and Turbine Building. The Zion site has a Trackmobile to move and stage rail cars around the site. Figures B-21 and B-22 are satellite views of the Zion site.

Figure B-16. Union Pacific Mainline at the Zion Site (2013)

Figure B-17. Rebuilt Lead from the Zion Site to the Union Pacific Mainline (2013)

Figure B-18. Private Crossing to Afford Beach Access (2013)

Figure B-19. Zion Site Plant Lead (2013)

Figure B-20. Derailers Outside of Zion Site (2013)

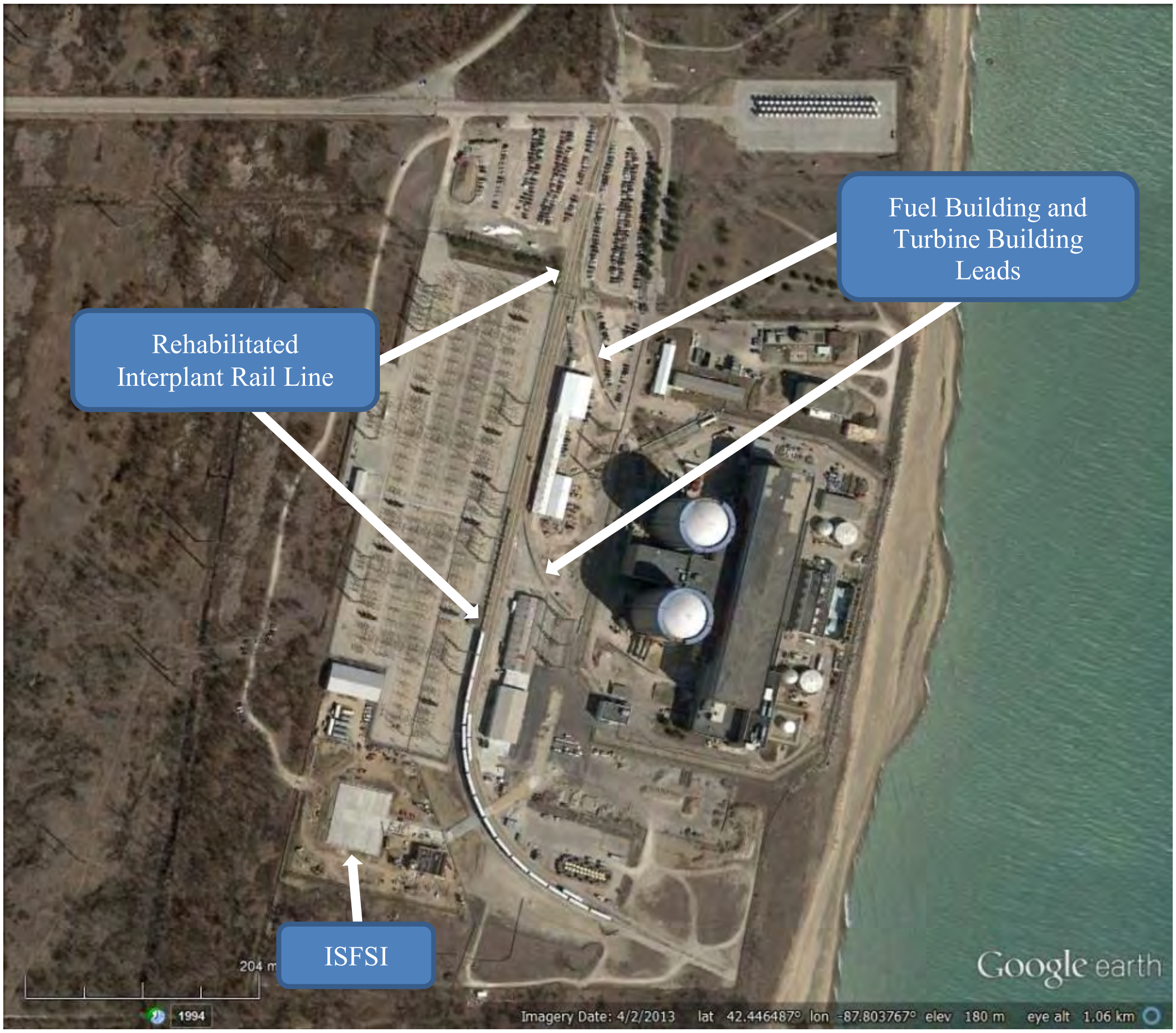

Figure B-21. Satellite view of Zion Site Showing Independent Spent Fuel Storage Installation Pad, the Rehabilitated Interplant Rail Line, and the Leads to the Reactor Containment Building (Google 2015)

Figure B-22. Satellite View of the Zion Lead and the Union Pacific Double Track Mainline (Google 2015)

B.6.2 Railroad Operational Overview

The Union Pacific Railroad is the serving railroad for the Zion site. The double track rail line is in the Union Pacific's Northern Region. The double track rail line is also commuter line operated by the Northeast Illinois Regional Commuter Rail Corporation. The commuter line operates from the Clybourn Station, located at 2001 N. Ashland Avenue, Chicago, Illinois, and runs north to Kenosha Station, located at 5414 13th Avenue, Kenosha, Wisconsin, a distance of approximately 60 miles. Zion Station is a commuter stop located at 2501 S. Eden Road, Zion, Illinois. This station is located less than 1,000 feet from the main line switch to the Zion site lead and approximately 4,000 feet from the plant entrance (Figure B-23).

Figure B-23. Location of Zion Station Commuter Stop (Google 2015)

B.7 References

Google, Inc. 2015. Google Earth (Version 7.1.5.1557). Available at http://www.google.com/earth/index.html

Appendix C:

Summary of Permitting Requirements for Oversize and Overweight Trucks

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Appendix C
Summary of Permitting Requirements for Oversize and Overweight Trucks

This appendix summarizes the permitting requirements for oversize and overweight trucks for states with shutdown sites (California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Oregon, Vermont, and Wisconsin). In addition, state super load dimension and weight requirements are also summarized. A vehicle and load is considered oversized when the vehicle and the cargo it carries exceed the legal dimensions of length or width, as defined by federal requirements or length, height, or width as defined by state requirements for the state in which the vehicle will be traveling (GAO 2015). A vehicle and load is considered overweight when the vehicle and the cargo it carries exceed the legal weight limit as defined by federal and state requirements (GAO 2015). A vehicle and load is considered a super load when its dimensions and weight exceed the dimensions and weight established for typical oversized and overweight loads. The dimensions and weights that qualify as a super load are set by the states and a super load is subject to additional state permitting requirements over and above the requirements for typical oversized and overweight vehicles and loads.

The permitting summaries were compiled from information contained in the *Vehicle Sizes and Weights Manual* (J.J. Keller and Associates, Inc. 2013) and the electronic supplement to *Transportation Safety: Federal Highway Administration Should Conduct Research to Determine Best Practices in Permitting Oversize Vehicles* (GAO 2015). The electronic supplement is available at http://www.gao.gov/special.pubs/gao-15-235sp/index.htm.

C.1 California

Table C-1 summarizes the oversize vehicle permitting practices in California.

Table C-1. California Oversize Vehicle Permitting Practices

Permit Issuing Agency	California Department of Transportation – Division of Traffic Operations – Office of Commercial Vehicle Operations
Permit Enforcement Agency	California Highway Patrol – Enforcement and Planning Division – Commercial Vehicle Section
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	6 [Permit types include: single trip (fax), single trip (electronic), variance, annual, repetitive, direct crossing]
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	14 ft. 0 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	15 ft. 0 in.
Super Load Height Requirement	17 ft. 0 in.
Super Load Length Requirement	135 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	None specified
Escort Vehicle Requirement for Overheight Permitted Vehicle	No
Pole Car Requirement for Overheight Permitted Vehicle	No
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes (California Highway Patrol escort may be required for anything over 17 ft. 0 in.)
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes (over 12 ft.)
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes (over 15 ft.)
Route Survey Requirement for Overheight Permitted Vehicle	Yes (over 17 ft.)
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.2 Connecticut

Table C-2 summarizes the oversize vehicle permitting practices in Connecticut.

Table C-2. Connecticut Oversize Vehicle Permitting Practices

Permit Issuing Agency	Connecticut Bureau of Highway Operations – Oversize and Overweight Permits
Permit Enforcement Agency	Connecticut State Police and Department of Motor Vehicles – Commercial Vehicle Safety Division
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	5
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	16 ft. 0 in.
Super Load Height Requirement	15 ft. 4 in.
Super Load Length Requirement	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	200,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes (Escorts required for loads over 12 ft. wide, 14 ft. height, and 90 ft. long)
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes (State Police escorts required for all super loads and loads over 15 ft. 4 in. height)
Route Survey Requirement for Overheight Permitted Vehicle	Yes (Required for loads over 14 ft. height)
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.3 Florida

Table C-3 summarizes the oversize vehicle permitting practices in Florida.

Table C-3. Florida Oversize Vehicle Permitting Practices

Permit Issuing Agency	Florida Department of Transportation – Permit Office
Permit Enforcement Agency	Florida Department of Transportation – Motor Carrier Size and Weight and Florida Highway Patrol – Commercial Vehicle Enforcement Unit
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	3
Regional Permit Agreement Membership	Southern Regional Permit
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	16 ft. 0 in.
Super Load Height Requirement	16 ft. 0 in.
Super Load Length Requirement	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	199,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	Yes
Certification Requirement for Escort Vehicle Driver	Yes
Source: GAO (2015)	

C.4 Illinois

Table C-4 summarizes the oversize vehicle permitting practices in Illinois.

Table C-4. Illinois Oversize Vehicle Permitting Practices

Permit Issuing Agency	Illinois Department of Transportation – Bureau of Operations – Permit Unit
Permit Enforcement Agency	Illinois State Police
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	11
Regional Permit Agreement Membership	None
Maximum Legal Width	96 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	65 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	14 ft. 6 in.
Super Load Height Requirement	14 ft. 6 in.
Super Load Length Requirement	145 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	120,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	No
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.5 Maine

Table C-5 summarizes the oversize vehicle permitting practices in Maine.

Table C-5. Maine Oversize Vehicle Permitting Practices

Permit Issuing Agency	Maine Bureau of Motor Vehicles – Office of Motor Carrier Services
Permit Enforcement Agency	Maine State Police – Troop K, Commercial Vehicle Enforcement
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	2
Regional Permit Agreement Membership	New England Transportation Consortium
Maximum Legal Width	102 in.
Maximum Legal Height	14 ft. 0 in. (13 ft. 6 in. structural height, additional 6 in. allowed for load)
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	100,000 lb.
Super Load Width Requirement	16 ft. 0 in.
Super Load Height Requirement	16 ft. 0 in.
Super Load Length Requirement	125 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	130,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	No
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	No
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.6 Massachusetts

Table C-6 summarizes the oversize vehicle permitting practices in Massachusetts.

Table C-6. Massachusetts Oversize Vehicle Permitting Practices

Permit Issuing Agency	Massachusetts Department of Transportation – Highway Division
Permit Enforcement Agency	Massachusetts Department of Public Safety
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	9
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	14 ft. 0 in.
Super Load Height Requirement	Varies
Super Load Length Requirement	120 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	130,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	No
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	Yes
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.7 Michigan

Table C-7 summarizes the oversize vehicle permitting practices in Michigan.

Table C-7. Michigan Oversize Vehicle Permitting Practices

Permit Issuing Agency	Michigan Department of Transportation, Michigan Transport Permits Unit – Michigan Transport Routing and Internet Permitting
Permit Enforcement Agency	Michigan State Police – Commercial Vehicle Enforcement Division
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	24
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	164,000 lb.
Super Load Width Requirement	16 ft. 0 in.
Super Load Height Requirement	15 ft. 0 in.
Super Load Length Requirement	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	None specified
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	No
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes (Over 12 ft. wide)
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	No
Route Survey Requirement for Overheight Permitted Vehicle	Yes (Prior to movement)
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.8 Oregon

Table C-8 summarizes the oversize vehicle permitting practices in Oregon.

Table C-8. Oregon Oversize Vehicle Permitting Practices

Permit Issuing Agency	Oregon Department of Transportation – Over-Dimensional Permit Unit
Permit Enforcement Agency	Oregon Department of Transportation
Online Oversize and Overweight Permit System	Partial
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	41
Regional Permit Agreement Membership	Western Regional Permit
Maximum Legal Width	102 in.
Maximum Legal Height	14 ft. 0 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	> 16 ft. (interstates and other multilane highways) > 14 ft. (state two-lane highways)
Super Load Height Requirement	17 ft. 0 in.
Super Load Length Requirement	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	None specified
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	No
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	No
Route Survey Requirement for Overheight Permitted Vehicle	Route survey may be required.
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.9 Vermont

Table C-9 summarizes the oversize vehicle permitting practices in Vermont.

Table C-9. Vermont Oversize Vehicle Permitting Practices

Permit Issuing Agency	Vermont Department of Motor Vehicles – Commercial Vehicle Operations Unit
Permit Enforcement Agency	Vermont Department of Motor Vehicles – Commercial Vehicle Enforcement Unit
Online Oversize and Overweight Permit System	No
Automated Truck Routing Software	No
Number of Different Oversize and Overweight Permit Types Available	6
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	15 ft. 0 in.
Super Load Height Requirement	14 ft. 0 in.
Super Load Length Requirement	100 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	150,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	No
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	Yes
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	Yes
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.10 Wisconsin

Table C-10 summarizes the oversize vehicle permitting practices in Wisconsin.

Table C-10. Wisconsin Oversize Vehicle Permitting Practices

Permit Issuing Agency	Wisconsin Department of Transportation – Oversize Overweight Permit Section – Bureau of Highway Maintenance
Permit Enforcement Agency	Wisconsin Department of Transportation – State Patrol Division Headquarters
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	28
Regional Permit Agreement Membership	Bilateral Agreement Between Wisconsin and Minnesota
Maximum Legal Width	102 in.
Maximum Legal Height	13 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb.
Super Load Width Requirement	16 ft. 0 in.
Super Load Height Requirement	None specified
Super Load Length Requirement	160 ft. 0 in.
Super Load Gross Vehicle Weight Requirement	270,000 lb.
Escort Vehicle Requirement for Overheight Permitted Vehicle	Yes
Pole Car Requirement for Overheight Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overheight Permitted Vehicle	No
Escort Vehicle Requirement for Overwidth Permitted Vehicle	Yes
Law Enforcement Escort Requirement for Overwidth Permitted Vehicle	Yes
Route Survey Requirement for Overheight Permitted Vehicle	No
Certification Requirement for Escort Vehicle Driver	No
Source: GAO (2015)	

C.11 Summary of State Super Load Dimension and Weight Requirements

Table C-11 summarizes the super load width, height, length, and gross vehicle weight requirements for California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Oregon, Vermont, and Wisconsin.

Table C-11. Summary of State Super Load Dimension and Weight Requirements

State	Super Load Width Requirement	Super Load Height Requirement	Super Load Length Requirement	Super Load Gross Vehicle Weight Requirement
California	15 ft. 0 in.	17 ft. 0 in.	135 ft. 0 in.	None specified
Connecticut	16 ft. 0 in.	15 ft. 4 in.	150 ft. 0 in.	200,000 lb.
Florida	16 ft. 0 in.	16 ft. 0 in.	150 ft. 0 in.	199,000 lb.
Illinois	14 ft. 6 in.	14 ft. 6 in.	145 ft. 0 in.	120,000 lb.
Maine	16 ft. 0 in.	16 ft. 0 in.	125 ft. 0 in.	130,000 lb.
Massachusetts	14 ft. 0 in.	Varies	120 ft. 0 in.	130,000 lb.
Michigan	16 ft. 0 in.	15 ft. 0 in.	150 ft. 0 in.	None specified
Oregon	16 ft. 0 in.[a] 14 ft. 0 in.[b]	17 ft. 0 in.	150 ft. 0 in.	None specified
Vermont	15 ft. 0 in.	14 ft. 0 in.	100 ft. 0 in.	150,000 lb.
Wisconsin	16 ft. 0 in.	None specified	160 ft. 0 in.	270,000 lb.

Source: GAO (2015)
a. Interstates and other multilane highways.
b. State two-lane highways.

C.12 References

GAO (U.S. Government Accountability Office). 2015. *Transportation Safety: Federal Highway Administration Should Conduct Research to Determine Best Practices in Permitting Oversize Vehicles*. GAO-15-236 and electronic supplement GAO-15-235SP. Available at http://www.gao.gov/special.pubs/gao-15-235sp/index.htm.

J.J. Keller and Associates, Inc. 2013. *Vehicle Sizes and Weights Manual*. J.J. Keller and Associates, Inc., Neenah, Wisconsin.