Nuclear Power Plant Infrastructure Evaluations for Removal of Spent Nuclear Fuel

Spent Fuel and Waste Disposition

Prepared for
U.S. Department of Energy
Office of Integrated
Waste Management
Steven J. Maheras (PNNL)
Lauren S. Rodman (PNNL)
Ralph E. Best (Independent Consultant)
Adam H. Levin (AHL Consulting)
Steven B. Ross (PNNL)
Lawrence M. Massaro (FRA)
Philip J. Jensen (PNNL)

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This is a technical report that does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). For example, under the provisions of the Standard Contract, spent nuclear fuel in multi-assembly canisters is not an acceptable waste form, absent a mutually agreed to contract amendment.

To the extent discussions or recommendations in this report conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this report in no manner supersedes, overrides, or amends the Standard Contract.

This report reflects technical work which could support future decision making by the U.S. Department of Energy (DOE or Department). No inferences should be drawn from this report regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository.

EXECUTIVE SUMMARY

This report fulfills the M3 milestone M3SF-20PN0203020412, "Nuclear Power Plant Site Infrastructure Report." This report is a 2020 update of the 2017 report entitled *Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites* (Maheras et al. 2017). The title of this report reflects the intent of the U.S. Department of Energy (DOE) to conduct site evaluations for operating nuclear power plant (NPP) sites as well as shutdown NPP sites (collectively referred to as NPP sites). Other changes from the 2017 report include:

- Adding information from the Oyster Creek and Pilgrim NPP site evaluations.
- Updating Google Earth imagery.
- Changing "used nuclear fuel" to "spent nuclear fuel" throughout the report.
- Incorporating revisions to transportation certificates of compliance.
- Updating NPP site condition information.
- Deleting data and sections from the report that were out of date.

This report provides evaluations of the NPP site infrastructure and near-site transportation infrastructure for removing spent nuclear fuel (SNF) from 16 NPP sites that have been evaluated as of the date of this report. The material to be removed from these NPP sites includes both the SNF and the greater-than-Class C low-level radioactive waste (GTCC waste)[1] that is stored, or will be stored, at the sites.

The evaluation for each of the 16 NPP sites evaluated is divided into four components:

- characterization of the SNF and GTCC 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 SNF and GTCC waste from the NPP sites
- identification of future information needs.

Sixteen NPP sites have been visited since 2012: Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim. The 16 NPP sites use designs from 4 different suppliers, including 12 different (horizontal and vertical) storage systems that would require 9 different transportation cask designs. At the 16 NPP sites, a total of 27,845 SNF assemblies containing a total of 8222.2 metric tons heavy metal (MTHM) of SNF are forecast to be stored in 674 storage canisters (actual plus estimated). In addition, 43 canisters (actual plus estimated) containing GTCC waste are forecast to be stored at these sites. Several issues were identified during the characterization of the SNF and GTCC waste inventory at these NPP sites that may affect future transportability. 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

[1] Removal of GTCC waste at NPP sites was analyzed in this report because the Court of Appeals for the Federal Circuit has opined that such waste is considered high-level radioactive waste under the terms of the Standard Contract. *Yankee Atomic Electric Co. v. U.S.*, 536 F.3d 1268; *Pacific Gas & Electric Co. v. U.S.*, 536 F.3d 1282.

determine if the canisters containing this damaged fuel can be shipped in the MP187 transportation cask without repackaging.

The approved contents in the certificates of compliance for the TS125, HI-STAR 100, MP187, and HI-STAR 190 transportation casks do not include GTCC waste. For GTCC waste to be shipped from the Rancho Seco, San Onofre, Vermont Yankee, Oyster Creek, and Pilgrim sites in these transportation casks, changes to the transportation certificates of compliance would be required. Additionally, 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 transportation casks or impact limiters could be fabricated or alternative transportation casks with -96 designations used.

Nine of the 16 sites, Maine Yankee, Zion, Crystal River, Kewaunee, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim, have high burnup (>45 gigawatt-day per metric ton heavy metal [GWd/MTHM]) SNF assemblies in storage. At Maine Yankee and Zion, these high burnup SNF assemblies are packaged in damaged fuel cans, which eliminates the concern over the transportability of this high burnup fuel. High burnup SNF stored in 32PTH1 canisters at Crystal River and 24PT4 canisters at San Onofre would be transportable in the MP197HB transportation cask. High burnup SNF stored in MPC-37 canisters at San Onofre and MPC-89 canisters at Oyster Creek would be transportable in the HI-STAR 190 transportation cask. High burnup SNF stored in MPC-68 and MPC-68M canisters at the Vermont Yankee and Pilgrim sites would not be transportable without changes to the approved contents in the certificate of compliance for the HI-STAR 100MB or HI-STAR 100 transportation cask. The certificate of compliance for the MAGNATRAN transportation cask allows for transport of high burnup SNF in damaged fuel cans; however, the undamaged high burnup SNF stored in TSC-37 canisters at Kewaunee is not contained in damaged fuel cans and a revision to the certificate of compliance would be required for this SNF to be transportable.

All 16 sites were found to have at least one off-site transportation mode option for removing their SNF and GTCC waste, and some sites have multiple options. Table S-1 provides a summary of these transportation mode options for these NPP sites. NPP site experience with shipping large equipment and components to and from the NPP sites provided an important source of information in developing Table S-1.

DOE intends to continue conducting site evaluations of additional NPP sites and plans to eventually conduct evaluations for all NPP sites. For NPP sites previously evaluated, DOE plans to continue to update inventory and site condition information and imagery as it becomes available.

Table S-1. Summary of Transportation Mode Options for Shipments from Nuclear Power Plant Sites

Site	Transportation Mode Options		Comments
Maine Yankee	Direct rail	Barge to rail	The on-site rail spur is not currently maintained. The condition of the Central Maine and Quebec Railway 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 distance would likely be about 52 miles to Gaylord, Michigan. A shorter heavy haul distance 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 currently 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 refurbished to support reactor decommissioning waste shipments.
Crystal River	Direct rail	Barge to rail	An extensive on-site rail system serves co-located fossil fuel plants.
Kewaunee	Heavy haul truck to rail	Heavy haul truck to barge to rail	The 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 refurbished to support reactor decommissioning waste shipments for San Onofre-1.
Vermont Yankee	Direct rail	–	The on-site rail spur was reactivated to support decommissioning.

Table S-1. (contd)

Site	Transportation Mode Options		Comments
Fort Calhoun	Direct rail	Barge to rail	The on-site rail spur could be reinstalled or on-site transload performed. Barge was used to ship steam generators, pressurizer, and reactor vessel head.
Oyster Creek	Barge to rail	Heavy haul truck to rail	Two on-site barge access locations exist at the site. Heavy haul truck transport to rail transload locations could range from 30 to 70 miles.
Pilgrim	Barge to rail	Heavy haul truck to rail	One on-site barge access location exists at the site. Heavy haul truck transport to rail transload location could range from 23 to 30 miles.

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Name	Affiliation	Name	Affiliation
Peykan Abbassi	North County Transit District	Joseph R. Lynch	Vermont Yankee
Mark Abrahamson	Wisconsin State Patrol	Mark Maday	Federal Railroad Administration
John Arnold	Maine Yankee	James Madigan	San Onofre
Roberto Arroyo	Humboldt Bay	Ted Maine	Fort Calhoun
James Ashley	Zion	Ziad Malhas	North County Transit District
Paul Ashley	U.S. Coast Guard	Vincent Malkoski	Massachusetts Division of Marine Fisheries
Briana DeBoer	U.S. Nuclear Regulatory Commission	Matt Mann	Windham Regional Commission
Jaime Becerra	North County Transit District	Caitlin Marmion	Holtec
Don Beckman	Zion	Tim McDonald	Lacey Township
Damon Blythe	North County Transit District	Laura McManniman	International Atomic Energy Agency
Robert Boeri	Massachusetts Office of Coastal Zone Management	Brian McWilliams	Pilgrim

[2] Currently NAC International.

Name	Affiliation	Name	Affiliation
Rick Boucher	New England Central Railroad	Jeff Mears	Oneida Nation
Joe Bowen	Federal Railroad Administration	Phillip Meraz	Iowa DOT Rail Transportation
Nick Boyd	Massachusetts Department of Transportation	Tom Miller	Oyster Creek
Maureen Brown	San Onofre	Peter Miner	Pilgrim
Tim Brown	San Onofre Community Engagement Panel	Robert M. Mitchell	Yankee Rowe
JB Buksa	Bragg Crane and Rigging	Bethany Moore	Humboldt Bay
Joe Caccamo	Conrail	Jim Moore	Pacific Sun Railroad
Manuel Camargo	San Onofre	Tim Morehead	North County Transit District
Chris Campany	Windham Regional Commission	John Moylan	Pilgrim
Robert Capstick	Maine Yankee, Yankee Rowe, Connecticut Yankee	Robert Munger	San Onofre
Joe Cascio	Holtec	Frank Myszewski	Florida Northern Railroad
Kathy Cederberg	Massachusetts Emergency Management Agency	Ken Niles	State of Oregon
Paul Chadourne	Crystal River	Wayne A. Norton	Maine Yankee, Yankee Rowe, Connecticut Yankee
Martin Cohn	Vermont Yankee	David Noyes	Pilgrim
Ryan Coholan	Massachusetts Bay Transportation Authority	Patrick O'Brien	Pilgrim
Tammy Collinson	Fort Calhoun	Mike O'Connell	Oyster Creek
James Connell	Maine Yankee	Kate O'Connor	Vermont Nuclear Decommissioning Citizens Advisory Panel
Billy Costa	Humboldt Bay	Rob Oglesby	California Energy Commission
Pamela B. Cowan	Holtec	Michael Olmstead	New England Central Railroad
Mark Cutter	U.S. Coast Guard	Cheryl Olson	La Crosse
Patrick Daly	Zion	Tim Olson	Kewaunee
Suzanne D'Ambrosio	Oyster Creek	Kevin O'Reilly	Pilgrim Nuclear Decommissioning Citizens Advisory Panel
Pete Davin	Humboldt Bay	David Pabst	State of Wisconsin
Kristi DeBoi	AREVA TN	Tom Palmisano	San Onofre
Adam Deidel	Union Pacific Railroad	Michelle Panos	Humboldt Bay
Jeffrey Dostal	Oyster Creek	Tony Parrish	Florida Northern Railroad
Scott Douglas	New Jersey Department of Transportation, Office of Maritime Resources	Himanshu Patel	New Jersey Department of Transportation
Daniel Dove	Pilgrim	Paul Plante	Maine Yankee, Yankee Rowe, Connecticut Yankee
August Dowling	Crystal River	Chris Podgurski	Massachusetts Coastal Railroad
Pine du Bois	Pilgrim Nuclear Decommissioning Citizens Advisory Panel	Ronald Pontes	San Onofre
Joseph Dwyer	Oyster Creek	Lawrence R. Potter	Big Rock Point
Donald G. Egge	La Crosse	Jené Reese	Fort Calhoun
Teri Engelhart	State of Wisconsin	Jerry D. Reid	Trojan

Name	Affiliation	Name	Affiliation
Anthony Farrar	Massachusetts Coastal Railroad	John Renda	Oyster Creek
Alan Fata	Crystal River	Bob Richardson	New England Central Railroad
Don Filippi	North County Transit District	Richard Ridder	Kewaunee
Jay P. Fischer	Trojan	Ralph Ritter	Oyster Creek
Alan Fisher	New Jersey Department of Transportation	Einar T. Ronningen	Rancho Seco
Scott Flake	Rancho Seco	Brian D. Rude	La Crosse
James Frank	Oyster Creek	Ben Salo	Union Pacific Railroad
Gary Fowler	Bragg Crane and Rigging	Julia Schmitt	Nebraska Department of Health and Human Services
Becky Gaines	Rancho Seco	Loren Sharp	Humboldt Bay
John Giarrusso	Massachusetts Emergency Management Agency	Bill Shelton	North County Transit District
Jill Gibson	North County Transit District	Mike Shepard	Oyster Creek
Wendy Gendron	U.S. Army Corps of Engineers	Mike Shepard	San Onofre
Astrid Glynn	Massachusetts Department of Transportation	Kailen Shores	Fort Calhoun
Randall Granaas	San Onofre	Joshua Sisak	Oyster Creek
Glenn Goode	Iowa DOT Motor Vehicle Enforcement	Brian Smith	Yankee Rowe
Veena Gubbi	New Jersey Department of Environmental Protection, Bureau of Nuclear Engineering	Mark Smith	Humboldt Bay
John Guerci	Dominion	Paul Smith	Pilgrim Nuclear Decomissioning Citizens Advisory Panel
Mike Hale	Kewaunee	Todd Smith	Maine Yankee, Yankee Rowe, Connecticut Yankee
Michael Hand	Oyster Creek	Shane Sousa	Massachusetts Department of Transportation
Steve Hart	Conrail	Dan Sperling	Walker Brothers
Matt Hassler	Oyster Creek	Dan Stetson	San Onofre Community Engagement Panel
Shae Hemingway	Connecticut Yankee	Brian Sullivan	Holtec Decommissioning International
Justin Herrera	Crystal River	Greg Sutter	Crystal River
Thomas H. Higinbotham	State of Michigan	Kenneth Swanger	Vermont Yankee
David Hill	Massachusetts Department of Environmental Protection	Dan Tallman	Rancho Seco
Julie Holt	San Onofre	Ken Tavares	Plymouth Board of Selectmen
Eric Howes	Maine Yankee	Ray Termini	Zion
Jerry Humphreys	New Jersey Department of Environmental Protection, Bureau of Nuclear Engineering	George Thomas	Vermont Yankee
Teddy Hutchison	Fort Calhoun	Herb Tritt	Oyster Creek

Name	Affiliation	Name	Affiliation
Mike Jacobs	Pilgrim	William J. Trubilowicz	La Crosse
Sam Jammal	Camp Pendleton	Mark Tursa	Trojan
Darin Jeanquart	Kewaunee	James Unger	North County Transit District
Ian Johnson	Bragg Crane and Rigging	Jim VanLooven	Trojan
Ron Johnson	Prairie Island Indian Community	Gerard van Noordennen	Zion
David Johnston	Massachusetts Department of Environmental Protection	Bob VanWagner	Big Rock Point
Steven Johnston	Oyster Creek	David Victor	San Onofre Community Engagement Panel
Skip Jordan	Kewaunee	John Viveiros	Massachusetts Emergency Management Agency
Greg Kaylor	New Hampshire	Jay Vouglitois	New Jersey Department of Environmental Protection, Bureau of Nuclear Engineering
Doug Kimmel	State of Michigan	Brad Wagner	Nebraska State Patrol
Daniel King	Oneida Nation	Brian Wakeman	Dominion
Lee Kshywonis	Fort Calhoun	Joan Walter	State of California
Stephen LaJoice	Big Rock Point	David Weeden	Mashpee Wampanoag Tribe
Martin Langeveld	Vermont Nuclear Decommissioning Citizens Advisory Panel	Bob Weyers	Bragg Heavy Transport
Valerie Laudeman	Oyster Creek	Frederick N. Williams	Zion
Lee Laurendeau	Holtec	Ivan Wilson	Crystal River
Mark Lawson	Pilgrim	Brian Wood	Zion
Suzanne Leblang	Big Rock Point	Jan Wyckoff	BNSF (Retired)
James Lenois	Connecticut Yankee	Michael Wygant	North County Transit District
Tony Leshinskie	Vermont	Ken Yale	State of Michigan
Tim Lesniak	New England Central Railroad	Dave Yorke	Yankee Rowe
Eric Levin	Conrail	Stewart Yuen	Kewaunee
David Lohman	Kewaunee	William Zipp	Kewaunee
Douglas G. Low	New England Central Railroad	Rick Zuffa	State of Illinois
Andrew Ludasi	New Jersey Department of Transportation		

CONTENTS

EXECUTIVE SUMMARY iii

ACKNOWLEDGMENTS vii

ACRONYMS xxxi

1. INTRODUCTION 1

2. SITE INVENTORY, SITE CONDITIONS, NEAR-SITE TRANSPORTATION INFRASTRUCTURE AND EXPERIENCE, AND FUTURE INFORMATION NEEDS 3

2.1 Maine Yankee 14
2.1.1 Site Inventory 14
2.1.2 Site Conditions 18
2.1.3 Near-site Transportation Infrastructure and Experience 23
2.1.4 Future Information Needs 27

2.2 Yankee Rowe 27
2.2.1 Site Inventory 27
2.2.2 Site Conditions 30
2.2.3 Near-site Transportation Infrastructure and Experience 31
2.2.4 Future Information Needs 31

2.3 Connecticut Yankee 38
2.3.1 Site Inventory 38
2.3.2 Site Conditions 41
2.3.3 Near-site Transportation Infrastructure and Experience 41
2.3.4 Future Information Needs 51

2.4 Humboldt Bay 52
2.4.1 Site Inventory 52
2.4.2 Site Conditions 55
2.4.3 Near-site Transportation Infrastructure and Experience 55
2.4.4 Future Information Needs 66

2.5 Big Rock Point 69
2.5.1 Site Inventory 69
2.5.2 Site Conditions 72
2.5.3 Near-site Transportation Infrastructure and Experience 76
2.5.4 Future Information Needs 89

2.6 Rancho Seco 90
2.6.1 Site Inventory 90
2.6.2 Site Conditions 94
2.6.3 Near-site Transportation Infrastructure and Experience 98
2.6.4 Future Information Needs 102

2.7 Trojan 103
2.7.1 Site Inventory 103
2.7.2 Site Conditions 106

2.7.3 Near-site Transportation Infrastructure and Experience....106
2.7.4 Future Information Needs....117
2.8 La Crosse....117
2.8.1 Site Inventory....117
2.8.2 Site Conditions....120
2.8.3 Near-site Transportation Infrastructure and Experience....126
2.8.4 Future Information Needs....126
2.9 Zion....128
2.9.1 Site Inventory....128
2.9.2 Site Conditions....133
2.9.3 Near-site Transportation Infrastructure and Experience....138
2.9.4 Future Information Needs....139
2.10 Crystal River....144
2.10.1 Site Inventory....144
2.10.2 Site Conditions....147
2.10.3 Near-site Transportation Infrastructure and Experience....157
2.10.4 Future Information Needs....158
2.11 Kewaunee....178
2.11.1 Site Inventory....178
2.11.2 Site Conditions....183
2.11.3 Near-site Transportation Infrastructure and Experience....186
2.11.4 Future Information Needs....224
2.12 San Onofre....225
2.12.1 Site Inventory....225
2.12.2 Site Conditions....235
2.12.3 Near-site Transportation Infrastructure and Experience....243
2.12.4 Future Information Needs....257
2.13 Vermont Yankee....257
2.13.1 Site Inventory....257
2.13.2 Site Conditions....259
2.13.3 Near-site Transportation Infrastructure and Experience....268
2.13.4 Future Information Needs....278
2.14 Fort Calhoun....278
2.14.1 Site Inventory....278
2.14.2 Site Conditions....280
2.14.3 Near-site Transportation Infrastructure and Experience....290
2.14.4 Future Information Needs....304
2.15 Oyster Creek....304
2.15.1 Site Inventory....305
2.15.2 Site Conditions....307
2.15.3 Near-site Transportation Infrastructure and Experience....315
2.15.4 Future Information Needs....327
2.16 Pilgrim....328
2.16.1 Site Inventory....328
2.16.2 Site Conditions....330

2.16.3 Near-site Transportation Infrastructure and Experience.....336
2.16.4 Future Information Needs.....353

3. CONCLUSIONS AND RECOMMENDATIONS.....354

4. REFERENCES.....358

Appendix A: U.S. Nuclear Regulatory Commission Certificates of Compliance..... A-1

Appendix B: Summary of Permitting Requirements for Oversize and Overweight Trucks B-1

FIGURES

1-1. Locations of Reactor Sites Evaluated 2
2-1. Number of Canisters at Nuclear Power Plant Sites 5
2-2. Number of Assemblies by Cladding Type at Nuclear Power Plant Sites 7
2-3. Metric Tons of Heavy Metal by Cladding Type at Nuclear Power Plant Sites 8
2-4. Number of Canisters at Nuclear Power Plant Sites Associated with Nine Transportation Cask Models 13
2-5. Maine Yankee Independent Spent Fuel Storage Installation 15
2-6. Failed Canister Overpack at Maine Yankee Site 15
2-7. Maine Yankee Number of Assemblies versus Discharge Year 16
2-8. Maine Yankee Number of Assemblies versus Burnup 16
2-9. Damaged Fuel Cans 17
2-10. Damaged Fuel Can Lid with Screened Openings 17
2-11. Ends of Damaged Fuel Cans with Screened Openings 18
2-12. Aerial View of the Maine Yankee Site 20
2-13. On-site Rail Spur at the Maine Yankee Site 21
2-14. Paved-over Railroad Tracks at the Maine Yankee Site 22
2-15. Barge Dock at the Maine Yankee Site 22
2-16. Rail Interface at Maine Yankee 24
2-17. Paved Over Rail Spur at Maine Yankee Site 25
2-18. Maine Yankee Reactor Pressure Vessel Being Loaded onto Barge 26
2-19. Maine Yankee Reactor Pressure Vessel Being Transported on Barge 26
2-20. Yankee Rowe Independent Spent Fuel Storage Installation 28
2-21. NAC-STC Transportation Cask 29
2-22. Yankee Rowe Number of Assemblies versus Discharge Year 29
2-23. Yankee Rowe Number of Assemblies versus Burnup 30
2-24. Aerial View of the Yankee Rowe Site 32
2-25. Yankee Rowe Reactor Pressure Vessel Crossing the Sherman Dam 33
2-26. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck Moving Under Power Lines 33
2-27. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck 34
2-28. Rail Line at East Portal of the Hoosac Tunnel 34
2-29. East Portal of the Hoosac Tunnel 35

2-30. Yankee Rowe Reactor Pressure Vessel on Railcar 35
2-31. Yankee Rowe Reactor Pressure Vessel Heavy Haul Truck Route 37
2-32. Connecticut Yankee Independent Spent Fuel Storage Installation 39
2-33. Connecticut Yankee Number of Assemblies versus Discharge Year 40
2-34. Connecticut Yankee Number of Assemblies versus Burnup 40
2-35. Aerial View of the Connecticut Yankee Site 42
2-36. Aerial View of the Connecticut Yankee Independent Spent Fuel Storage Installation 43
2-37. Aerial View of the Connecticut Yankee Site and Cooling Water Discharge Canal 44
2-38. Barge Slip at the Connecticut Yankee Site 44
2-39. Connecticut Yankee Pressurizer on Heavy Haul Truck Transporter 46
2-40. Connecticut Yankee Heavy Haul Truck Route 47
2-41. Connecticut Yankee Pressurizer at the End of the Portland Rail Spur 48
2-42. Conditions at the End of the Portland Rail Spur 49
2-43. Connecticut Yankee Reactor Pressure Vessel Being Loaded onto Barge 50
2-44. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge 50
2-45. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge in the Connecticut River 51
2-46. Humboldt Bay Independent Spent Fuel Storage Installation 53
2-47. Humboldt Bay Number of Assemblies versus Discharge Year 54
2-48. Humboldt Bay Number of Assemblies versus Burnup 54
2-49. Aerial View of Humboldt Bay Site 56
2-50. Empty HI-STAR HB Cask Being Transported by Heavy Haul Truck 57
2-51. Humboldt Bay Independent Spent Fuel Storage Installation and Fields Landing Terminal 59
2-52. Fields Landing Terminal 60
2-53. Condition of Fields Landing Terminal 61
2-54. Wartsila Engine Being Loaded on a Barge 61
2-55. Wartsila Engine on a Barge Being Towed to Fields Landing Terminal 62
2-56. Barge with Wartsila Engine Arriving at Fields Landing Terminal 62
2-57. Wartsila Engine Being Unloaded at Fields Landing Terminal 63
2-58. Wartsila Engine Being Transported by Heavy Haul Truck to Humboldt Bay Generating Station 63
2-59. Humboldt Bay Site and Schneider Dock 64

2-60. Schneider Dock 65
2-61. Heavy Haul Routes from Humboldt Bay Independent Spent Fuel Storage Installation to Alternative Rail Access Locations 68
2-62. Big Rock Point Independent Spent Fuel Storage Installation 70
2-63. Big Rock Point Number of Assemblies versus Discharge Year 71
2-64. Big Rock Point Number of Assemblies versus Burnup 72
2-65. Aerial View of Big Rock Point Site 74
2-66. Transfer Cask and J-Skid at Big Rock Big Rock Point Independent Spent Fuel Storage Installation 75
2-67. Big Rock Point Gantry Towers 75
2-68. Big Rock Point Horizontal Transfer System 76
2-69. Big Rock Point Reactor Pressure Vessel on Heavy Haul Truck 78
2-70. ETMX1001 Railcar Staged for Transfer 78
2-71. Heavy Haul Truck with Reactor Pressure Vessel beside ETMX1001 Railcar 79
2-72. Transfer of Reactor Pressure Vessel onto ETMX1001 Railcar 79
2-73. Big Rock Point Reactor Pressure Vessel on ETMX1001 Railcar 80
2-74. Big Rock Point Reactor Pressure Vessel and Steam Drum Heavy Haul Truck Routes 81
2-75. Route Taken By Reactor Pressure Vessel to Bypass Low Overhead Clearance Abandoned Railroad Bridge 82
2-76. Low Overhead Clearance Abandoned Railroad Bridge on U.S. 31 83
2-77. Route Taken By Reactor Pressure Vessel in the Vicinity of Gaylord, Michigan 84
2-78. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking North) 85
2-79. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking South) 85
2-80. Big Rock Point Steam Drum on Heavy Haul Truck 86
2-81. Big Rock Point Steam Drum on Railcar 86
2-82. Route Taken By Steam Drum in the Vicinity of Petoskey, Michigan 87
2-83. Condition of Petoskey Rail Siding 88
2-84. Condition of Potential Barge Area at Big Rock Point 89
2-85. Rancho Seco Independent Spent Fuel Storage Installation 90
2-86. MP187 Transportation Cask at Rancho Seco 91
2-87. Hydraulic Ram Used to Emplace and Withdraw Canisters from Horizontal Storage Modules at Rancho Seco 91

2-88. MP187 Transportation Cask and Hydraulic Ram Being Used to Load a Canister into a Horizontal Storage Module at Rancho Seco 92
2-89. Rancho Seco Number of Assemblies versus Discharge Year 95
2-90. Rancho Seco Number of Assemblies versus Burnup 95
2-91. Aerial View of Rancho Seco Site 96
2-92. 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) 97
2-93. On-site Rail Spur Running into Rancho Seco Site 97
2-94. Aerial View of Ione Industrial Lead and Union Pacific Mainline 99
2-95. Rancho Seco Pressurizer on Railcar 100
2-96. Rancho Seco Steam Generator Segments on Railcars 100
2-97. Rancho Seco Generator on Heavy Haul Truck Being Transported to the Port of Stockton, California 101
2-98. MP187 Cask Transported by Heavy Haul Truck 102
2-99. Trojan Independent Spent Fuel Storage Installation 104
2-100. Trojan Number of Assemblies versus Discharge Year 105
2-101. Trojan Number of Assemblies versus Burnup 105
2-102. Aerial View of Trojan Site 107
2-103. Trojan Transfer Cask 108
2-104. Trojan Transfer Station 108
2-105. Trojan Transfer Station with Transfer Cask and Mobile Crane 109
2-106. Trojan Transfer Station with Transfer Cask and TranStor Vertical Concrete Storage Overpack 109
2-107. Rail Interface at Trojan 110
2-108. Portland and Western Railroad in the Vicinity of the Trojan Site 111
2-109. Location of Former Junction of Portland and Western Railroad and Trojan Rail Spur 111
2-110. Former Trojan Rail Spur Railbed 112
2-111. Remnants of On-site Rail Spur at Trojan 112
2-112. Trojan Barge Slip Access Road 113
2-113. Trojan Barge Slip 113
2-114. Trojan Steam Generator Being Loaded at Barge Slip 115
2-115. Trojan Reactor Pressure Vessel on Transport Cradle 115
2-116. Trojan Reactor Pressure Vessel Being Transported by Barge 116

2-117. Trojan Reactor Pressure Vessel Passing Through Locks on the Columbia River 116
2-118. Trojan Reactor Pressure Vessel Being Transported by Heavy Haul Truck 117
2-119. La Crosse Independent Spent Fuel Storage Installation 118
2-120. La Crosse Number of Assemblies versus Discharge Year 119
2-121. La Crosse Number of Assemblies versus Burnup 119
2-122. Aerial View of La Crosse Site 121
2-123. Aerial View of La Crosse Barge Facility and On-site Rail Spur 122
2-124. Aerial View of La Crosse Independent Spent Fuel Storage Installation and Boat Ramp 123
2-125. Remnants of the On-site Rail System at La Crosse Site 124
2-126. On-site Rail Spur at Northern End of La Crosse Site 124
2-127. Junction of On-site Rail Spur with BNSF Railroad at La Crosse Site 125
2-128. Coal Barge at Barge Dock Area at La Crosse Site 125
2-129. La Crosse Reactor Pressure Vessel on Rail Spur 127
2-130. La Crosse Reactor Pressure Vessel on BNSF Railroad 127
2-131. Zion Independent Spent Fuel Storage Installation 128
2-132. TSC-37 Canister Showing Internal Baskets Which Hold Spent Nuclear Fuel Assemblies 129
2-133. Transfer Cask 130
2-134. TSC-37 Canister Inside Transfer Cask 130
2-135. Damaged Fuel Can Being Installed in TSC-37 Canister 131
2-136. Zion Number of Assemblies versus Discharge Year 132
2-137. Zion Number of Assemblies versus Burnup 132
2-138. Aerial View of Zion Site 134
2-139. Aerial View of Zion Independent Spent Fuel Storage Installation 135
2-140. Vertical Concrete Storage Casks Staged at Zion 136
2-141. Spent Nuclear Fuel Transportable Storage Canisters Staged at Zion 136
2-142. Transporter Used to Move Vertical Concrete Storage Casks 137
2-143. Steam Generators Being Delivered to Zion Site by Barge during Construction 137
2-144. Barge Pilings at the North End of the Zion Site 138
2-145. Rail Interface at Zion 140
2-146. Trackmobile Used to Move Railcars On-site 141
2-147. On-site Rail Spur Entering Zion Site 141

2-148. Junction of Zion On-site Rail Spur with Union Pacific Railroad Showing Concrete Rail Ties 142
2-149. Steam Generator Being Prepared for Shipping 143
2-150. Two Steam Generators Awaiting Departure from the Zion Site 143
2-151. Zion Reactor Head on Heavy Haul Truck Transporter 144
2-152. Transfer Cask Being Used to Load Canister into Horizontal Storage Module 146
2-153. Crystal River Number of Assemblies versus Discharge Year 146
2-154. Crystal River Number of Assemblies versus Burnup 147
2-155. Site of the Crystal River Independent Spent Fuel Storage Installation Before Construction 148
2-156. Crystal River Independent Spent Fuel Storage Installation with Horizontal Storage Modules Installed 149
2-157. Aerial View of the Crystal River Energy Complex 150
2-158. Location of Crystal River Independent Spent Fuel Storage Installation 151
2-159. Nuclear Spur 152
2-160. Junction of On-site Industrial Spur (Left) and Nuclear Spur (Right) 152
2-161. On-site Industrial Rail Spur in Front of the Independent Spent Fuel Storage Installation Site (Looking East) 153
2-162. On-site Industrial Rail Spur in Front of the Independent Spent Fuel Storage Installation Site (Looking West) 153
2-163. On-site Industrial Rail Spur at the Coal Loop Junction 154
2-164. On-site Industrial Rail Spur Approaching U.S. Highway 19 from the West 154
2-165. Aerial View of the Crystal River Intake and Discharge Canals 155
2-166. Current Barge Area Used for Unloading Coal Barges 156
2-167. Barge Turning Basin 156
2-168. Aerial View of the Crystal River Industrial Rail Spur and Florida Northern Railroad 159
2-169. Aerial View of the Crystal River Industrial Rail Spur, Florida Northern Railroad, and CSXT Railroad 160
2-170. Newberry Wye 161
2-171. Florida Northern Railroad near Dunnellon, Florida 161
2-172. Highway Bridge over Florida Northern Railroad 162
2-173. Florida Northern Railroad Grade Crossing 162
2-174. Florida Northern Railroad Bridge 163
2-175. Wheel Detectors on Florida Northern Railroad 163

2-176. Hot Bearing Detector on Florida Northern Railroad 164
2-177. Dragging Equipment Detector on Florida Northern Railroad 164
2-178. Track Maintenance Equipment Staged at the Mine Spur 165
2-179. Hi-Rail Vehicle Used for Track Inspections 165
2-180. Moisture Separator Reheaters Being Shipped by Rail to the Crystal River Site 166
2-181. Moisture Separator Reheaters Being Unloaded at the Crystal River Site 166
2-182. Generator Rotor Being Shipped by Rail to the Crystal River Site 167
2-183. Generator Rotor Being Unloaded at the Crystal River Site 167
2-184. Old Moisture Separator Reheaters Being Shipped Off-site by Rail 168
2-185. Locomotive Picking Up Old Moisture Separator Reheaters 168
2-186. Two Horizontal Storage Modules Loaded on Railcars 169
2-187. Horizontal Storage Module Staged for Unloading 170
2-188. Horizontal Storage Module Being Unloaded from Railcar 171
2-189. Horizontal Storage Modules at Nuclear Spur after Unloading 172
2-190. Crystal River Site Barge Area 173
2-191. Crystal River Turbine Components on Barge 174
2-192. Barge with Turbine Components Approaching Ramp 174
2-193. Barge with Turbine Components Just Before Grounding at Ramp 175
2-194. Barge with Turbine Components Grounded at Ramp 175
2-195. Turbine Components Being Unloaded Using Self-Propelled Modular Transporter 176
2-196. Turbine Components Driving Off of Unloading Ramp 176
2-197. Turbine Components Fully Unloaded from Barge 177
2-198. Self-Propelled Modular Transporter Turning with Turbine Components 177
2-199. High Pressure Turbine Rotor Delivered to Crystal River Site by Heavy Haul Truck 178
2-200. Kewaunee Number of Assemblies versus Discharge Year 180
2-201. Kewaunee Number of Assemblies versus Burnup 181
2-202. Kewaunee Number of Assemblies Stored in 32PT Canisters versus Discharge Year 181
2-203. Kewaunee Number of Assemblies Stored in 32PT Canisters versus Burnup 182
2-204. Kewaunee Number of Assemblies Stored in TSC-37 Canisters versus Discharge Year 182
2-205. Kewaunee Number of Assemblies Stored in TSC-37 Canisters versus Burnup 183

2-206. Kewaunee Independent Spent Fuel Storage Installation 184
2-207. Aerial View of Kewaunee Site 185
2-208. Potential Rail Transload Locations and Heavy Haul Truck Routes for the Kewaunee Site 188
2-209. Potential Luxemburg Transload Location 189
2-210. Potential Luxemburg Heavy Haul Route 190
2-211. Potential Luxemburg Transload Location (Looking West) 191
2-212. Potential Luxemburg Transload Location Further Down Track (Looking West) 191
2-213. Potential Luxemburg Transload Location (Looking East) 192
2-214. Gantry System Used to Transfer Transformers from Railcars to Goldhofer Trailers 192
2-215. Transformer on 15-axle Goldhofer Trailer 193
2-216. Potential Bellevue Transload Location 194
2-217. Potential Bellevue Heavy Haul Route 195
2-218. Potential Bellevue Transload Location (Looking North) 196
2-219. Potential Bellevue Transload Location (Looking South) 196
2-220. Potential Bellevue Transload Location at WI-29 197
2-221. Approaching Potential Bellevue Transload Location on WI-29 (Looking West) 197
2-222. Horizontal Storage Module Transloading at Bellevue Location 198
2-223. Horizontal Storage Module on 6-axle Goldhofer Trailer 198
2-224. Potential Denmark Transload Location 199
2-225. Potential Denmark Heavy Haul Route 200
2-226. Potential Denmark Transload Location (Looking South) 201
2-227. Potential Denmark Transload Location (Looking North) 201
2-228. Potential Denmark Transload Location (Looking West) 202
2-229. Potential Denmark Transload Location (Looking East) 202
2-230. Potential Rockwood Spur at WI-310 Transload Location 203
2-231. Potential Rockwood Spur at WI-310 Heavy Haul Routes 204
2-232. Potential Rockwood Spur at WI-310 Transload Location (Looking North) 205
2-233. Potential Rockwood Spur at WI-310 Transload Location (Looking South) 205
2-234. Approaching Rockwood Spur at WI-310 from the East 206
2-235. Turning into Parking Lot at Rockwood Spur at WI-310 206
2-236. Traffic Circle on WI-310 (Looking East) 206
2-237. Potential Rockwood Spur at the Manitowoc Airport Transload Location 207

2-238. Potential Rockwood Spur at the Manitowoc Airport Heavy Haul Route 208
2-239. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) 209
2-240. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking South) 209
2-241. Access Road at Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) 210
2-242. Potential Manitowoc Transload Location 211
2-243. Potential Manitowoc Heavy Haul Routes 212
2-244. Potential Manitowoc Transload Location (Looking Northwest) 213
2-245. Potential Manitowoc Transload Location (Looking Southeast) 213
2-246. Potential Manitowoc Transload Location (Looking South) 214
2-247. Aerial View of Potential Kewaunee Barge Transload Location 216
2-248. Potential Heavy Haul Truck Route to City Of Kewaunee Dock Facilities 217
2-249. Potential Kewaunee Barge Transload Location Parking Lot 218
2-250. Potential Kewaunee Barge Transload Location Water Front 218
2-251. Horizontal Storage Modules Being Unloaded from a Barge 219
2-252. Horizontal Storage Module on 6-axle Goldhofer Trailer 219
2-253. Steam Generator on Goldhofer Trailer 220
2-254. First Steam Generator on Goldhofer Trailer Moving onto Barge 220
2-255. Barge with Two Steam Generators at Kewaunee Barge Transload Location 221
2-256. Fourth Steam Generator Moving onto Barge 221
2-257. Barge with Four Steam Generators at Kewaunee Barge Transload Location 222
2-258. Transloading of Steam Generator from Barge to Railcar in Houston, Texas 222
2-259. Steam Generators Arriving at Waste Control Specialists Low-Level Radioactive Waste Disposal Facility 223
2-260. Replacement Reactor Pressure Vessel Head on Heavy Haul Truck 223
2-261. Old Reactor Pressure Vessel Head on Heavy Haul Truck 224
2-262. Cutaway View of the HI-STORM UMAX Dry Storage System 226
2-263. 24PT4 Dry Storage Canisters 227
2-264. 32PTH2 Dry Storage Canisters (On Left) 227
2-265. Transfer Cask for 32PTH2 Canisters 228
2-266. Horizontal Storage Modules 228
2-267. San Onofre-1 Number of On-site Assemblies versus Discharge Year 230

2-268. San Onofre-1 Number of On-site Assemblies versus Burnup 231
2-269. San Onofre-2 and San Onofre-3 Number of Assemblies versus Discharge Year 231
2-270. San Onofre-2 and San Onofre-3 Number of Assemblies versus Burnup 232
2-271. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in 24PT4 Canisters versus Discharge Year 233
2-272. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in 24PT4 Canisters versus Burnup 233
2-273. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in MPC-37 Canisters versus Discharge Year 234
2-274. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in MPC-37 Canisters versus Burnup 234
2-275. Original San Onofre Independent Spent Fuel Storage Installation 236
2-276. Close-up View of Original San Onofre Independent Spent Fuel Storage Installation 236
2-277. Expanded San Onofre Independent Spent Fuel Storage Installation 237
2-278. Aerial View of San Onofre Site 238
2-279. Aerial View of the San Onofre Original and Expanded Independent Spent Fuel Storage Installation 239
2-280. Expanded San Onofre Independent Spent Fuel Storage Installation Location 240
2-281. On-site Rail System at San Onofre Site 240
2-282. On-site Rail System near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Southwest) 241
2-283. On-site Rail System and Vehicle Barrier near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Northeast) 241
2-284. On-site Rail Spur at San Onofre Site 242
2-285. Junction of On-site Rail Spur with Mainline at San Onofre Site 242
2-286. Aerial View of On-Site Rail Spur and the Administrative, Warehouse and Shop Building 243
2-287. Gondola Railcar Used to Transport Large Non-Containerized Components 244
2-288. Articulating Intermodal Railcar Transporting Low-Level Radioactive Waste 245
2-289. Main Generator Rotor on QTTX Railcar 245
2-290. San Onofre-1 Reactor Pressure Vessel on Goldhofer Trailer 246
2-291. San Onofre-1 Reactor Pressure Vessel on Schnabel Railcar 246
2-292. San Onofre-1 Reactor Pressure Vessel on Heavy Haul Truck Platform Trailer 247
2-293. Mainline at San Onofre Site (Looking North) 247
2-294. Mainline at San Onofre Site (Looking South) 248

2-295. Aerial View of Stuart Mesa Rail Yard 248
2-296. Stuart Mesa Rail Yard (Looking South) 249
2-297. San Onofre Steam Generators on Barge Arriving at Del Mar Boat Basin 251
2-298. Del Mar Boat Basin 252
2-299. Offloading of Steam Generator on Goldhofer Trailer at Del Mar Boat Basin Bulkhead 253
2-300. Steam Generator on Tracked Vehicle on Beach 253
2-301. Steam Generator on Goldhofer Trailer 254
2-302. Steam Generator Route from the Del Mar Boat Basin to the San Onofre Site 255
2-303. Del Mar Boat Basin Bulkhead 256
2-304. Old Steam Generator on Heavy Haul Truck Transporter 256
2-305. Vermont Yankee Number of Assemblies versus Discharge Year 258
2-306. Vermont Yankee Number of Assemblies versus Burnup 259
2-307. Aerial View of Vermont Yankee Site 261
2-308. Vernon Dam and Hydroelectric Station 262
2-309. Vermont Yankee Independent Spent Fuel Storage Installation 262
2-310. Aerial View of Vermont Yankee Independent Spent Fuel Storage Installation 263
2-311. Paved Over Portions on On-Site Rail Spur 264
2-312. On-Site Rail Spur Approaching Turbine Building 264
2-313. On-site Rail Spur Looking North 265
2-314. On-site Rail Spur Looking South 265
2-315. On-site Rail Spur Approaching Site Exit 266
2-316. Rail Spur at Entrance to Vermont Yankee Site 266
2-317. Aerial View of On-site Rail Spur 267
2-318. Aerial View of Vermont Yankee Rail Spur 269
2-319. Rail Spur at Vermont Yankee Site Entrance 270
2-320. Junction of Vermont Yankee Rail Spur (Left) and New England Central Railroad Mainline (Right) Looking South 270
2-321. Junction of Vermont Yankee Rail Spur and New England Central Railroad Mainline Looking North 271
2-322. Derailer on Vermont Yankee Rail Spur 271
2-323. Dragging Equipment Detector and Hot Bearing Detector on New England Central Railroad Mainline 272
2-324. Brattleboro Railyard 272

2-325. Palmer Railyard 273
2-326. Junction of New England Central Railroad (Left) and Pan Am Southern Railroad (Right) in East Northfield, Massachusetts 273
2-327. State Route 142 Grade Crossing at Milepost 115.97 274
2-328. Grade Crossing at Milepost 112.68 274
2-329. Connecticut River Railroad Bridge at Milepost 109.15 275
2-330. Railroad Bridge at Milepost 103.33 275
2-331. MP197HB Transportation Cask Without Impact Limiters on Railcar 276
2-332. MP197HB Transportation Cask With Impact Limiters on Railcar 277
2-333. MP197HB Transportation Cask Carrying Segmented Reactor Internals from Vermont Yankee Arriving at the Waste Control Specialists Low-Level Radioactive Waste Disposal Facility in Andrews, Texas 277
2-334. Fort Calhoun Number of Assemblies versus Discharge Year 279
2-335. Fort Calhoun Number of Assemblies versus Burnup 280
2-336. Aerial View of Fort Calhoun Site 282
2-337. Fort Calhoun Independent Spent Fuel Storage Installation 283
2-338. Aerial View of Fort Calhoun Independent Spent Fuel Storage Installation 284
2-339. Cargill Industrial Spur 285
2-340. Cargill Industrial Spur (Looking Northwest) 286
2-341. Cargill Industrial Spur (Looking Southeast) 286
2-342. Rail, Concrete Ties, and Pandrol Clips on Cargill Industrial Spur 287
2-343. Former On-site Rail Spur at Fort Calhoun 288
2-344. Aerial View of Barge Area at Fort Calhoun 289
2-345. Track at Entrance to Cargill Industrial Spur (Looking South) 290
2-346. Track at Entrance to Cargill Industrial Spur (Looking North) 291
2-347. Derailer at Entrance to Cargill Industrial Spur 291
2-348. Cargill Railyard and 7.5-8 Degree Curve on the Cargill Industrial Spur 292
2-349. Derailer and Greaser on Cargill Industrial Spur 293
2-350. Close-up of Greaser Activators on Cargill Industrial Spur 293
2-351. Track at Junction of Cargill Industrial Spur and Union Pacific Railroad (Looking South) 294
2-352. Track at Junction of Cargill Industrial Spur and Union Pacific Railroad (Looking North) 294
2-353. Horizontal Storage Modules Being Transported by Rail to Fort Calhoun 295
2-354. Horizontal Storage Modules Being Delivered to Fort Calhoun 296

2-355. Aerial View of Transload Location 296
2-356. Horizontal Storage Module Being Transloaded from Railcar to Self-Propelled Modular Transporter 297
2-357. Horizontal Storage Modules Being Moved on Haul Road to Independent Spent Fuel Storage Installation 297
2-358. Installation of Horizontal Storage Modules at Independent Spent Fuel Storage Installation 298
2-359. Completed Fort Calhoun Independent Spent Fuel Storage Installation 298
2-360. Current Condition of Transload Location 299
2-361. Current Condition of Haul Road 299
2-362. Reactor Vessel Being Shipped by Barge During Construction 300
2-363. Steam Generators Being Shipped by Barge During Construction 301
2-364. Steam Generators, Pressurizer, and Reactor Vessel Head Being Shipped by Barge 301
2-365. Tugboats Stabilizing Barge for Unloading 302
2-366. Bulldozers Stabilizing Barge for Unloading 302
2-367. Preparing to Unload Barge 303
2-368. Installation of Temporary Ramps for Unloading 303
2-369. Steam Generator on Transporter After Unloading 304
2-370. Oyster Creek Number of Assemblies versus Discharge Year 306
2-371. Oyster Creek Number of Assemblies versus Burnup 306
2-372. Aerial View of Oyster Creek Site 308
2-373. Aerial View of Oyster Creek Independent Spent Fuel Storage Installation 309
2-374. Ground-Level View of Oyster Creek Independent Spent Fuel Storage Installation 309
2-375. Aerial View of Oyster Creek Barge Locations 310
2-376. Oyster Creek Barge Access (North Bank of Oyster Creek) 311
2-377. Oyster Creek Barge Access Road Looking North 311
2-378. Oyster Creek Barge Access Location on the South Bank of Oyster Creek 312
2-379. Oyster Creek Looking East from U.S. Route 9 Bridge 312
2-380. Aerial View of Potential Heavy Haul Truck Route to Garden State Parkway 313
2-381. Potential Heavy Haul Truck Route to Garden State Parkway Looking East 314
2-382. Potential Heavy Haul Truck Route Looking West Towards Garden State Parkway 314
2-383. Potential Oyster Creek Rail Access Locations 316

2-384. Rail Line in Lakehurst, New Jersey Looking Northeast 317
2-385. End of Rail Line in Lakehurst, New Jersey Looking Northeast 317
2-386. Rail Line in Freehold, New Jersey Looking Northwest 318
2-387. Rail Line in Freehold, New Jersey Looking Southeast 318
2-388. End of Rail Line in Freehold, New Jersey Looking Northwest 319
2-389. Location of Morrisville, Pennsylvania Railyard and Potential Heavy Haul Truck Routes from Oyster Creek 320
2-390. Aerial View of the Morrisville, Pennsylvania Railyard 321
2-391. Morrisville Railyard Looking East 322
2-392. Potential Transload Location at Morrisville Railyard 322
2-393. 131-lb. Rail at Morrisville Railyard 323
2-394. Morrisville Railyard Access Road 323
2-395. Aerial View of the Oyster Creek State and Federal Channels, the Intracoastal Waterway, and the Barnegat Bay Inlet Channel 326
2-396. Entrance to Barnegat Bay Inlet 327
2-397. Pilgrim Number of Assemblies versus Discharge Year 329
2-398. Pilgrim Number of Assemblies versus Burnup 329
2-399. Aerial View of Pilgrim Site 331
2-400. Current Pilgrim Independent Spent Fuel Storage Installation 332
2-401. Storage System Mover at Pilgrim Independent Spent Fuel Storage Installation 332
2-402. Location of New Pilgrim Independent Spent Fuel Storage Installation 333
2-403. Construction of New Pilgrim Independent Spent Fuel Storage Installation 334
2-404. Construction of New Pilgrim Independent Spent Fuel Storage Installation 334
2-405. Aerial View of Pilgrim Barge Access Location 335
2-406. Barge Access at Pilgrim Site 336
2-407. Potential Heavy Haul Truck Routes to Rail Transload Locations 338
2-408. Aerial View of First Potential Rail Transload Location in Middleborough, Massachusetts 339
2-409. First Potential Rail Transload Location Looking East 340
2-410. First Potential Rail Transload Location Looking West 340
2-411. Derailer at First Potential Rail Transload Location 341
2-412. Positive Train Control Sensors at First Potential Rail Transload Location 341
2-413. 132-lb. Rail at First Potential Rail Transload Location 342
2-414. Low Overhead Bridges (13’11”) Near First Potential Rail Transload Location 342

2-415. Aerial View of Second Potential Rail Transload Location 343
2-416. Mainline at Second Potential Rail Transload Location Looking Southeast 344
2-417. Mainline at Second Potential Rail Transload Location Looking Northwest 344
2-418. Industrial Spur at Second Potential Rail Transload Location Looking Southeast 345
2-419. Industrial Spur at Second Potential Rail Transload Location Looking South 345
2-420. Industrial Spur at Second Potential Rail Transload Location Looking Northwest 346
2-421. Industrial Spur at Second Potential Rail Transload Location Looking East 346
2-422. Industrial Spur at Second Potential Rail Transload Location Covered with Compost 347
2-423. End of Industrial Spur at Second Potential Rail Transload Location 347
2-424. 115-lb. Rail at Industrial Spur at Second Potential Rail Transload Location 348
2-425. Aerial View of Potential Barge to Heavy Haul Truck to Rail Transload Locations on the South Bank of the Cape Cod Canal 349
2-426. Closeup Aerial View of Potential Barge to Heavy Haul Truck to Rail Transload Locations 350
2-427. West Barge Transload Location Looking East 351
2-428. East Barge Transload Location Looking West 351
2-429. Rail Line Approaching Barge Transload Locations 352
2-430. Cape Cod Canal Railroad Bridge 352

TABLES

S-1. Summary of Transportation Mode Options for Shipments from Nuclear Power Plant Sites v
2-1. Characteristics of Nuclear Power Plant Site Reactors 4
2-2. Storage Systems and Transportation Casks Used at Nuclear Power Plant Sites 9
2-3. Alternative Rail Access for Humboldt Bay 67
2-4. Assembly Identification Numbers for Mixed Oxide Spent Nuclear Fuel Assemblies at Big Rock Point 69
2-5. Details of Damaged Fuel Assemblies at Rancho Seco 94
2-6. Potential Kewaunee Rail Transload Locations 186
3-1. Summary of Transportation Mode Options for Shipments from Nuclear Power Plant Sites 356
A-1. Transportation Casks Certified to Transport Spent Nuclear Fuel from the Nuclear Power Plant Sites A-3
A-2. General Licensed Storage Systems Used at the Nuclear Power Plant Sites A-4
A-3. Site-Specific Licenses at the Nuclear Power Plant Sites A-4
B-1. California Oversize Vehicle Permitting Practices B-4
B-2. Connecticut Oversize Vehicle Permitting Practices B-5
B-3. Florida Oversize Vehicle Permitting Practices B-6
B-4. Illinois Oversize Vehicle Permitting Practices B-7
B-5. Maine Oversize Vehicle Permitting Practices B-8
B-6. Massachusetts Oversize Vehicle Permitting Practices B-9
B-7. Michigan Oversize Vehicle Permitting Practices B-10
B-8. Nebraska Oversize Vehicle Permitting Practices B-11
B-9. New Jersey Oversize Vehicle Permitting Practices B-12
B-10. Oregon Oversize Vehicle Permitting Practices B-13
B-11. Pennsylvania Oversize Vehicle Permitting Practices B-14
B-12. Vermont Oversize Vehicle Permitting Practices B-15
B-13. Wisconsin Oversize Vehicle Permitting Practices B-16
B-14. Summary of State Super Load Dimension and Weight Requirements B-17

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ACRONYMS

AC&T	American Cranes & Transport
ADAMS	U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System
BWR	boiling water reactor
CN	Canadian National Railway
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
NCTD	North County Transit District
NRC	U.S. Nuclear Regulatory Commission
PG&E	Pacific Gas and Electric Company
PWR	pressurized water reactor
QA	quality assurance
SCRRA	Southern California Regional Rail Authority
SNF	spent nuclear fuel
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
USACE	U.S. Army Corps of Engineers
UTC	Universal Transport Cask

OFFICE OF INTEGRATED WASTE MANAGEMENT

Nuclear Power Plant Infrastructure Evaluations for Removal of Spent Nuclear Fuel

1. INTRODUCTION

This report provides evaluations of the nuclear power plant (NPP) site infrastructure and near-site transportation infrastructure for removing spent nuclear fuel (SNF) from 16 NPP sites. The U.S. Department of Energy (DOE) intends to expand the report in the future as site evaluations of additional NPP sites are completed and to update information on sites previously evaluated. The locations of the 16 NPP sites are shown in Figure 1-1. The material to be removed from the NPP sites includes both the SNF and the greater-than-Class C low-level radioactive waste (GTCC waste) that is stored, or will be stored, at the sites.

The evaluation for each of the 16 NPP sites evaluated is divided into four components:

- characterization of the SNF and GTCC 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 SNF from the NPP sites
- identification of future information needs.

Section 2 contains the NPP site evaluations and is organized by site. Subsections contain information on the SNF inventory (e.g., discharge date and burnup), damaged fuel, high burnup fuel, dry storage systems, potential transportation casks, and on-site-infrastructure and equipment at the site; information on the near-site transportation infrastructure around the site, such as roads, railroads, barge facilities (e.g., slips or docks), and potential transload locations; information on shipping large equipment to and from the site, such as reactor pressure vessels, steam generators, pressurizers, and transformers; and future information needs, such as transportation cask certificate of compliance revisions, issues associated with the transportation infrastructure near the site, and potential transload locations.

Section 3 identifies transportation mode options for removing SNF from the NPP sites.

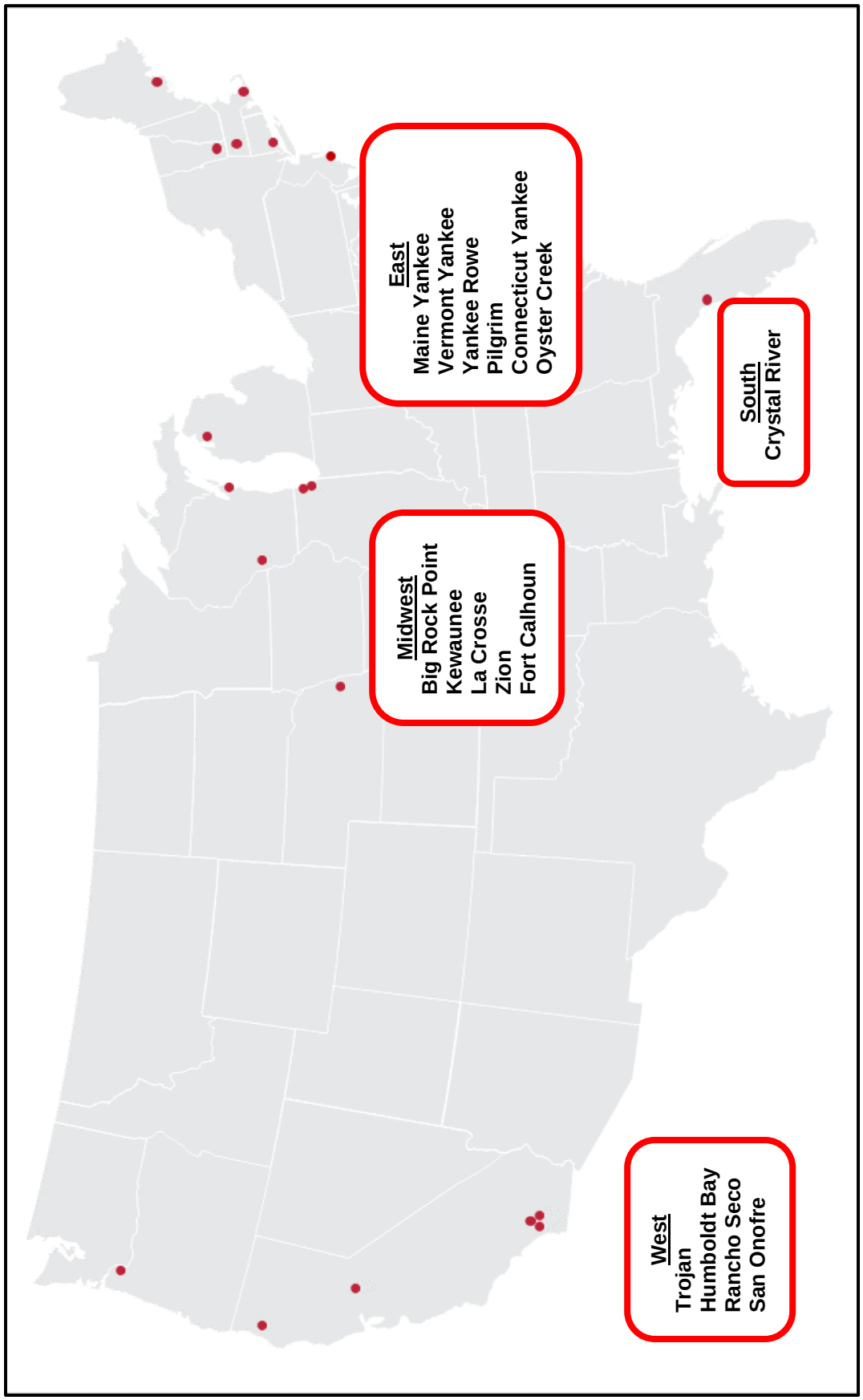


Figure 1-1. Locations of Reactor Sites Evaluated

2. SITE INVENTORY, SITE CONDITIONS, NEAR-SITE TRANSPORTATION INFRASTRUCTURE AND EXPERIENCE, AND FUTURE INFORMATION NEEDS

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs for the NPP sites. The primary sources for the inventory of SNF and GTCC waste are the GC-859 database (EIA 2013), 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, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim NPP sites; information provided by managers at the NPP 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 2019).

Table 2-1 lists the characteristics of the NPPs at the sites. These reactors operated between the years 1961 and 2019. Six of the reactors (Humboldt Bay, Big Rock Point, La Crosse, Vermont Yankee, Oyster Creek, and Pilgrim) were boiling water reactors and thirteen of the reactors were pressurized water reactors (Maine Yankee, Yankee Rowe, Connecticut Yankee, Rancho Seco, Trojan, Zion 1 and 2, Crystal River, Kewaunee, San Onofre-1, -2, and -3, and Fort Calhoun). The licensed capacities for these reactors ranged from 165 to 3438 MWt (48 to 1095 MWe).

Figure 2-1 illustrates the number of canisters and type of storage canisters containing SNF and GTCC waste that are stored or will be stored at each of the NPP sites. The number of SNF and GTCC waste 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 SNF canisters at Kewaunee, Crystal River, San Onofre, Vermont Yankee, and Fort Calhoun represents the actual canisters in storage. The number of SNF canisters at Oyster Creek and Pilgrim represents an estimate of the number of canisters that will be stored at the conclusion of canister loading and the number of GTCC waste canisters at Crystal River, Kewaunee, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim represents an estimate of the number of canisters generated during decommissioning. There are expected to be a total of 717 canisters in storage at the 16 sites (actual plus estimated). The number of canisters ranges from 5 at La Crosse to an estimated 136 at San Onofre.

Table 2-1. Characteristics of Nuclear Power Plant Site Reactors

Site Location[a]	Reactor Type[a]	MWt[a]	MWe (net)[b,c]	Operating Period[b,d]
Maine Yankee, Wiscasset, Maine	PWR	2700	860	1972-1996
Yankee Rowe, Rowe, Massachusetts	PWR	600	167	1961-1991
Connecticut Yankee, Haddam Neck, Connecticut	PWR	1825	560	1968-1996
Humboldt Bay, Eureka, California	BWR	200	63	1963-1976
Big Rock Point, Charlevoix, Michigan	BWR	240	67	1963-1997
Rancho Seco, Herald, California	PWR	2772	873	1975-1989
Trojan, Rainier, Oregon	PWR	3411	1095	1976-1992
La Crosse, Genoa, Wisconsin	BWR	165	48	1969-1987
Zion 1, Zion, Illinois	PWR	3250	1040	1973-1997
Zion 2, Zion, Illinois	PWR	3250	1040	1974-1996
Crystal River, Crystal River, Florida	PWR	2609	860	1977-2009
Kewaunee, Carlton, Wisconsin	PWR	1772	566	1974-2013
San Onofre-1, San Clemente, California	PWR	1347	436	1968-1992
San Onofre-2, San Clemente, California	PWR	3438	1070	1983-2013
San Onofre-3, San Clemente, California	PWR	3438	1080	1984-2013
Vermont Yankee, Vernon, Vermont	BWR	1912	605	1972-2014
Fort Calhoun, Fort Calhoun, Nebraska	PWR	1500	502	1973-2016
Oyster Creek, Forked River, New Jersey	BWR	1930	619	1969-2018
Pilgrim, Plymouth, Massachusetts	BWR	2028	677	1972-2019

a. Source: NRC (2019)
b. Source: IAEA (2020)
c. Reference unit power from IAEA (2020).
d. The operating period represents the date of commercial operation to the date of shutdown.
PWR= pressurized water reactor
BWR= boiling water reactor

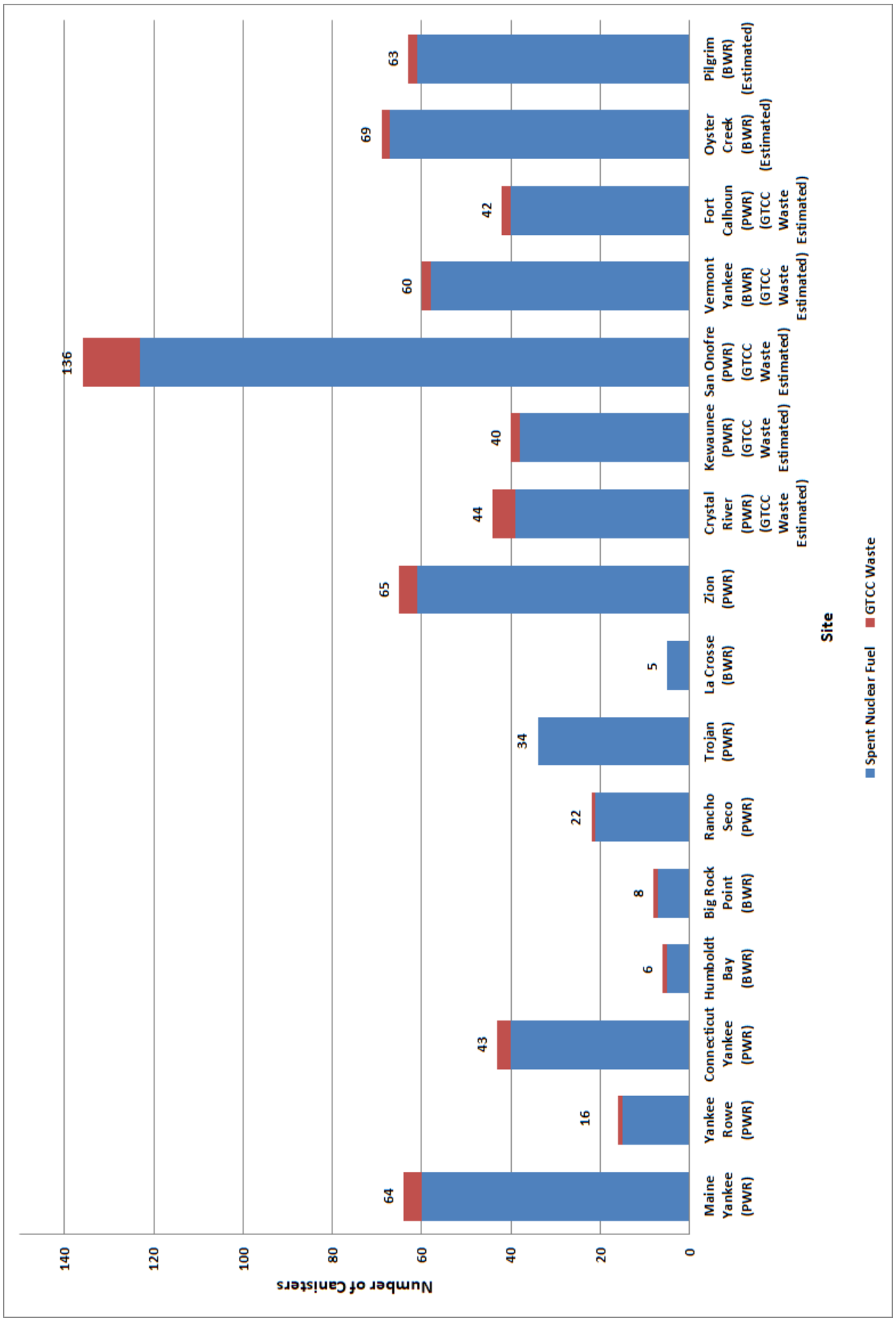


Figure 2-1. Number of Canisters at Nuclear Power Plant Sites

Figure 2-2 illustrates the number of SNF assemblies stored at each of the 16 NPP sites evaluated. There are a total of 27,845 SNF assemblies present at these 16 NPP sites. These assemblies are composed of 14,183 pressurized water reactor assemblies and 13,662 boiling water reactor assemblies. The number of assemblies ranges from 333 at La Crosse to 4504 at Oyster Creek. The majority (26,183) of the SNF assemblies are zirconium alloy-clad;[3] but Yankee Rowe, Connecticut Yankee, La Crosse, and San Onofre-1 have 1662 stainless steel-clad SNF 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 8222.2 metric tons heavy metal (MTHM) of SNF at the NPP sites consists of 5862.9 MTHM of pressurized water reactor SNF and 2359.3 MTHM of boiling water reactor SNF. The number of assemblies and MHTM of SNF at each NPP site were obtained from the GC-859 database (EIA 2013), from information provided by the NPP sites, and from projections made using the U.S. Commercial Spent Fuel Projection Tool (Vinson 2015), and may not include material such as fuel debris and failed fuel rods that may also be present in the storage canisters at the NPP sites.

Table 2-2 lists the storage systems used at the NPP sites and the corresponding transportation casks that are certified to ship the storage canisters containing SNF and GTCC waste at each of the sites and Figure 2-4 illustrates the number of canisters that are associated with each transportation cask.[4] Out of the nine transportation cask designs listed in Table 2-2 and Figure 2-4, only four types have been fabricated for U.S. use: the HI-STAR HB, the MP187, the HI-STAR 100,[5] and the MP197HB. The HI-STAR HB can only be used to ship SNF from the Humboldt Bay site. The MP187 can be used to ship SNF 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 2017). For these HI-STAR 100 casks to be used to ship SNF from the Trojan, Vermont Yankee, or Pilgrim sites, they would need to be unloaded, their contents placed in other storage overpacks, and the casks transported to the Trojan, Vermont Yankee, or Pilgrim sites. It would also be necessary to procure impact limiters and spacers for these HI-STAR 100 casks. Six NAC-STC transportation casks have been fabricated for use in China, but not for use in the United States. An MP197HB transportation cask has been fabricated and is in use in the U.S.

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

[4] 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 SNF from the NPP 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 NPP 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 presents a summary of state permitting requirements for oversize and overweight truck shipments in California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Nebraska, New Jersey, Oregon, Pennsylvania, Vermont, and Wisconsin.

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

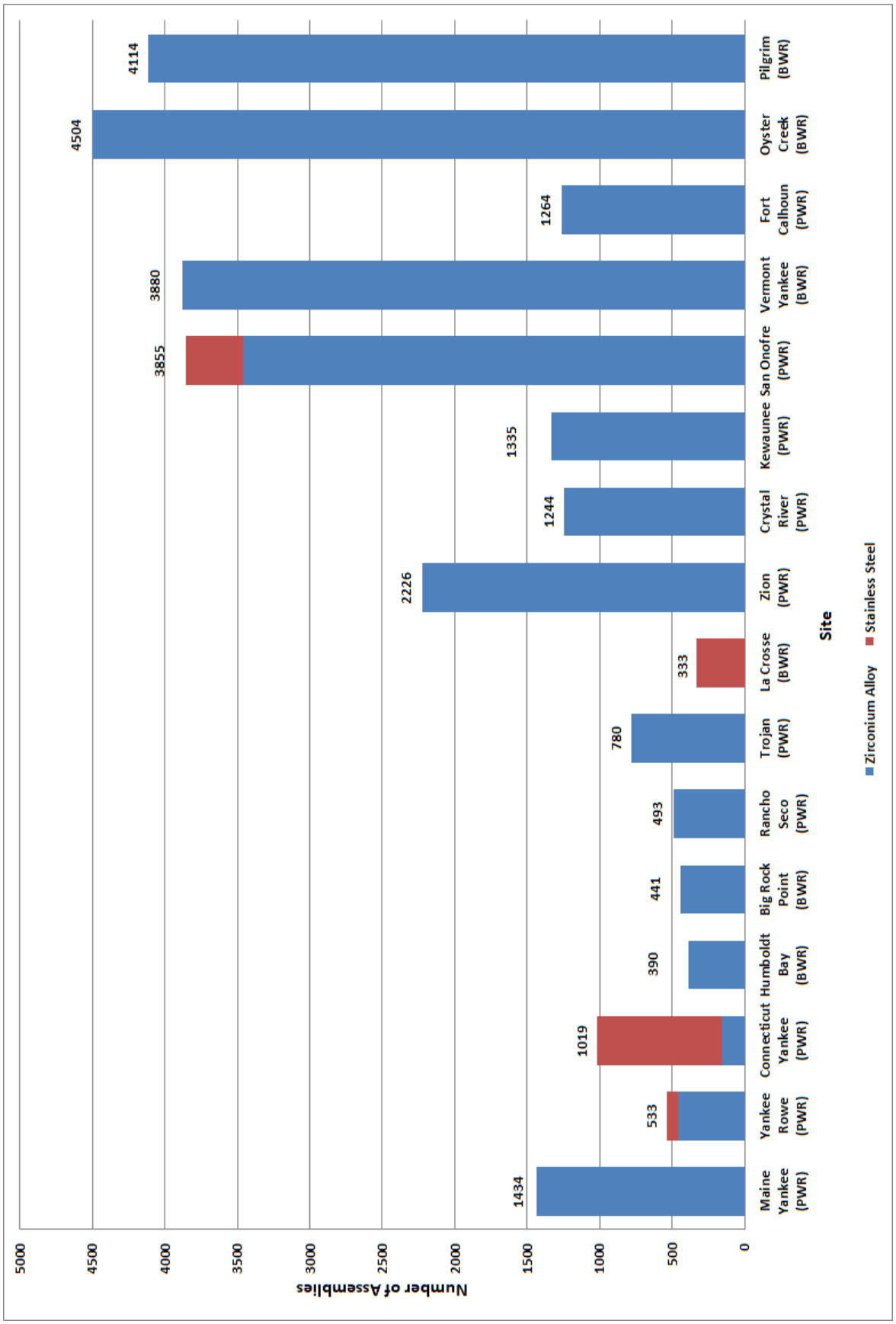


Figure 2-2. Number of Assemblies by Cladding Type at Nuclear Power Plant Sites

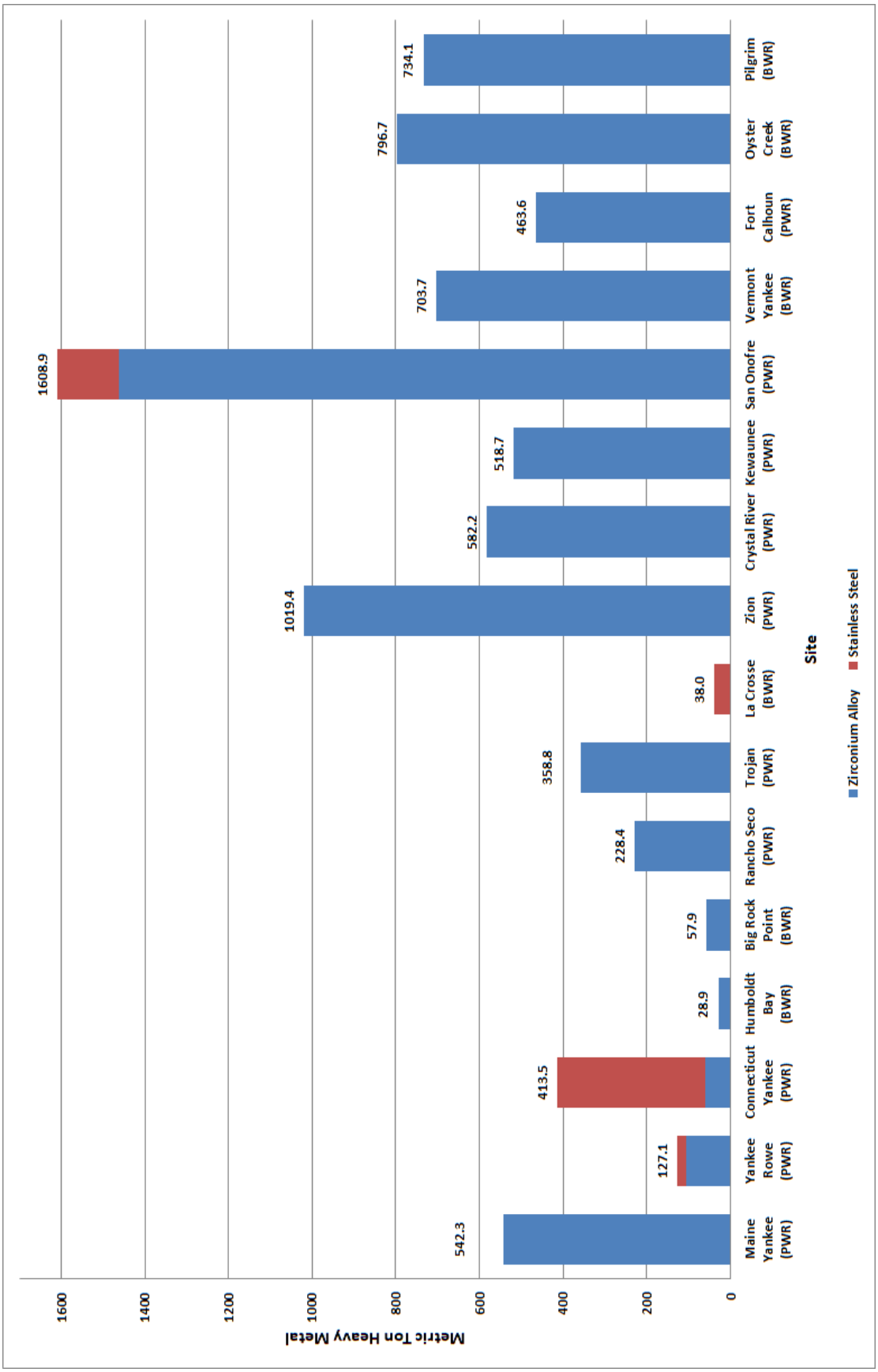


Figure 2-3. Metric Tons of Heavy Metal by Cladding Type at Nuclear Power Plant Sites

Table 2-2. Storage Systems and Transportation Casks Used at Nuclear Power Plant Sites

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters SNF/GTCC
Maine Yankee	PWR	08/2002-03/2004	NAC-UMS/transportable storage canister	NAC-UMS UTC (Docket No. 71-9270) Certificate expires 10/31/2022. 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 05/31/2024. 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 05/31/2024. 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 04/30/2024. 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 10/31/2022. 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 11/30/2023. 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 04/30/2024. 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 05/31/2024. 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) Certificate expires 04/30/2024. None fabricated.	61/4

Table 2-2. (contd.)

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters SNF/GTCC
Crystal River	PWR	06/2017-01/2018	TN Standardized NUHOMS/32PTH1 canister	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2022. One cask fabricated.	39/5[b,c]
Kewaunee	PWR	08/2009 06/2010 07/2011-08/2011 07/2014-08/2014	TN Standardized NUHOMS/32PT canister	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2022. One cask fabricated.	14/2[b,c]
Kewaunee	PWR	01/2017-06/2017	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN (Docket No. 71-9356) Certificate expires 04/30/2024. None fabricated.	24/0
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 11/30/2023. One cask fabricated. No impact limiters.	17/1
San Onofre-2 and San Onofre-3	PWR	03/2007-07/2012	TN Standardized Advanced NUHOMS/24PT4 canisters and Radioactive Waste Containers (RWCs)	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2022. One cask fabricated.	33/12[b,c]
San Onofre-2 and San Onofre-3	PWR	02/2018-08/2020	Holtec HI-STORM UMAX/MPC-37 canisters	HI-STAR 190 (Docket No. 71-9373) Certificate expires 08/31/2022. None fabricated.	73/0
San Onofre Total					123/13
Vermont Yankee	BWR	05/2008-07/2008 06/2011-08/2011 05/2012-06/2012 06/2017-08/2018	Holtec HI-STORM 100S/MPC-68 and MPC-68M canisters	HI-STAR 100 (Docket No. 71-9261) Certificate expires 04/30/2024. Units fabricated but dedicated to storage at other sites. No impact limiters or spacers.	58/2[b,c]

Table 2-2. (contd.)

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters SNF/GTCC
Fort Calhoun	PWR	07/2006-08/2006 07/2009-08/2009 11/2019-05/2020	TN Standardized NUHOMS/32PT canister	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2022. One cask fabricated.	40/2[b,c]
Oyster Creek	BWR	04/2002-05/2002 04/2003-05/2003 04/2004-05/2004 04/2005-05/2005 05/2010 04/2012-05/2012 05/2016-06/2016 04/2018-05/2018	TN Standardized NUHOMS/61BT and 61BTH canisters	MP197HB (Docket No. 71-9302) Certificate expires 08/31/2022. One cask fabricated.	34/0
Oyster Creek	BWR	2021	Holtec HI-STORM FW/MPC-89 canister	HI-STAR 190 (Docket No. 71-9373) Certificate expires 08/31/2022. None fabricated	33/2[b,c]
Oyster Creek Total					67/2

Table 2-2. (contd.)

Reactor Site	Type	ISFSI Load Dates[a]	Storage System/Canister(s)	Transportation Cask Status	Canisters SNF/GTCC
Pilgrim	BWR	01/2015- 02/2015 10/2016 07/2018- 10/2018 05/2020- Ongoing	Holtec HI-STORM 100S/MPC-68 and MPC-68M canisters	HI-STAR 100 (Docket No. 71-9261) Certificate expires 04/30/2024. Units fabricated but dedicated to storage at other sites. No impact limiters or spacers.	61/2[b,c]
Total					674/43

a. Dates represent the dates that the SNF was transferred to the ISFSI.
b. Estimated.
c. Additional canisters of GTCC waste could be generated during decommissioning.
BWR= boiling water reactor
GTCC= greater-than-Class C low-level radioactive waste
ISFSI= independent spent fuel storage installation
PWR= pressurized water reactor
SNF= spent nuclear fuel

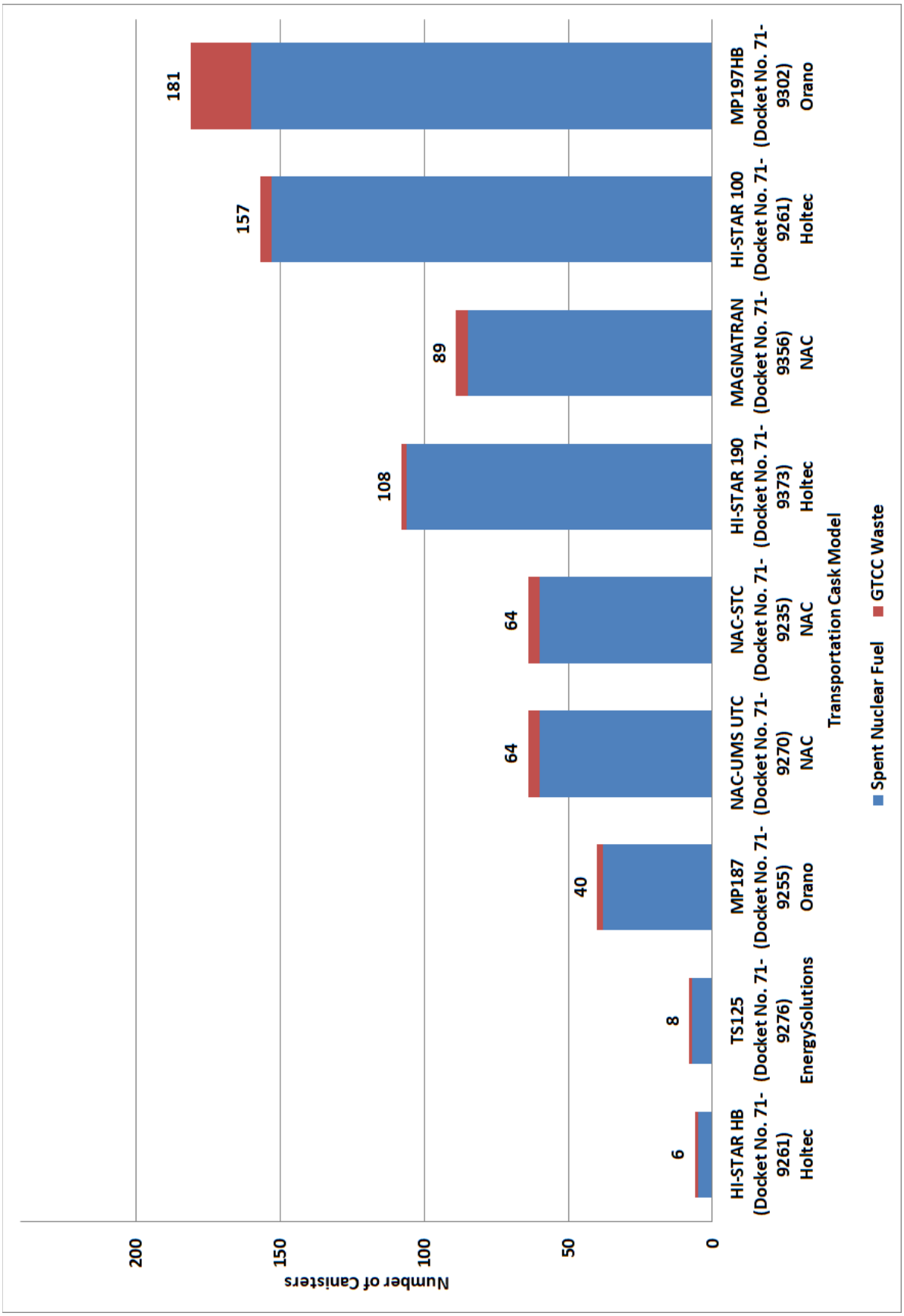


Figure 2-4. Number of Canisters at Nuclear Power Plant Sites Associated with Nine Transportation Cask Models

2.1 Maine Yankee

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies, 2 consolidated fuel rod containers, and 2 failed fuel rod containers (i.e., damaged fuel cans[6]) and 4 canisters of GTCC waste are stored at the Maine Yankee ISFSI (Docket No. 72-30). Figure 2-5 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 SNF 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 SNF or GTCC waste is the NAC-UMS Universal Transport Cask (UTC) Package (Docket No. 71-9270). No NAC-UMS UTC transportation casks have been fabricated.

A failed canister overpack is also present at the Maine Yankee site (see Figure 2-6). The failed canister overpack is a bolted closure overpack that may be used to remediate a postulated canister leak without the need to access a spent fuel pool. The sealed failed canister overpack is capable of providing an additional confinement boundary for a postulated leaking canister inside a vertical concrete storage cask. The failed canister overpack is not licensed for storage in the NAC-UMS storage system and is not certified for transport in the NAC-UMS UTC transportation cask.

Figure 2-7 illustrates the number of SNF 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 2-8 illustrates the number of SNF 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. SNF with a burnup greater than 45 GWd/MTHM is termed as high burnup SNF by the NRC. There are 90 of these high burnup SNF assemblies at Maine Yankee. These high burnup SNF assemblies were packaged in Maine Yankee Fuel Cans (i.e., damaged fuel cans, see Figure 2-9 through Figure 2-11) and were loaded in the four basket corner positions in the transportable storage canisters. Twenty-three transportable storage canisters containing high burnup SNF 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.

[6] A damaged fuel can is a stainless steel container that confines damaged spent 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.

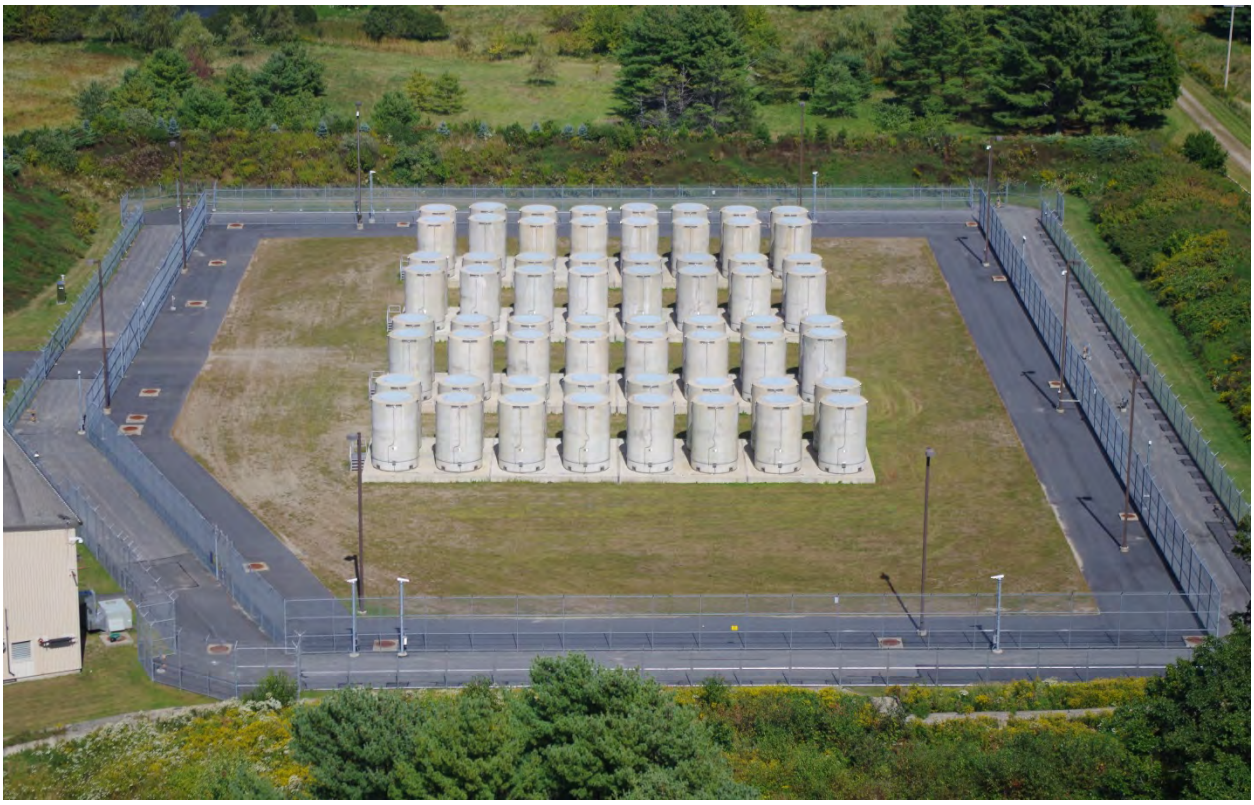


Photo courtesy of Maine Yankee

Figure 2-5. Maine Yankee Independent Spent Fuel Storage Installation (2014)



Photo courtesy of Maine Yankee

Figure 2-6. Failed Canister Overpack at Maine Yankee Site

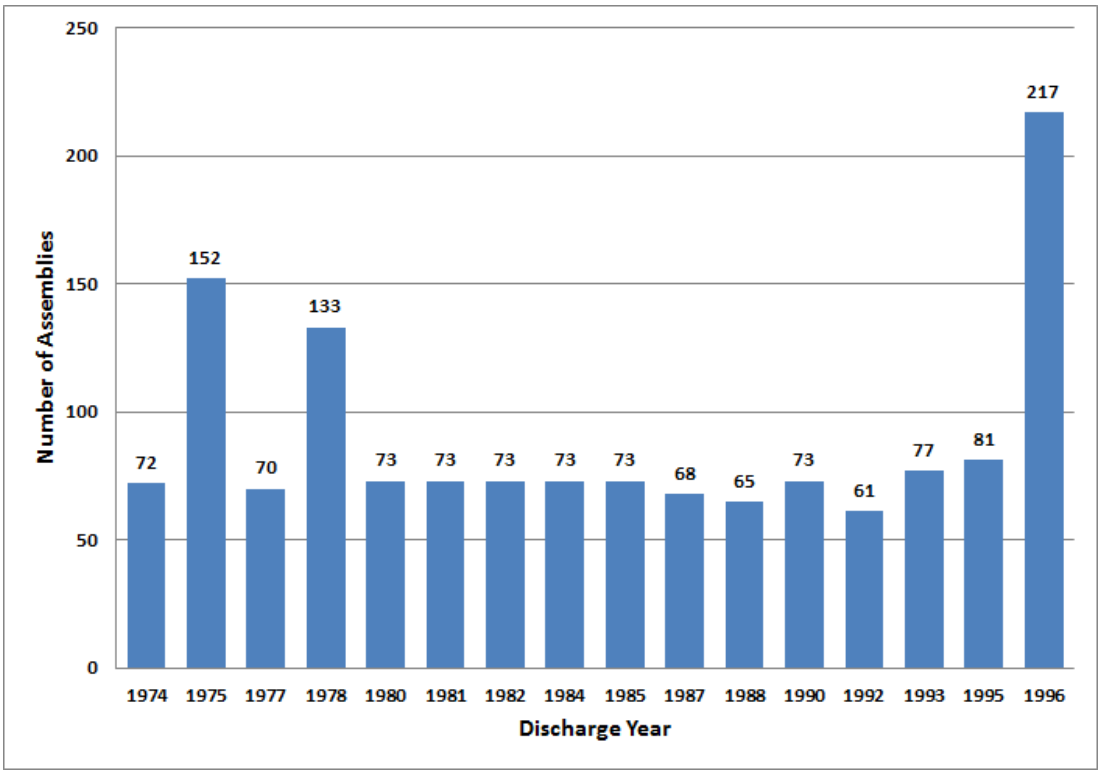


Figure 2-7. Maine Yankee Number of Assemblies versus Discharge Year (EIA 2013)

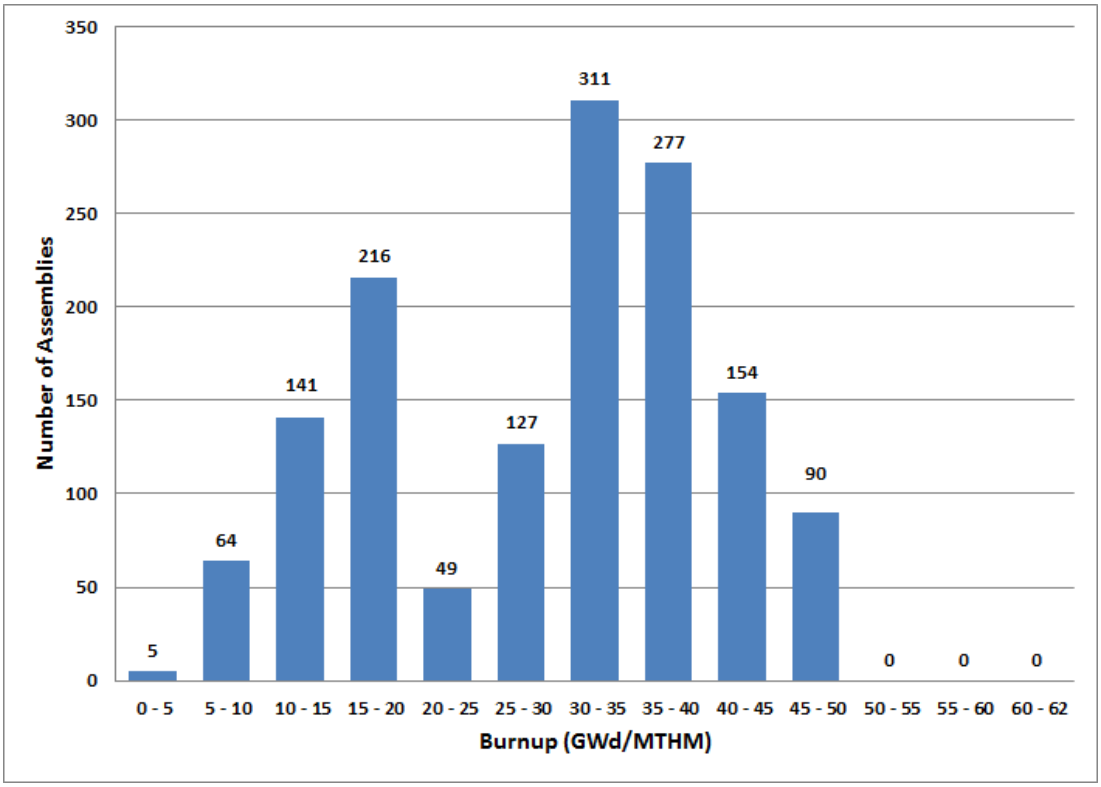


Figure 2-8. Maine Yankee Number of Assemblies versus Burnup (EIA 2013)



Photo courtesy of NAC International

Figure 2-9. Damaged Fuel Cans

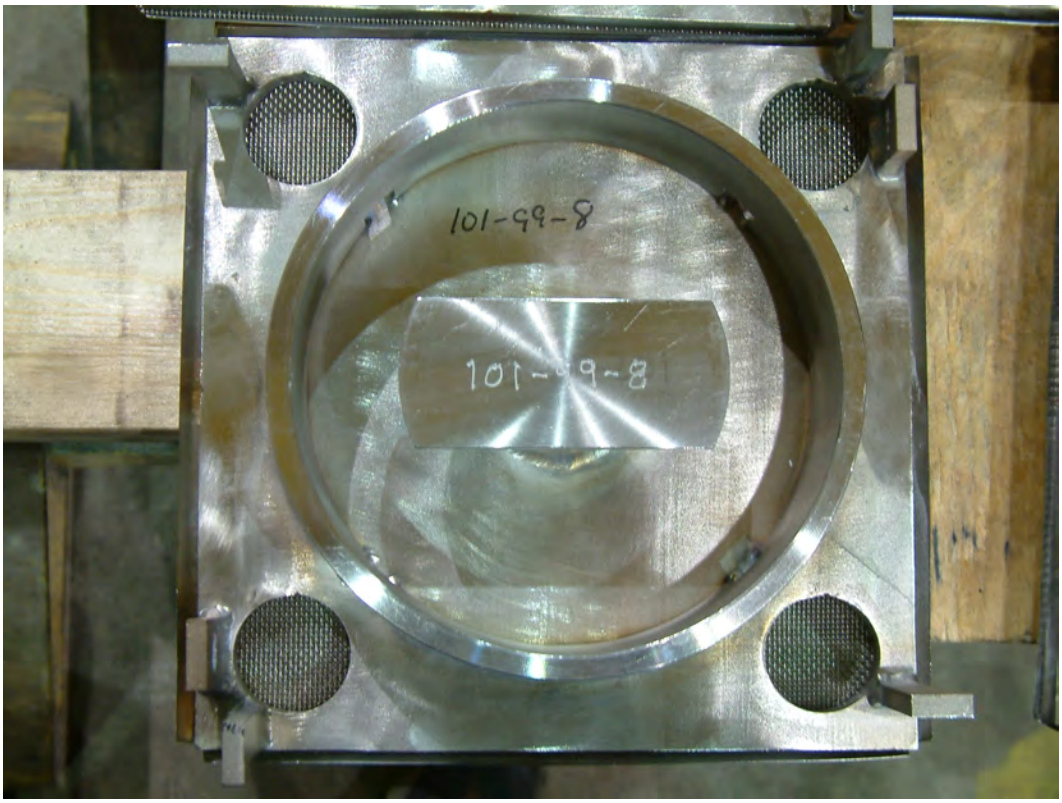


Photo courtesy of NAC International

Figure 2-10. Damaged Fuel Can Lid with Screened Openings



Photo courtesy of NAC International

Figure 2-11. Ends of Damaged Fuel Cans with Screened Openings

2.1.2 Site Conditions

Figure 2-12 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 SNF and GTCC 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 2-13). This spur connects to the Rockland branch of the Central Maine and Quebec Railway at milepost 46.66, which is designated as track class 2.[7] The Rockland branch is owned by by the State of Maine and leased to the Central

[7] 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.

Maine and Quebec Railway. 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.[8] 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 2-14) and is not being maintained.

A barge dock that exists at Maine Yankee (Figure 2-15) 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, measured 19 ft. in diameter, was 35 ft. long, 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.

[8] 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 – greater than $250 million, Class II – $20 million to $250 million, and Class III – less than $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 2-12. Aerial View of the Maine Yankee Site (Google 2019)

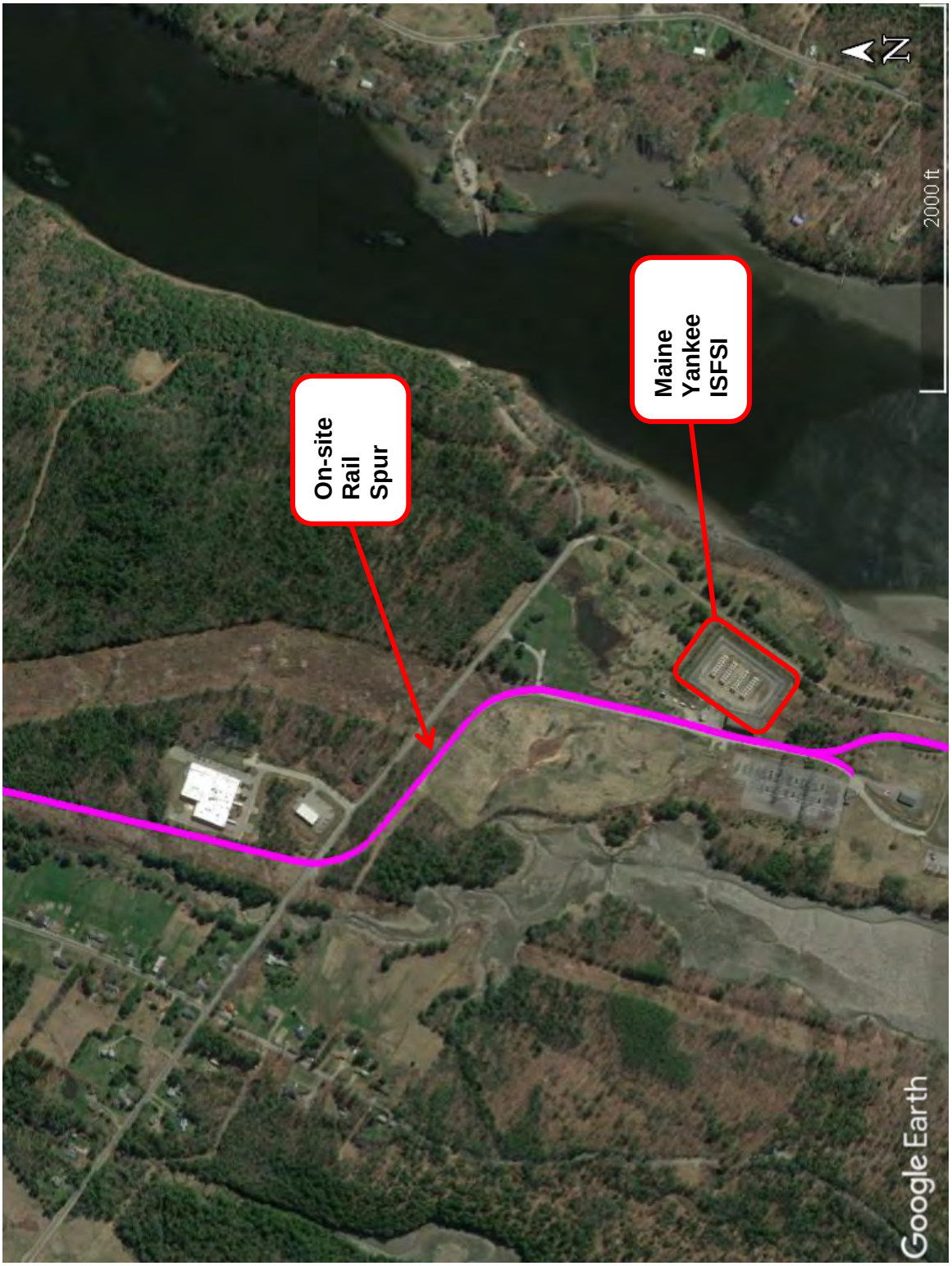


Figure 2-13. On-site Rail Spur at the Maine Yankee Site (Google 2019)



Figure 2-14. Paved-over Railroad Tracks at the Maine Yankee Site (2012)



Figure 2-15. 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 Central Maine and Quebec Railway via a rail spur (see Figure 2-16). In some off-site locations, the rail spur has been paved over (see Figure 2-17). This rail spur was used for radioactive and nonradioactive waste shipments during decommissioning. There is sufficient room on the Maine Yankee site for a 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 2-15) and therefore could be accessible by barges that would transport SNF 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 2-18 and Figure 2-19 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 transportation 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 transportation casks could roll onto the barge, thereby not requiring heavy-lift capability at the barge dock to move the transportation casks from the heavy haul truck to the barge.

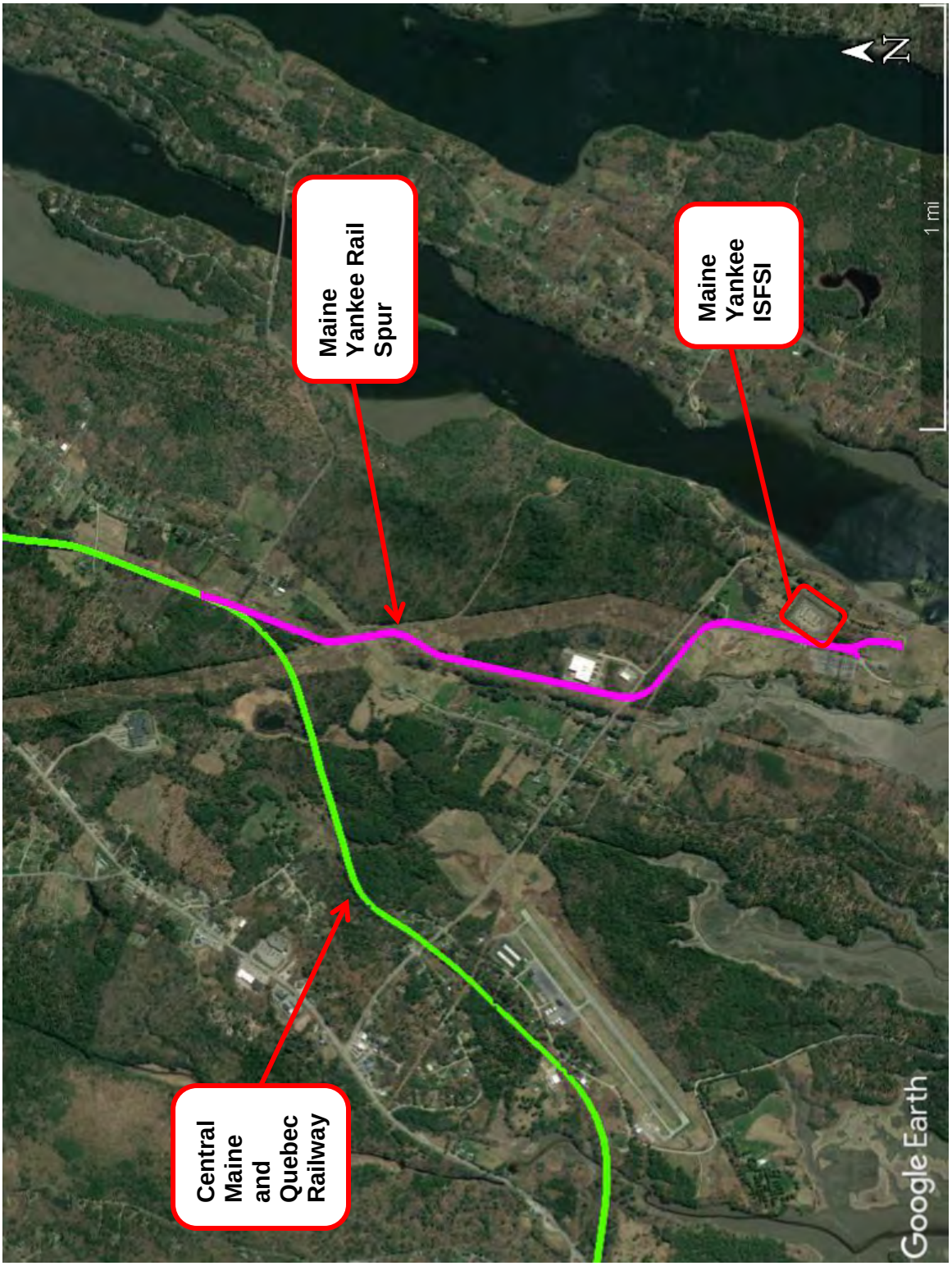


Figure 2-16. Rail Interface at Maine Yankee (Google 2019)



Photo courtesy of Maine Yankee

Figure 2-17. Paved Over Rail Spur at Maine Yankee Site (2017)



Photo courtesy of Maine Yankee

Figure 2-18. Maine Yankee Reactor Pressure Vessel Being Loaded onto Barge (2003)



Photo courtesy of Maine Yankee

Figure 2-19. Maine Yankee Reactor Pressure Vessel Being Transported on Barge (2003)

2.1.4 Future Information Needs

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 Central Maine and Quebec Railway is capable of accepting and moving railcars carrying SNF transportation casks. An assessment by the Federal Railroad Administration's track safety engineers and of the Central Maine and Quebec Railway's maintenance-of-way staff would be necessary. If the railroad's infrastructure cannot accommodate the shipments, it would be necessary to ship the SNF transportation 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 SNF transportation 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 SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and 1 reconfigured fuel assembly,[9] and 1 canister of GTCC waste stored at the Yankee Rowe ISFSI (Docket No. 72-31). The 15 canisters contain 7 damaged SNF assemblies, which have been placed in damaged fuel cans.

Figure 2-20 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 SNF is the Yankee-MPC, which holds 36 Yankee Rowe pressurized water reactor SNF 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, including canisters containing GTCC waste. Figure 2-21 illustrates the NAC-STC transportation cask. No NAC-STC transportation casks

[9] A Yankee Rowe reconfigured fuel assembly is a stainless steel container having approximately the same external dimensions as a spent 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).

have been fabricated for use in the United States. Six NAC-STC transportation casks have been fabricated for use in China.

Figure 2-22 illustrates the number of SNF 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 2-23 illustrates the number of SNF 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 SNF assemblies (burnup greater than 45 GWd/MTHM) stored at Yankee Rowe.



Photo courtesy of Yankee Rowe

Figure 2-20. Yankee Rowe Independent Spent Fuel Storage Installation



Photo courtesy of NAC International

Figure 2-21. NAC-STC Transportation Cask

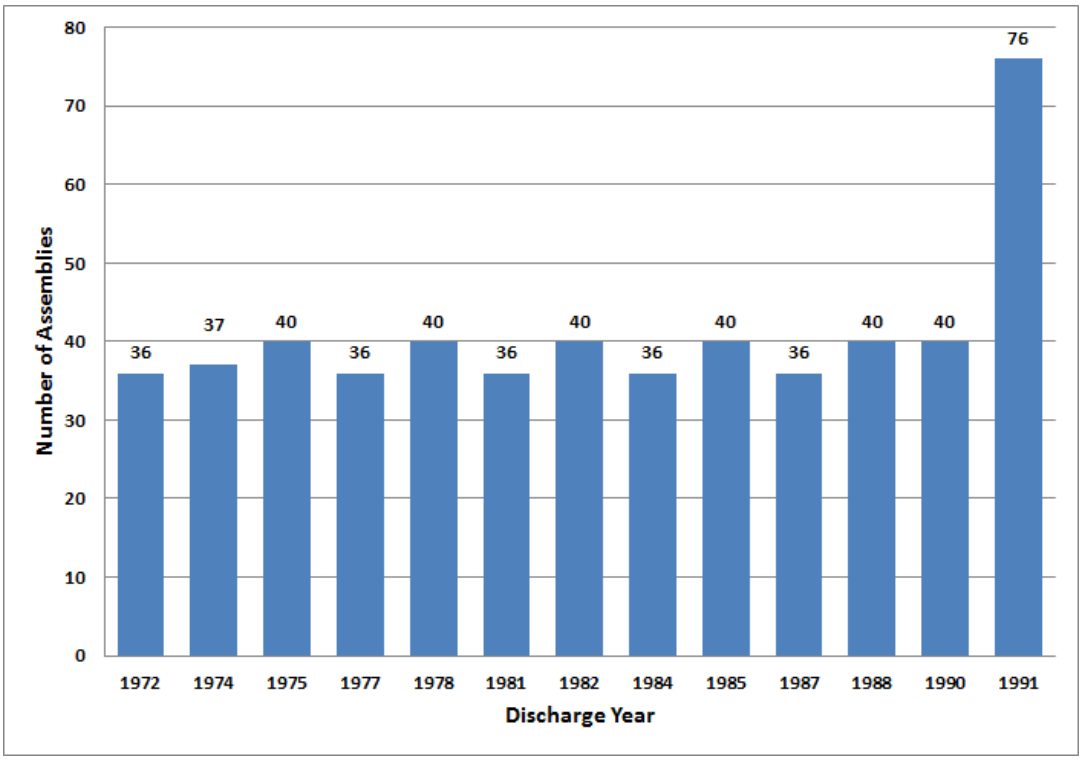


Figure 2-22. Yankee Rowe Number of Assemblies versus Discharge Year (EIA 2013)

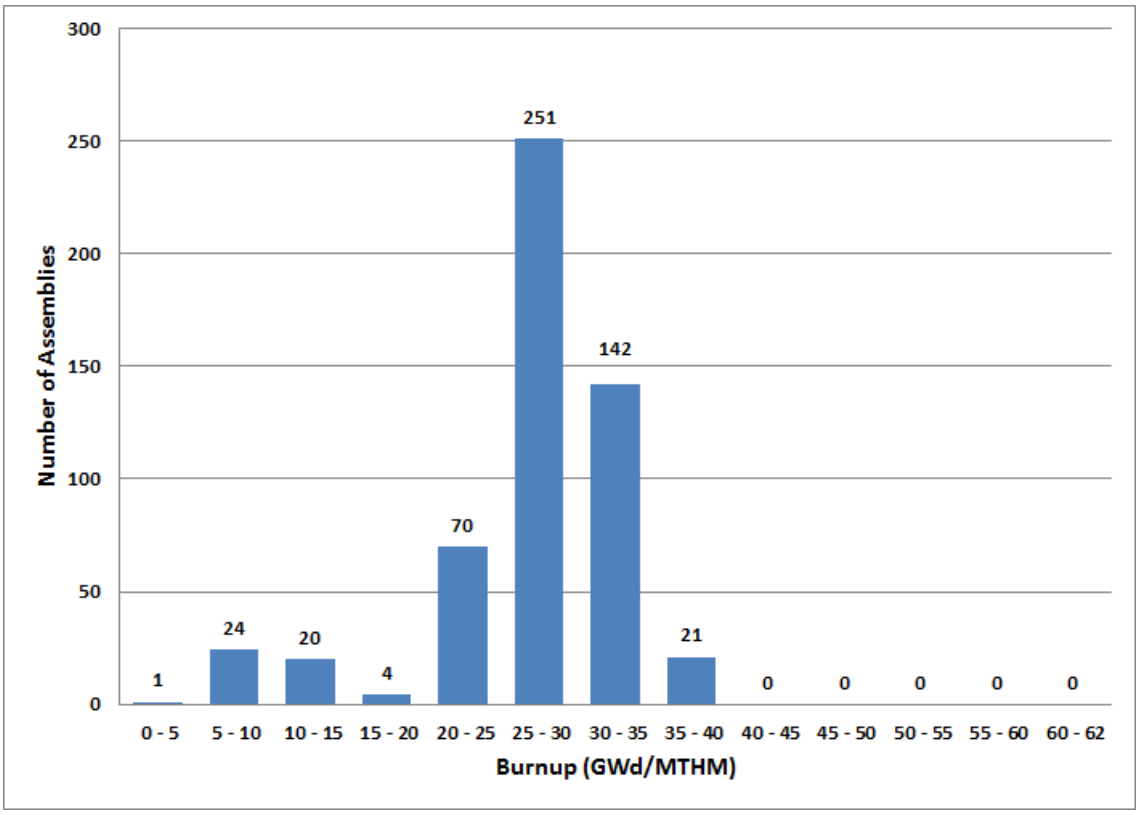


Figure 2-23. Yankee Rowe Number of Assemblies versus Burnup (EIA 2013)

2.2.2 Site Conditions

Figure 2-24 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 SNF and GTCC 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 SNF or GTCC 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 SNF 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 2-25 through Figure 2-27). 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), measured 13.5 ft. in diameter, and was 35 ft. long. 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 2-28 shows the rail line at the east portal of the Hoosac Tunnel and Figure 2-29 shows the east portal of the Hoosac Tunnel. Figure 2-30 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 2-31 shows the route taken from the Yankee Rowe site to the east portal of the Hoosac Tunnel.

2.2.4 Future Information Needs

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.

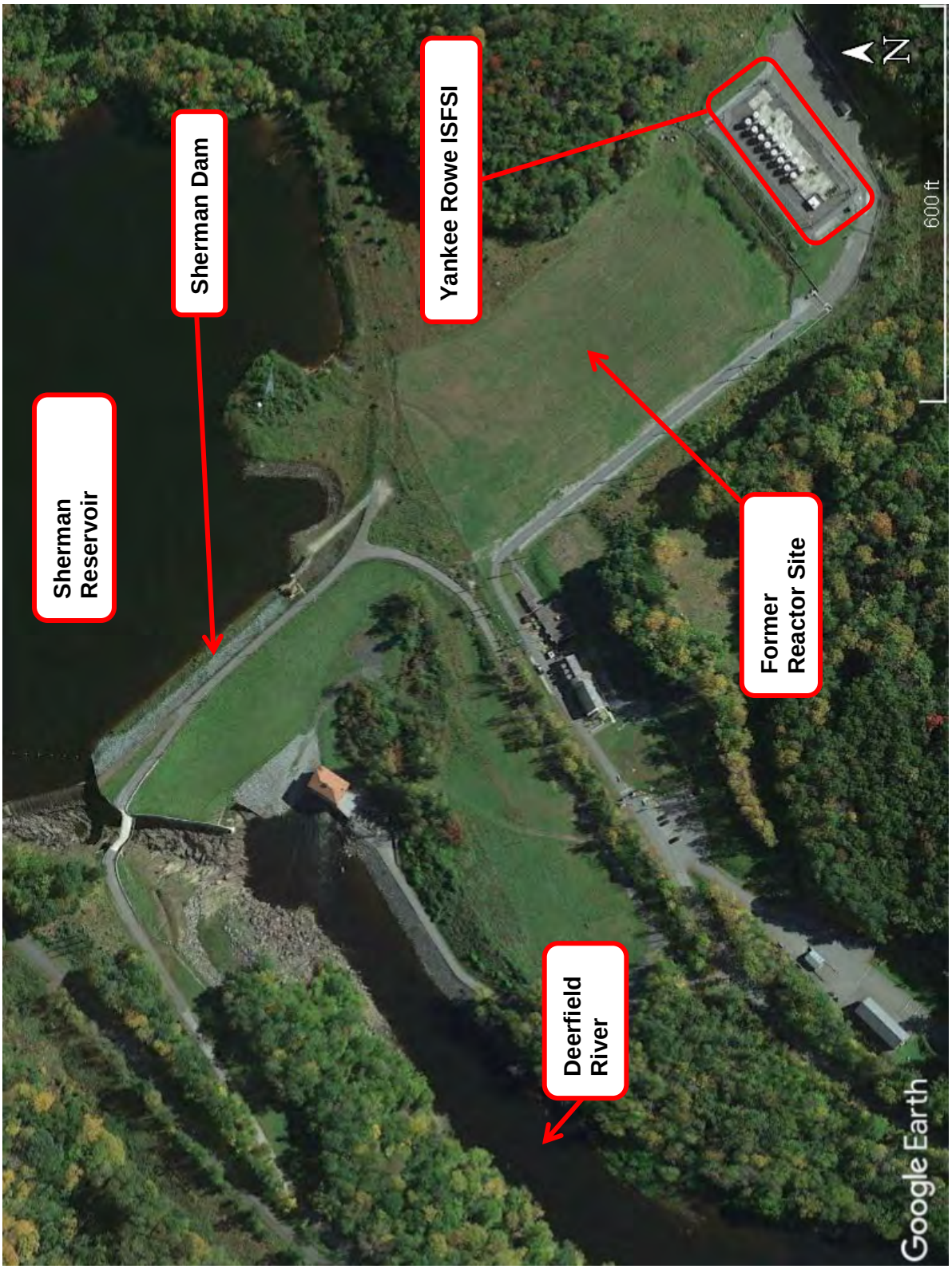


Figure 2-24. Aerial View of the Yankee Rowe Site (Google 2019)



Photo courtesy of AREVA

Figure 2-25. Yankee Rowe Reactor Pressure Vessel Crossing the Sherman Dam (1997)



Photo courtesy of Yankee Rowe

Figure 2-26. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck Moving Under Power Lines (1997)



Photo courtesy of AREVA

Figure 2-27. Yankee Rowe Reactor Pressure Vessel on Heavy Haul Truck (1997)



Figure 2-28. Rail Line at East Portal of the Hoosac Tunnel (2012)



Figure 2-29. East Portal of the Hoosac Tunnel (2012)



Photo courtesy of Yankee Rowe

Figure 2-30. Yankee Rowe Reactor Pressure Vessel on Railcar (1997)

Consequently, it would be necessary to use heavy haul trucks to transport casks containing SNF 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 ArcLight Capital Partners, a private equity firm. Based on the experience during decommissioning, ArcLight Capital Partners 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.

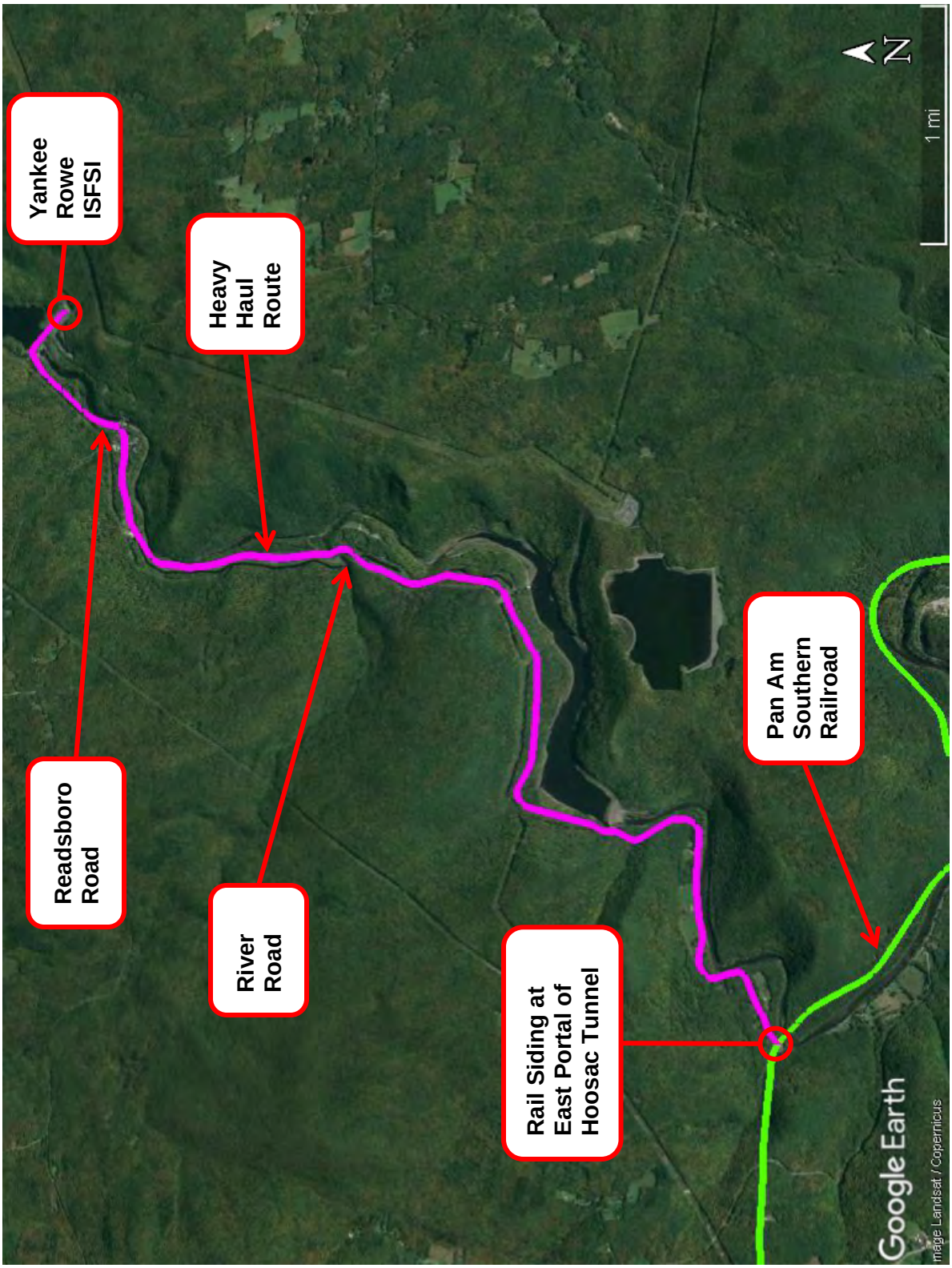


Figure 2-31. Yankee Rowe Reactor Pressure Vessel Heavy Haul Truck Route (Google 2019)

2.3 Connecticut Yankee

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and 5 fuel rod storage containers, and 3 canisters of GTCC waste are stored at the Connecticut Yankee ISFSI (Docket No. 72-39). The 40 canisters contain 71 damaged fuel cans, which contain 66 damaged SNF assemblies and 5 fuel rod storage containers. There are also an additional 82 stainless steel-clad SNF assemblies from Connecticut Yankee that are stored at the Morris, Illinois ISFSI (Docket No. 72-1).

Figure 2-32 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) SNF is the CY-MPC. This canister may be configured to hold 24 or 26 pressurized water reactor SNF 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 waste. No NAC-STC transportation casks have been fabricated for use in the United States. Six NAC-STC transportation casks have been fabricated for use in China.



Photo courtesy of Connecticut Yankee

Figure 2-32. Connecticut Yankee Independent Spent Fuel Storage Installation

In addition to the 43 canisters of SNF and GTCC 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 2-33 illustrates the number of SNF 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 2-34 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) stored at Connecticut Yankee.

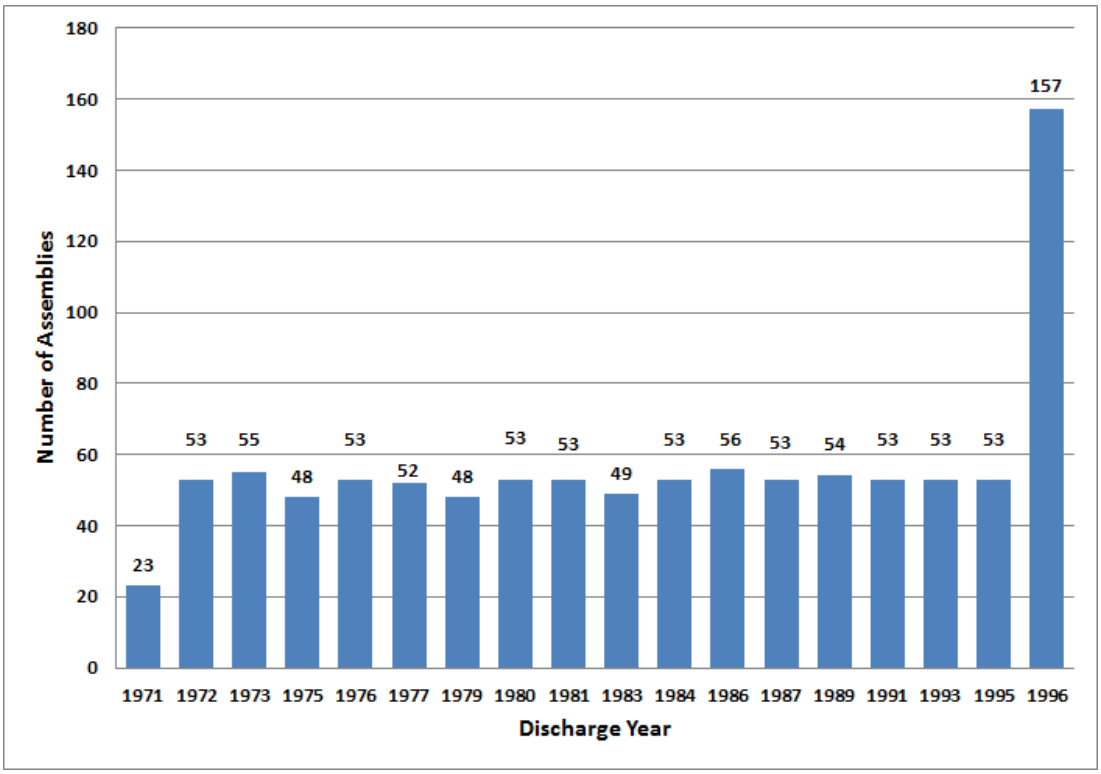


Figure 2-33. Connecticut Yankee Number of Assemblies versus Discharge Year (EIA 2013)

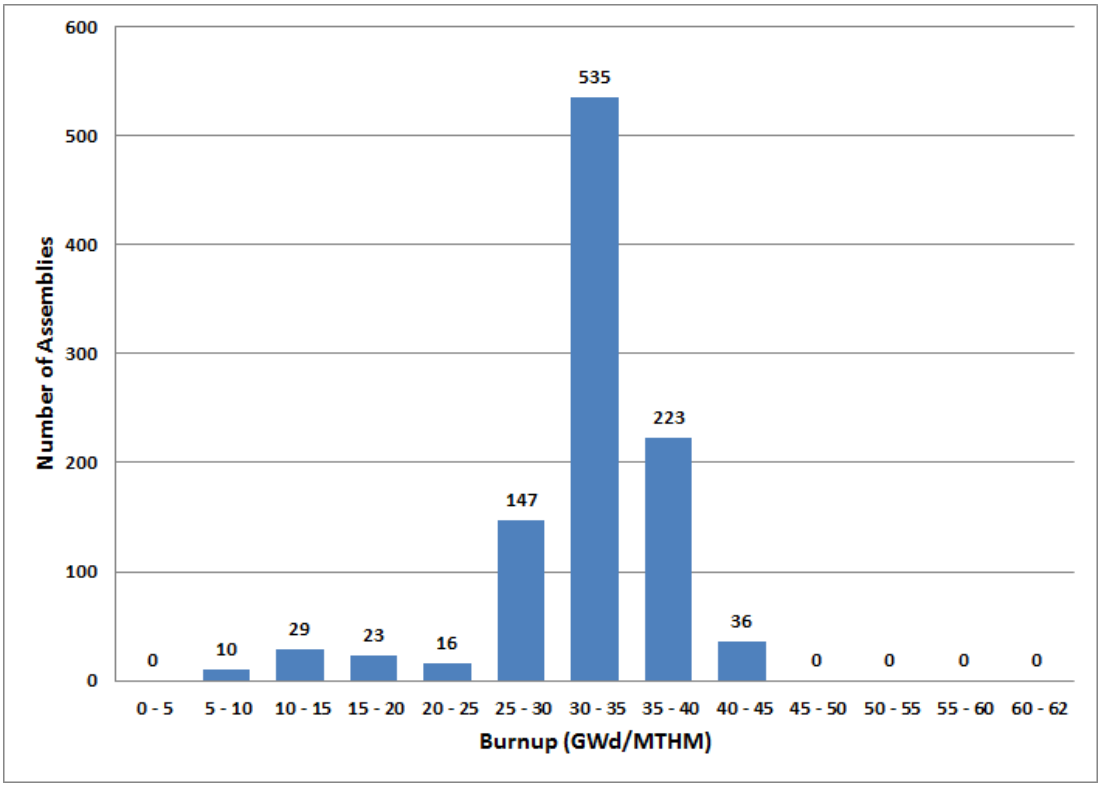


Figure 2-34. Connecticut Yankee Number of Assemblies versus Burnup (EIA 2013)

2.3.2 Site Conditions

Figure 2-35 and Figure 2-36 provide aerial views of the Connecticut Yankee site and ISFSI, 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 SNF and GTCC 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 cooling water discharge canal (see Figure 2-37 and Figure 2-38) 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). The reactor pressure vessel package weighed 820 tons, measured 18 ft. in diameter, and was 35 ft. long. 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

Eighty-two stainless steel-clad SNF assemblies from Connecticut Yankee are stored at the Morris, Illinois ISFSI. Eighty assemblies were shipped directly from Connecticut Yankee to Morris (SAIC 1991). Three assemblies (G11, H07, and S004) were shipped from Connecticut Yankee to Battelle West Jefferson for examination (EPRI 1996); two of these assemblies (G11 and H07) were subsequently returned to Connecticut Yankee and then shipped to Morris (EPRI 1996). Assembly S004 was shipped to and is currently stored at the Idaho National Laboratory.

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.

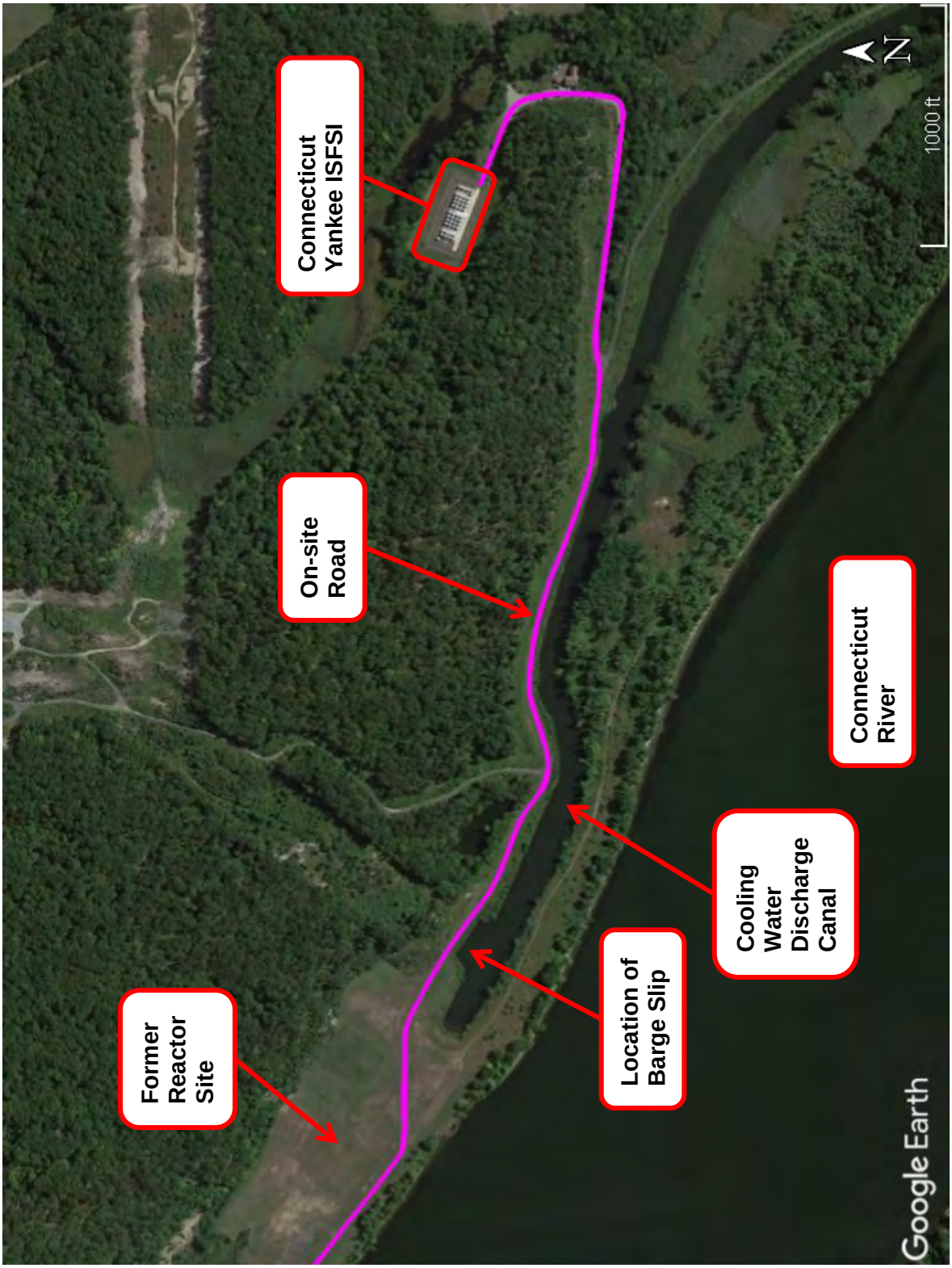


Figure 2-35. Aerial View of the Connecticut Yankee Site (Google 2019)



Photo courtesy of Connecticut Yankee

Figure 2-36. Aerial View of the Connecticut Yankee Independent Spent Fuel Storage Installation (2012)

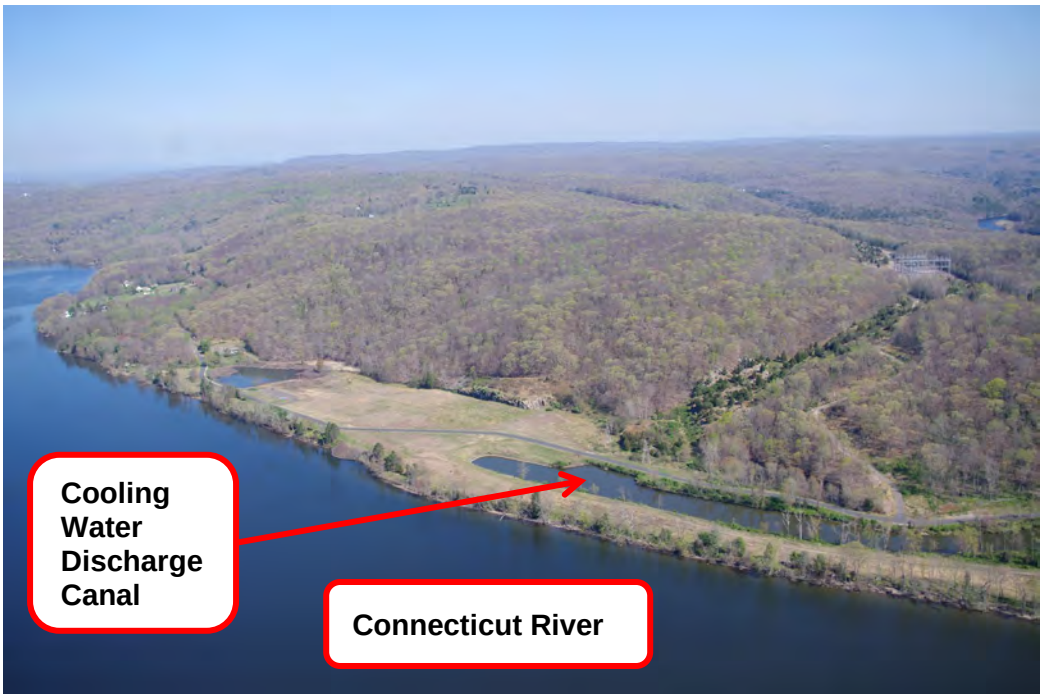


Photo courtesy of Connecticut Yankee

Figure 2-37. Aerial View of the Connecticut Yankee Site and Cooling Water Discharge Canal (2012)



Figure 2-38. Barge Slip at the Connecticut Yankee Site (2012)

For shipments of casks containing SNF 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[10] 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 2-39 shows the pressurizer on its heavy haul truck transporter and Figure 2-40 shows the route taken from the Connecticut Yankee site to the Portland rail spur. Figure 2-41 shows the pressurizer at the end of the Portland rail spur and Figure 2-42 shows the conditions at the end of the Portland rail spur in 2012.

If heavy haul trucks were used to move casks containing SNF 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 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.

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



Photo courtesy of Connecticut Yankee

Figure 2-39. Connecticut Yankee Pressurizer on Heavy Haul Truck Transporter

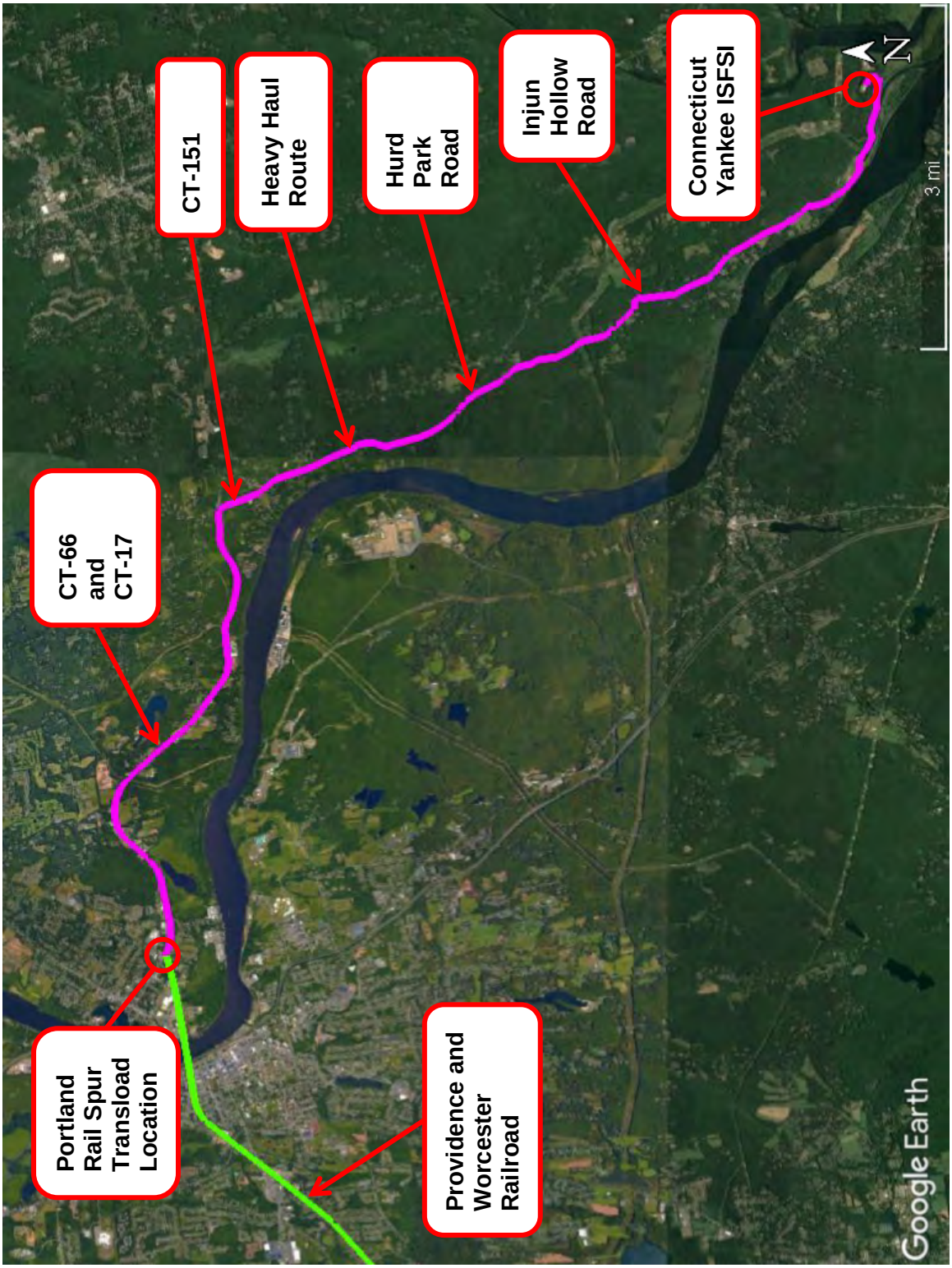


Figure 2-40. Connecticut Yankee Heavy Haul Truck Route (Google 2019)



Photo courtesy of Connecticut Yankee

Figure 2-41. Connecticut Yankee Pressurizer at the End of the Portland Rail Spur



Figure 2-42. 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 SNF 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 2-38. 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 2-43 through Figure 2-45 show the Connecticut Yankee reactor pressure vessel being loaded onto a barge and being transported by barge.



Photo courtesy of Connecticut Yankee

Figure 2-43. Connecticut Yankee Reactor Pressure Vessel Being Loaded onto Barge



Photo courtesy of Connecticut Yankee

Figure 2-44. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge



Photo courtesy of Connecticut Yankee

Figure 2-45. Connecticut Yankee Reactor Pressure Vessel Being Transported on Barge in the Connecticut River

2.3.4 Future Information Needs

The Connecticut Yankee site managers suggested that shipments of SNF 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 SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and one canister containing GTCC waste are stored at Humboldt Bay. Figure 2-46 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 SNF 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 HI-STAR HB is certified for the transport of GTCC waste. In addition, the certificate of compliance for the HI-STAR HB has been revised to allow transport of 44 spent nuclear fuel assemblies at the Humboldt Bay site with initial enrichments of 2.08 weight percent.



Photo courtesy of Humboldt Bay

Figure 2-46. Humboldt Bay Independent Spent Fuel Storage Installation

Figure 2-47 illustrates the number of SNF 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 2-48 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) is stored at Humboldt Bay.

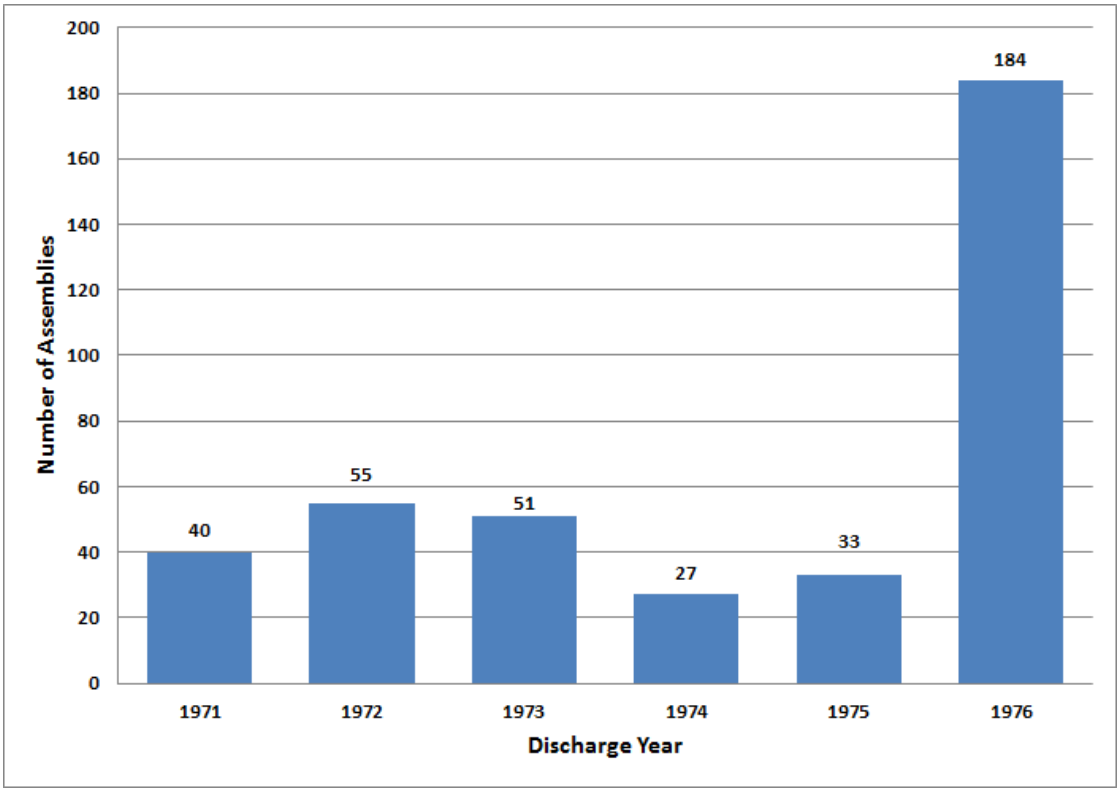


Figure 2-47. Humboldt Bay Number of Assemblies versus Discharge Year (EIA 2013)

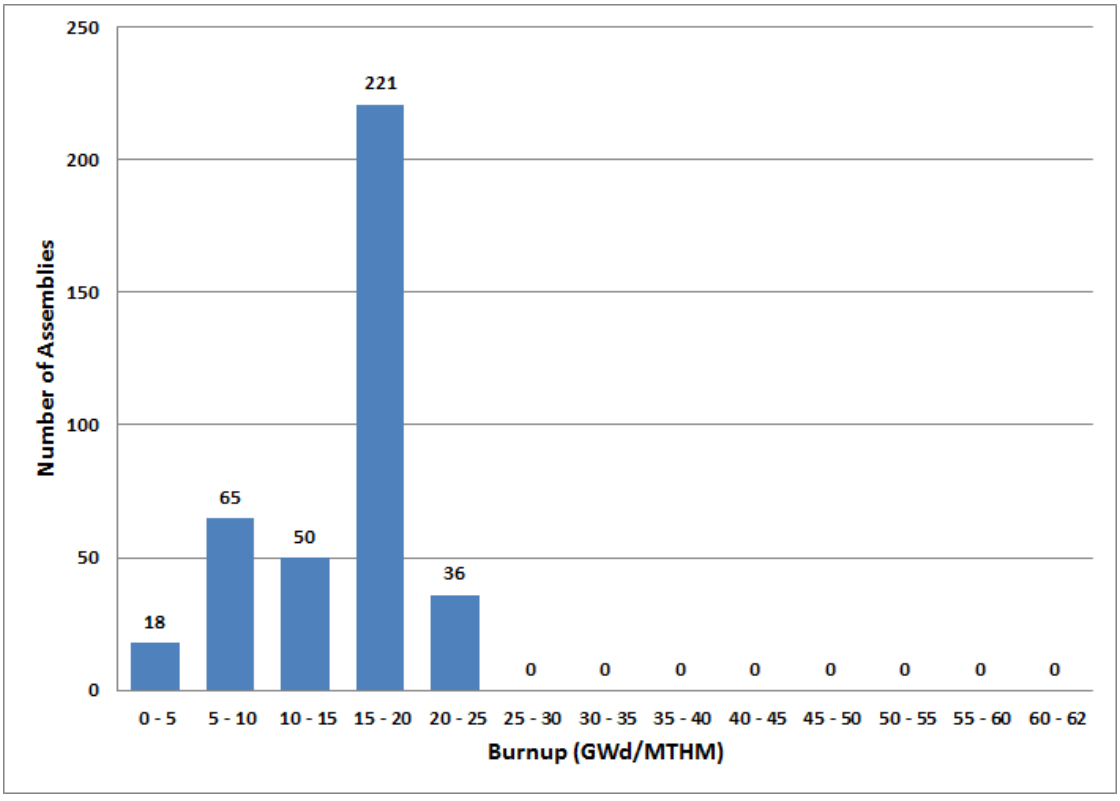


Figure 2-48. Humboldt Bay Number of Assemblies versus Burnup (EIA 2013)

2.4.2 Site Conditions

Figure 2-49 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 2-46 which is used to remove the HI-STAR HB casks containing the Humboldt Bay SNF or GTCC waste from their below-grade vaults is shared with the Diablo Canyon site; however, mobile equipment such as cranes is not on-site. The HI-STAR HB casks are certified for both the storage and transport of the Humboldt Bay SNF. 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 2-50).

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 SNF 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 2-49. Aerial View of Humboldt Bay Site



Photo courtesy of Humboldt Bay

Figure 2-50. 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:[11]

- 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.

[11] 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 SNF 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, Redwood Marine Terminal 1 and 2, Schneider Dock, Sierra Pacific Eureka Dock, and the California Redwood Chip Export Dock (HBHRCD 2017). 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 2-51 and Figure 2-52), which is about 2 miles from the Humboldt Bay Generating Station[12] (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 2-51 also shows the heavy haul route taken from the Fields Landing Terminal to the Humboldt Bay Generating Station. Figure 2-53 shows the conditions of the Fields Landing Terminal in 2013. Figure 2-54 through Figure 2-58 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 2-59 and Figure 2-60 show the location of the Schneider Dock in relation to the Humboldt Bay site.

[12] 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.

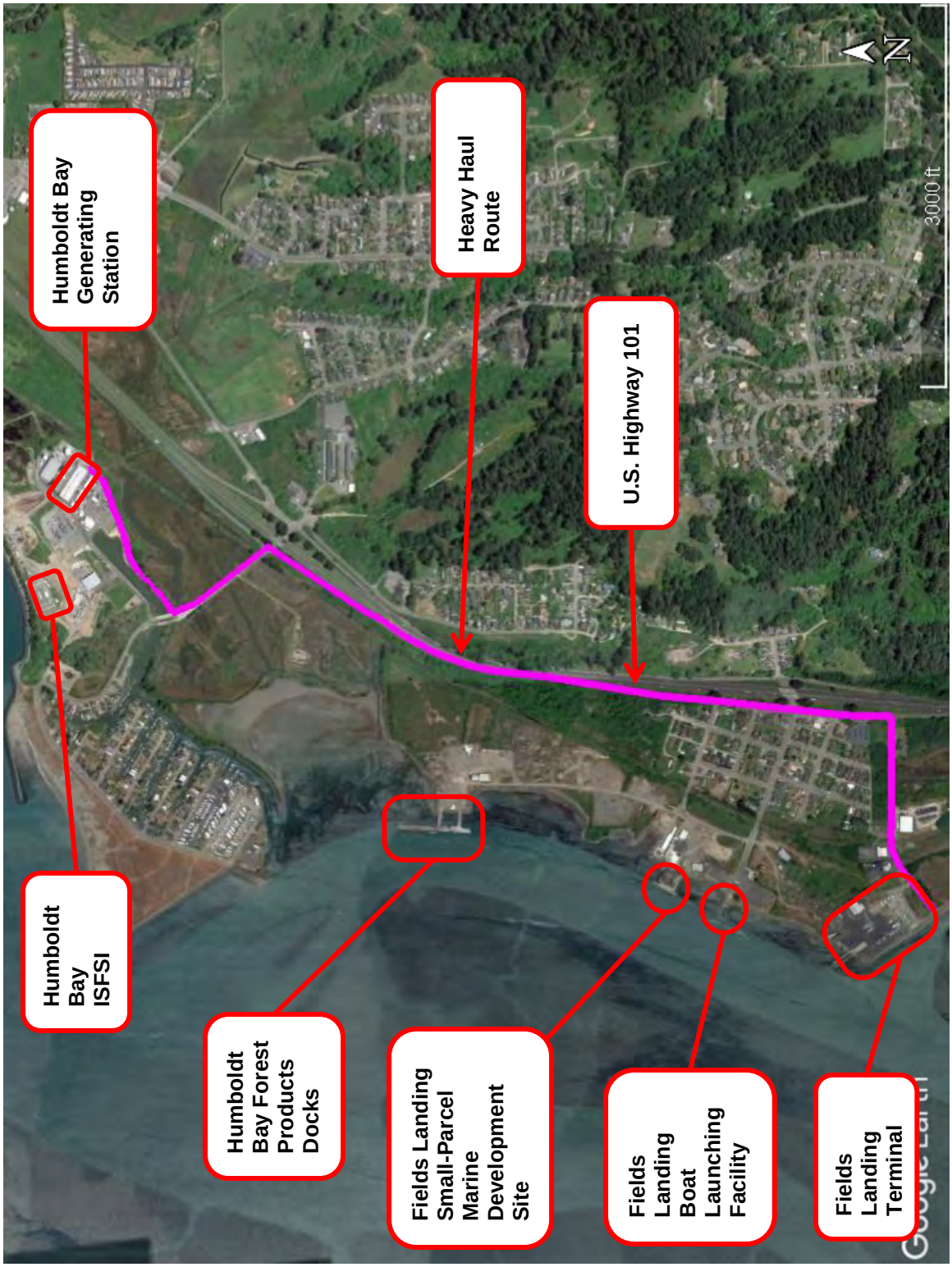


Figure 2-51. Humboldt Bay Independent Spent Fuel Storage Installation and Fields Landing Terminal (Google 2019)



Figure 2-52. Fields Landing Terminal (Google 2019)



Photo courtesy of Federal Railroad Administration

Figure 2-53. Condition of Fields Landing Terminal (2013)



Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-54. Wartsila Engine Being Loaded on a Barge (2010)



Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-55. Wartsila Engine on a Barge Being Towed to Fields Landing Terminal (2010)

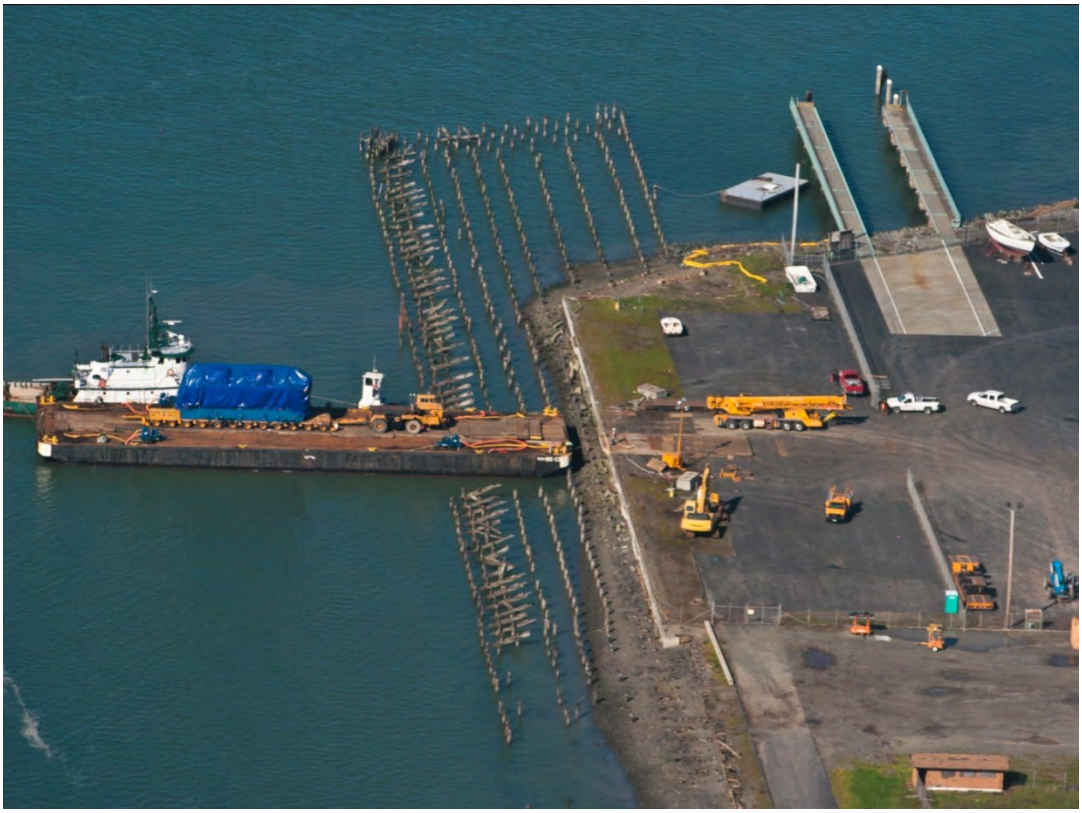


Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-56. Barge with Wartsila Engine Arriving at Fields Landing Terminal (2010)



Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-57. Wartsila Engine Being Unloaded at Fields Landing Terminal (2010)



Photo courtesy of Bragg Crane & Rigging Co.

Figure 2-58. Wartsila Engine Being Transported by Heavy Haul Truck to Humboldt Bay Generating Station (2010)

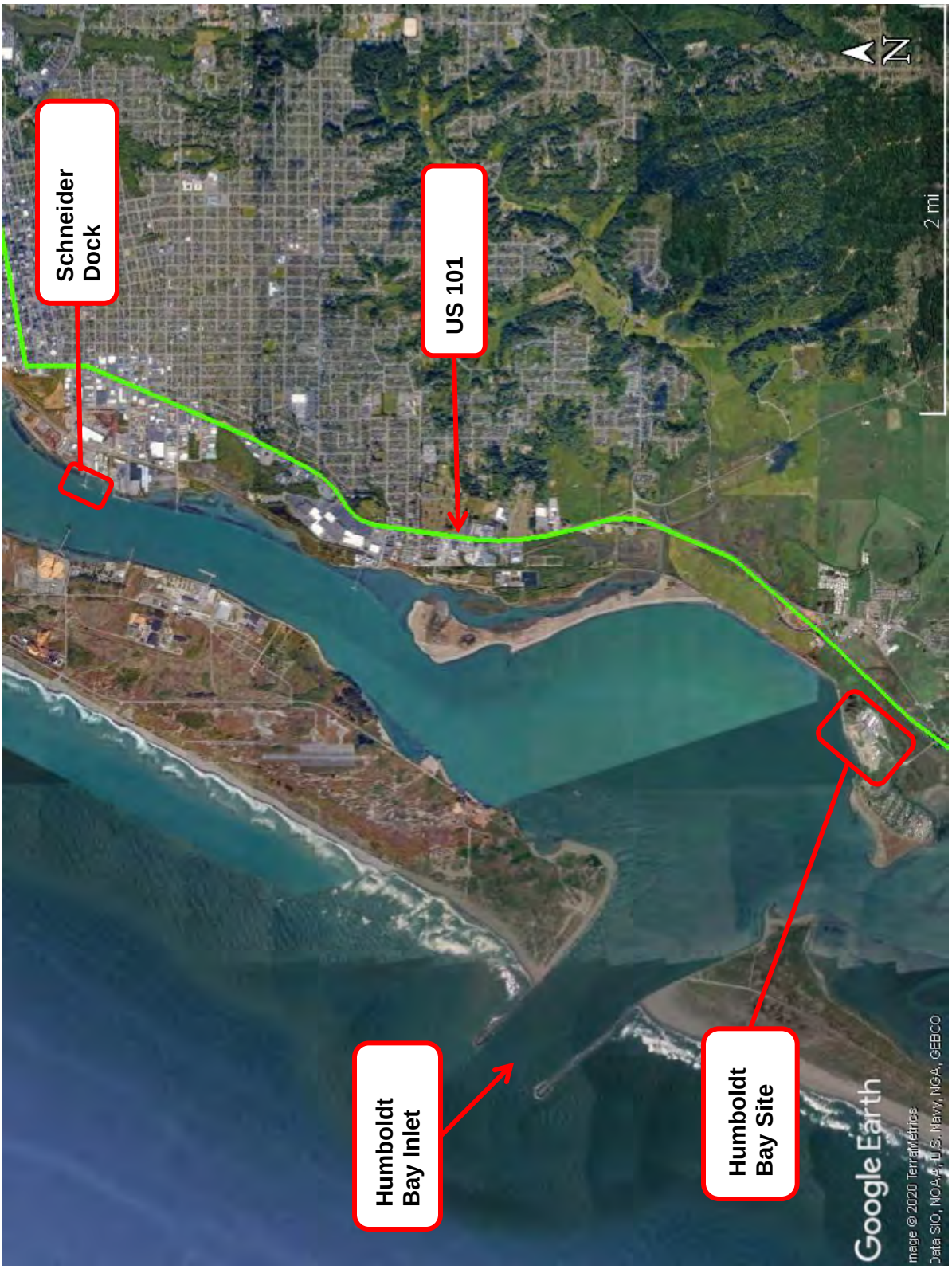


Figure 2-59. Humboldt Bay Site and Schneider Dock (Google 2019)



Figure 2-60. Schneider Dock (Google 2019)

2.4.4 Future Information Needs

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 2-61. 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 2-61. 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.[13]

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

[13] 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.[14]

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 SNF 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 SNF.

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.

[14] Spent nuclear fuel and GTCC waste would be Class 7 hazardous material.

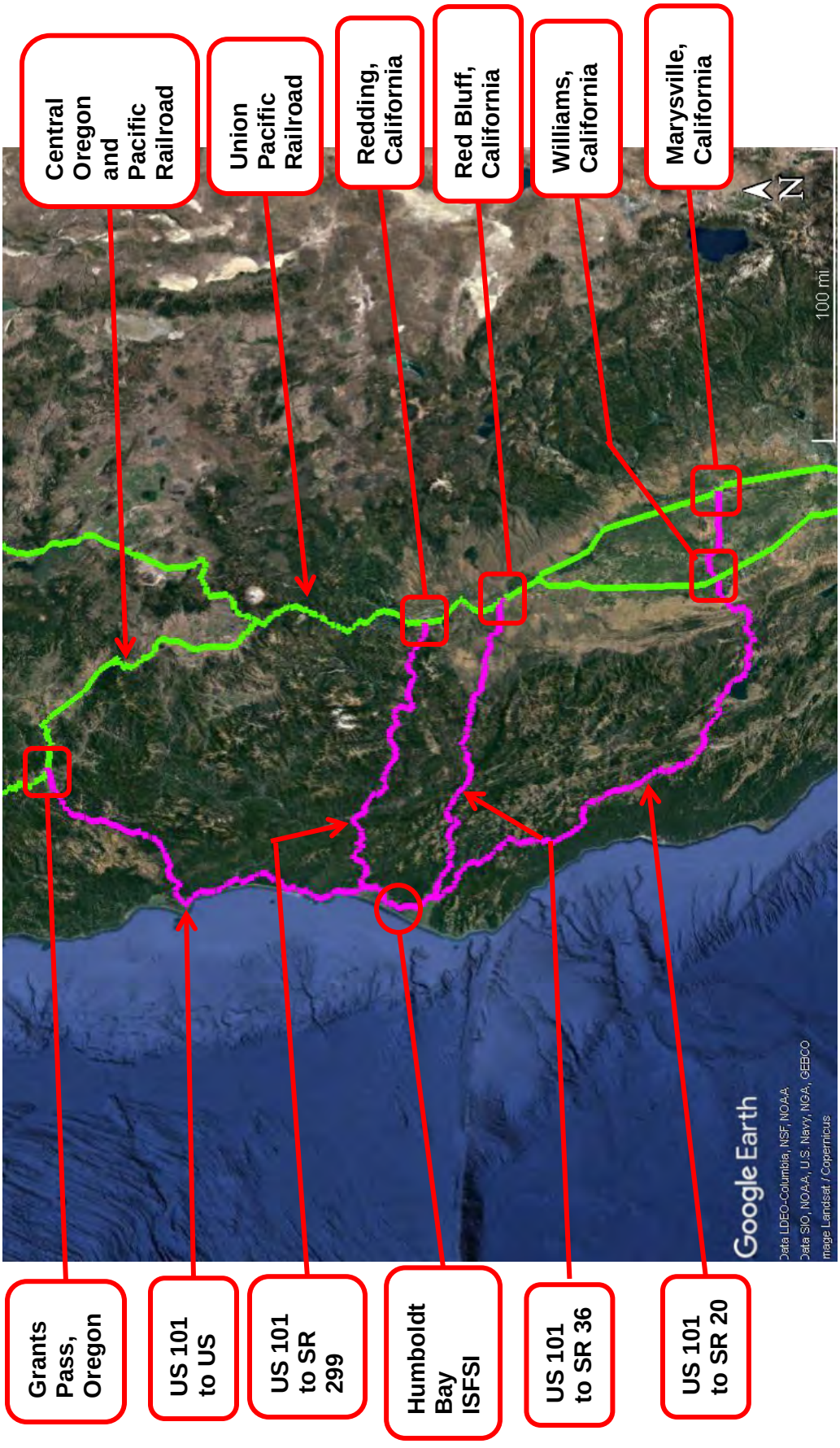


Figure 2-61. Heavy Haul Routes from Humboldt Bay Independent Spent Fuel Storage Installation to Alternative Rail Access Locations (Google 2019)

2.5 Big Rock Point

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and 1 canister of GTCC waste are stored at the Big Rock Point ISFSI (Docket No. 72-43). The seven canisters contain 50 damaged SNF assemblies which have been placed in damaged fuel cans. In addition to uranium dioxide (UO_2) SNF assemblies, there are 36 mixed oxide SNF assemblies stored at Big Rock Point. Table 2-4 lists the assembly identification numbers for these mixed oxide SNF assemblies.

Table 2-4. Assembly Identification Numbers for Mixed Oxide Spent 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 2-62 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 SNF 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 waste.



Photo courtesy of Big Rock Point

Figure 2-62. 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 waste. The effort to accomplish these changes and to obtain NRC review and approval is estimated to range from one to three years.

Figure 2-63 illustrates the number of SNF 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 2-64 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) is stored at Big Rock Point.

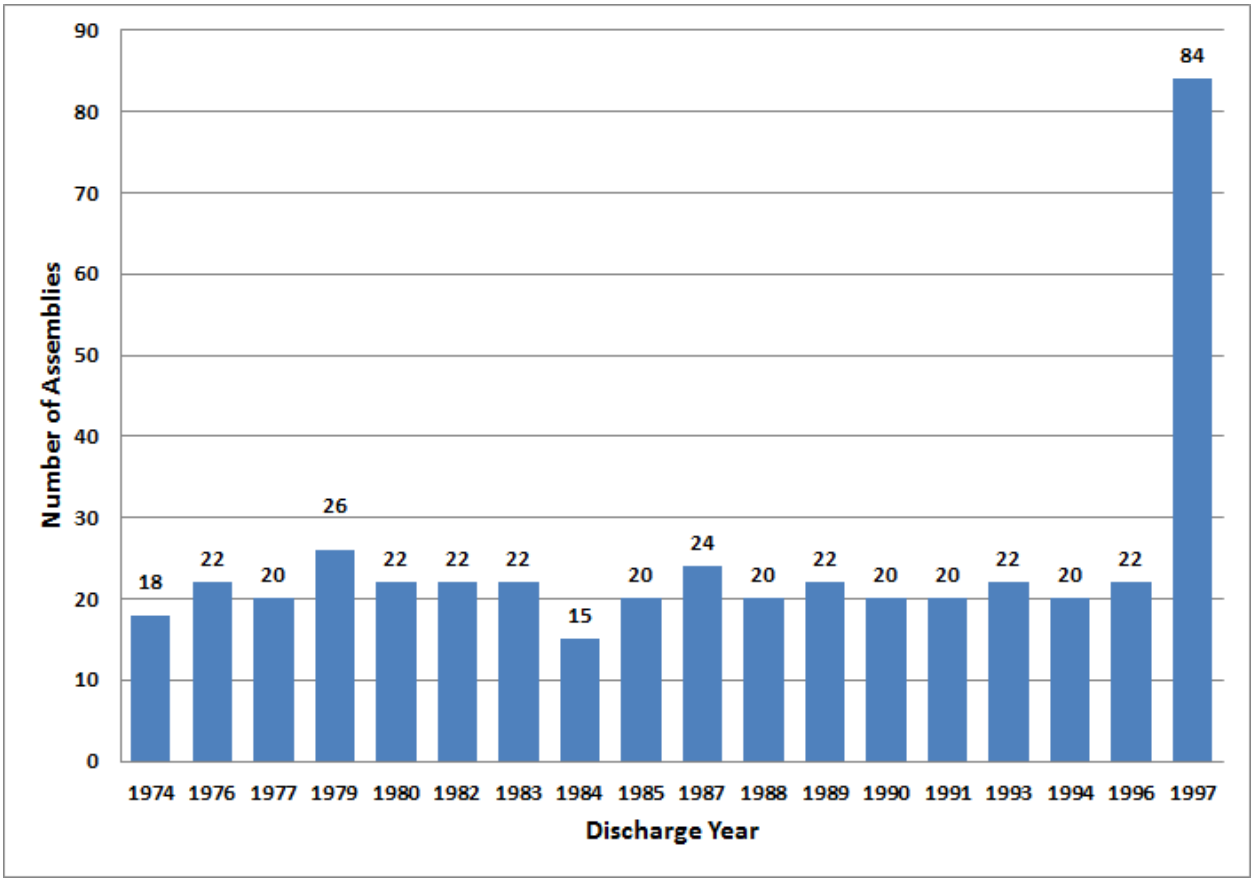


Figure 2-63. Big Rock Point Number of Assemblies versus Discharge Year (EIA 2013)

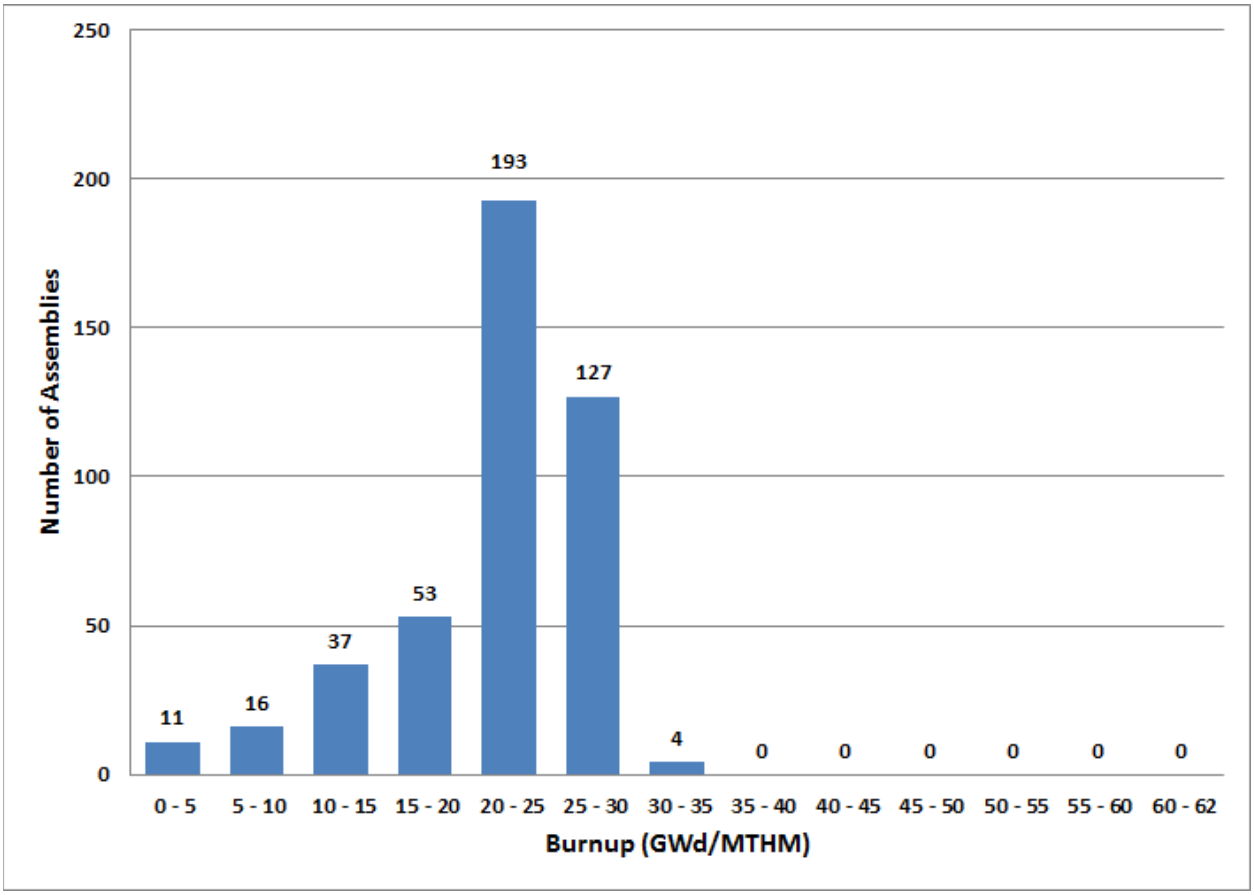


Figure 2-64. Big Rock Point Number of Assemblies versus Burnup (EIA 2013)

2.5.2 Site Conditions

Figure 2-65 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[15] are present at the ISFSI. Herron (2010) stated that the equipment needed to transfer SNF and GTCC 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 2-66 shows the transfer cask and J-skid, Figure 2-67 shows the gantry towers, and Figure 2-68 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 SNF 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

[15] 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.

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 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 2-65). However, NAC (1990) states that Big Rock Point has never had an on-site barge facility.

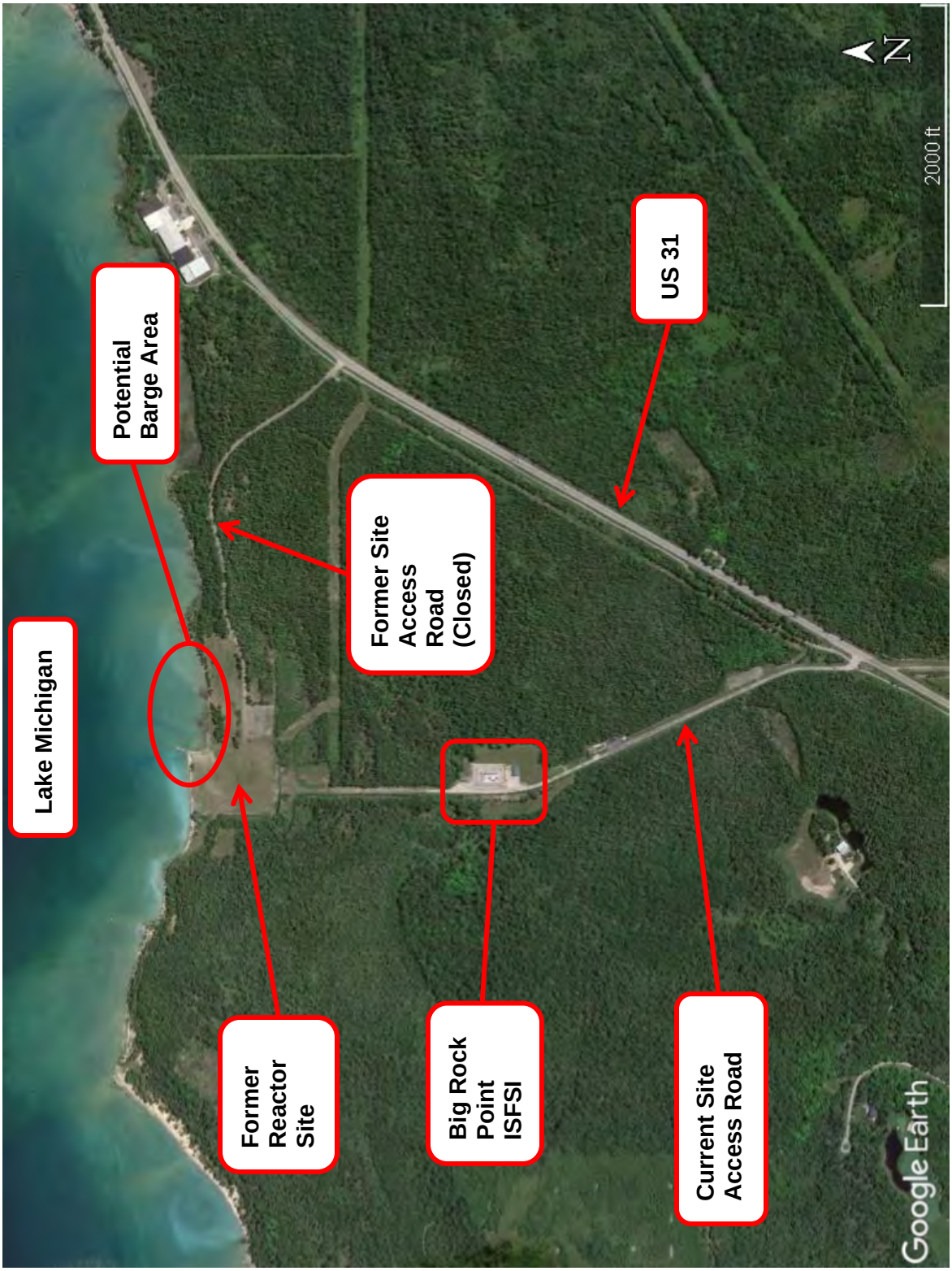


Figure 2-65. Aerial View of Big Rock Point Site (Google 2019)



Photo courtesy of Big Rock Point

Figure 2-66. Transfer Cask and J-Skid at Big Rock Big Rock Point Independent Spent Fuel Storage Installation (2013)



Photo courtesy of Big Rock Point

Figure 2-67. Big Rock Point Gantry Towers (2013)



Photo courtesy of Big Rock Point

Figure 2-68. 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 SNF 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 2-69) about 52 miles to a rail spur near Gaylord, Michigan, transloaded onto an ETMX1001 railcar (Figure 2-70 through Figure 2-72), and then transported by rail to the Barnwell, South Carolina low-level radioactive waste disposal facility (Petrosky 2004, Slimp et al. 2014) (Figure 2-73). The Big Rock Point pressure vessel and its shipping package weighed more than 565,000 lb. Figure 2-74 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 2-75 shows this detour and Figure 2-76 shows the bridge. Figure 2-77 shows the route taken by the reactor pressure vessel in the vicinity of Gaylord, Michigan and Figure 2-78 and Figure 2-79 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 SNF 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 2-80 and Figure 2-81). 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 2-74). Figure 2-82 shows the route taken by the reactor pressure vessel in the vicinity of Petoskey, Michigan and Figure 2-83 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 2-69. Big Rock Point Reactor Pressure Vessel on Heavy Haul Truck (2003)



Photo courtesy of William J. Trubilowicz

Figure 2-70. ETMX1001 Railcar Staged for Transfer (2003)



Photo courtesy of William J. Trubilowicz

Figure 2-71. Heavy Haul Truck with Reactor Pressure Vessel beside ETMX1001 Railcar (2003)



Photo courtesy of William J. Trubilowicz

Figure 2-72. Transfer of Reactor Pressure Vessel onto ETMX1001 Railcar (2003)



Photo courtesy of Consumers Energy

Figure 2-73. Big Rock Point Reactor Pressure Vessel on ETMX1001 Railcar (2003)

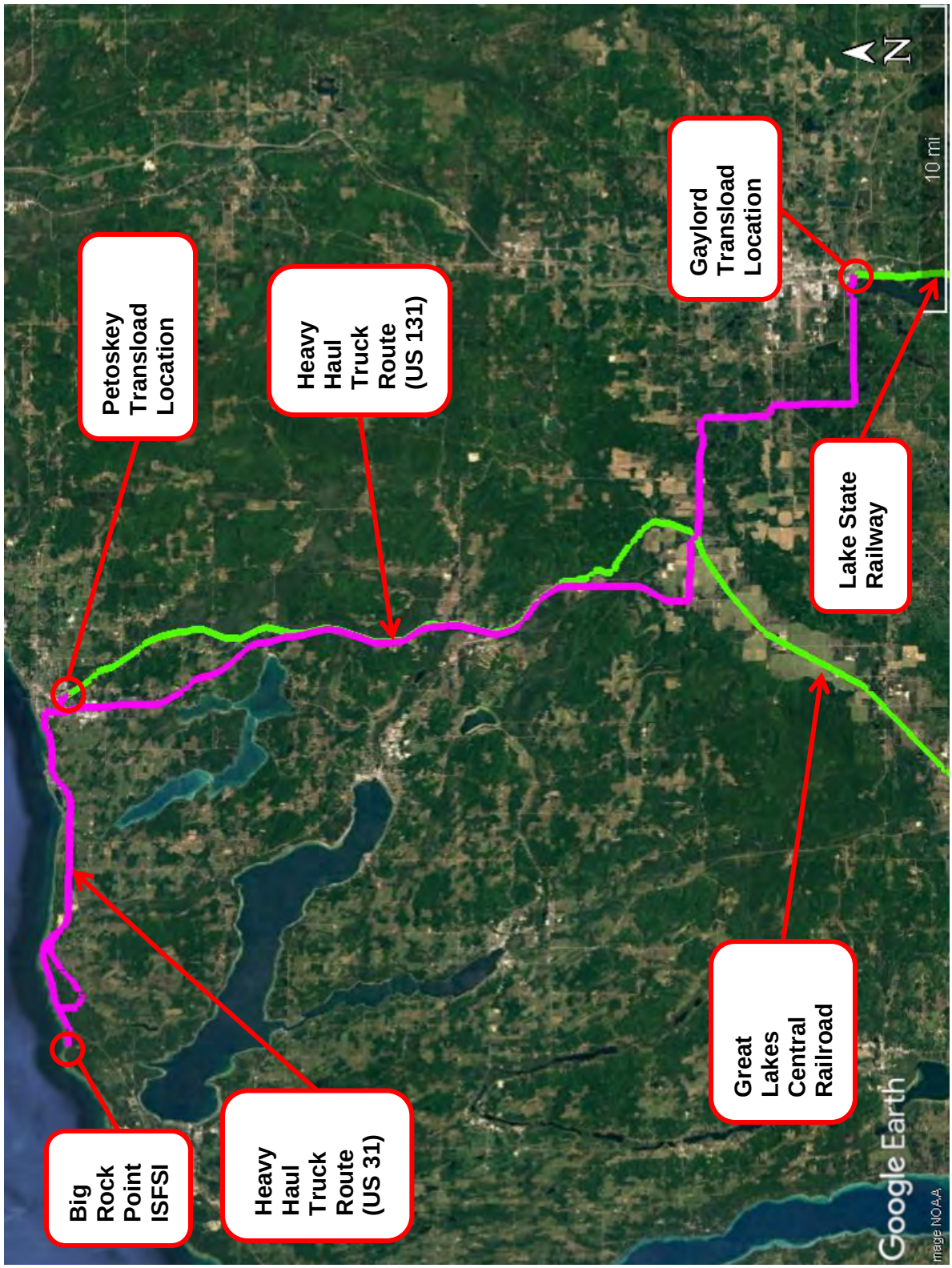


Figure 2-74. Big Rock Point Reactor Pressure Vessel and Steam Drum Heavy Haul Truck Routes (Google 2019)

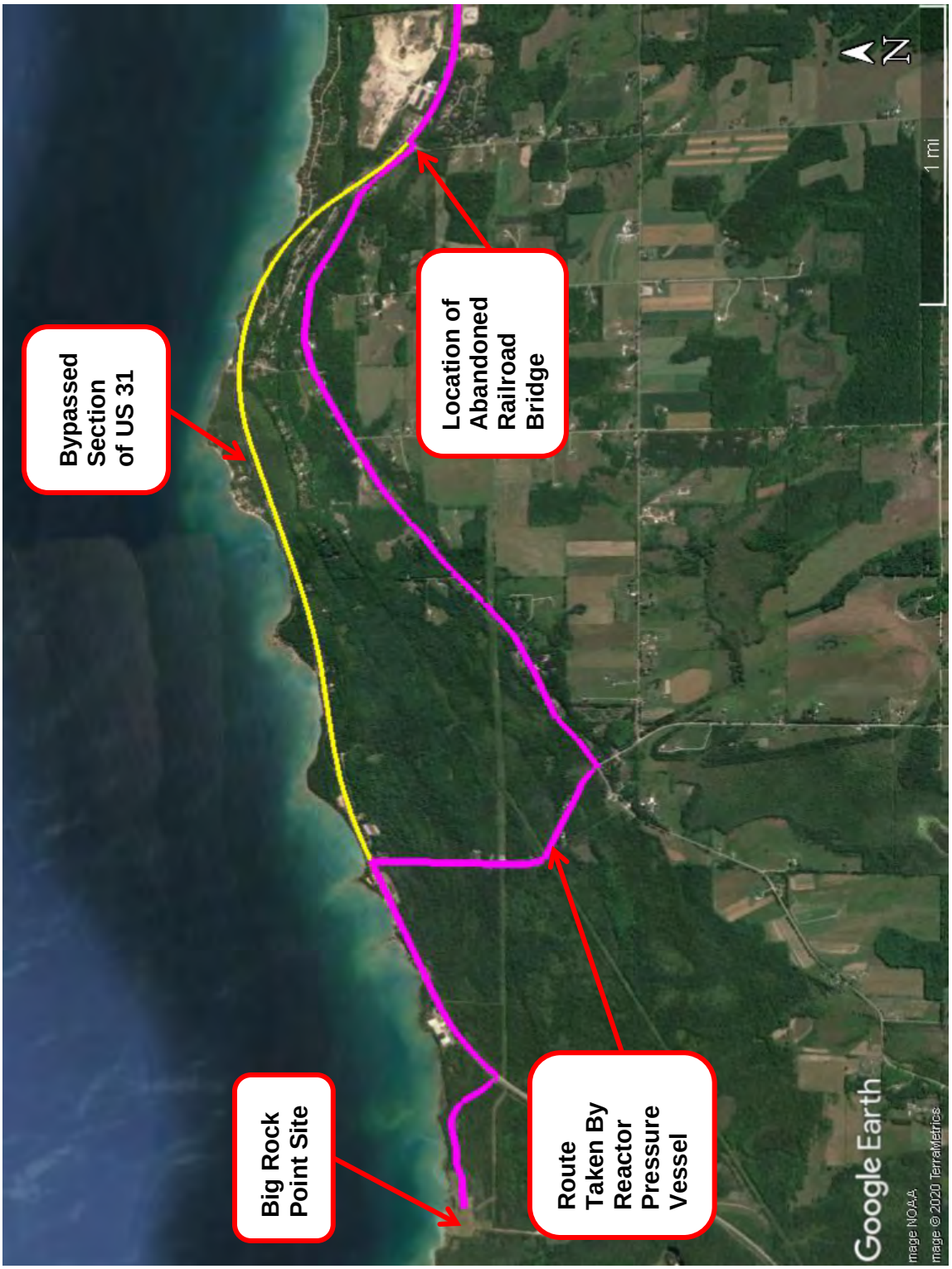


Figure 2-75. Route Taken By Reactor Pressure Vessel to Bypass Low Overhead Clearance Abandoned Railroad Bridge (Google 2019)



Figure 2-76. Low Overhead Clearance Abandoned Railroad Bridge on U.S. 31 (2013)

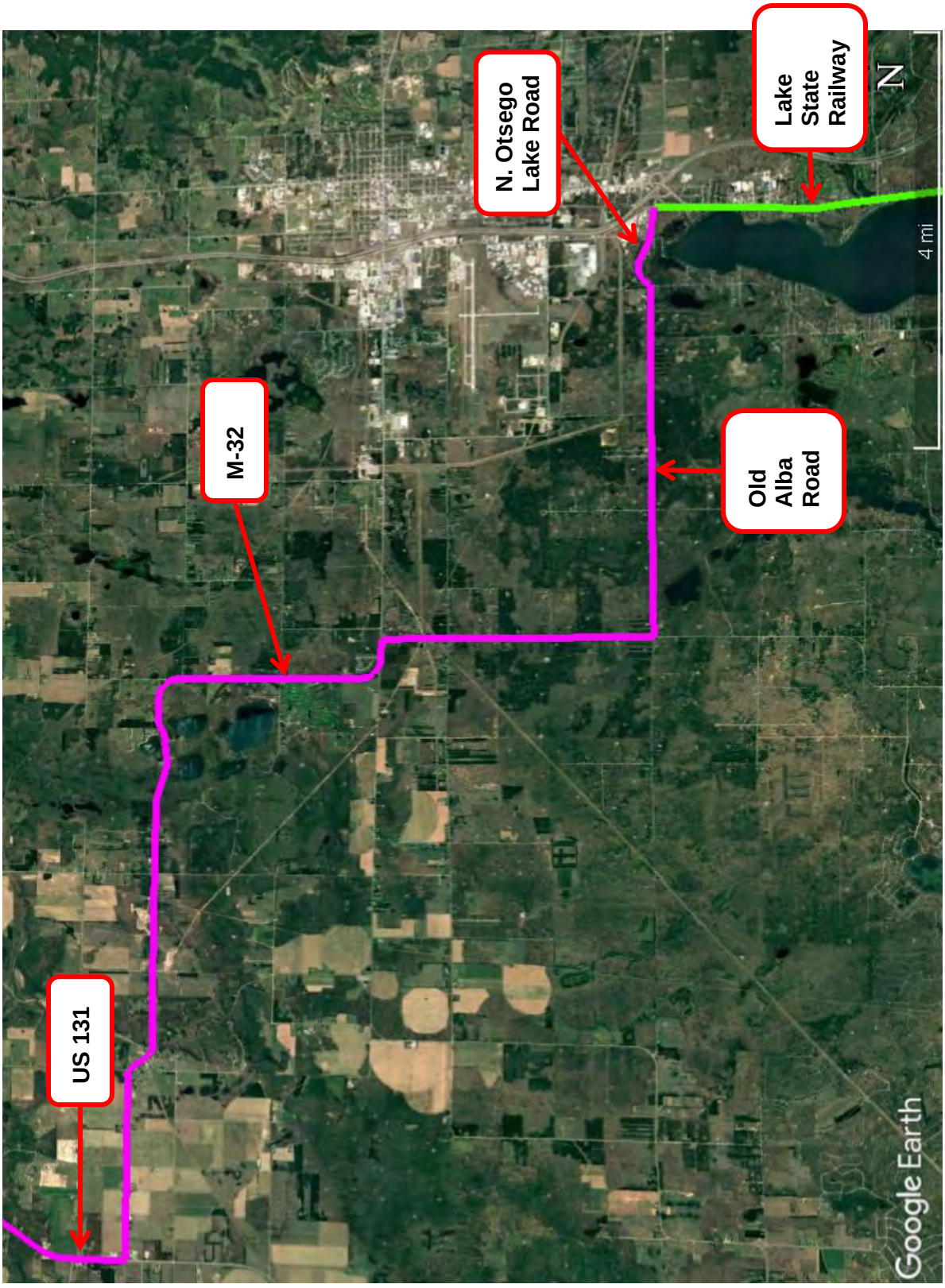


Figure 2-77. Route Taken By Reactor Pressure Vessel in the Vicinity of Gaylord, Michigan (Google 2019)



Figure 2-78. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking North) (2013)



Figure 2-79. Condition of Rail Crossing Used for Big Rock Point Reactor Pressure Vessel Transload (Looking South) (2013)



Photo courtesy of Consumers Energy

Figure 2-80. Big Rock Point Steam Drum on Heavy Haul Truck (2003)



Photo courtesy of Consumers Energy

Figure 2-81. Big Rock Point Steam Drum on Railcar (2003)

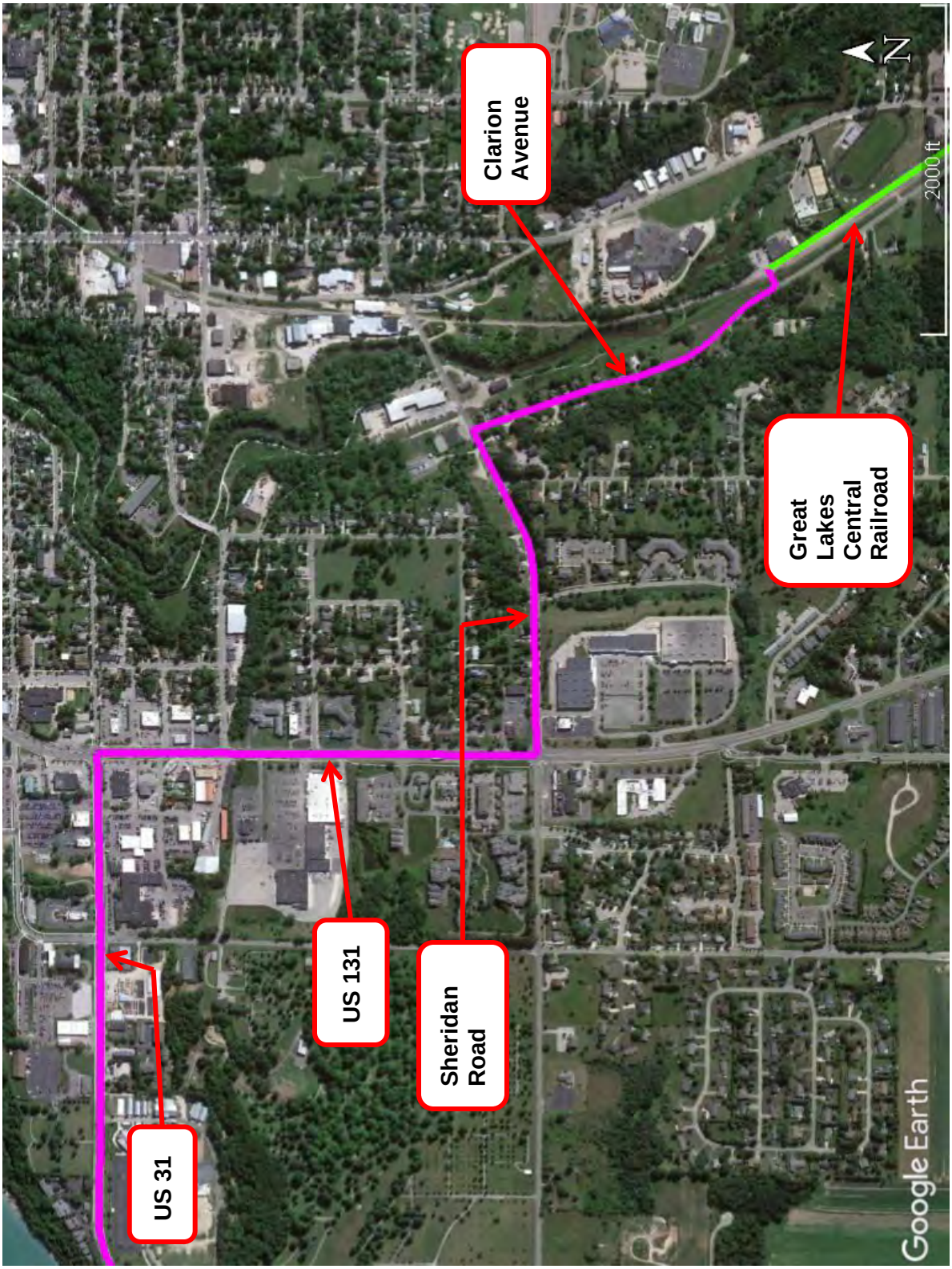


Figure 2-82. Route Taken By Steam Drum in the Vicinity of Petoskey, Michigan (Google 2019)



Photo courtesy of Federal Railroad Administration

Figure 2-83. 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 SNF 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 2-84 shows the condition of the shoreline in 2013 in the vicinity of the potential barge area identified in Figure 2-65.



Photo courtesy of Big Rock Point

Figure 2-84. Condition of Potential Barge Area at Big Rock Point (2013)

2.5.4 Future Information Needs

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 SNF 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 SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and 1 canister of GTCC waste are stored at Rancho Seco. Figure 2-85 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 SNF assemblies and the FF-DSC holds 13 pressurized water reactor SNF 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 2-86). The hydraulic ram used to emplace and withdraw canisters from the horizontal storage modules is also stored at the Rancho Seco site (see Figure 2-87). Figure 2-88 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 waste.



Photo courtesy of Rancho Seco

Figure 2-85. Rancho Seco Independent Spent Fuel Storage Installation



Figure 2-86. MP187 Transportation Cask at Rancho Seco (2013)



Figure 2-87. Hydraulic Ram Used to Emplace and Withdraw Canisters from Horizontal Storage Modules at Rancho Seco (2013)



Photo courtesy of Rancho Seco

Figure 2-88. 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).[16] 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.

[16] 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.[17] A -96 designation must also be obtained before the MP187 transportation cask is certified for the transport of GTCC 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 five FC-DSCs containing the six damaged fuel assemblies 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 SNF 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.

[17] 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

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

Source: Transnuclear (2008)

Figure 2-89 illustrates the number of SNF 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 2-90 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) is stored at Rancho Seco.

2.6.2 Site Conditions

Figure 2-91 provides an aerial view of the Rancho Seco site. The reactor building equipment and SNF pool have been decommissioned and removed, but the cooling towers, reactor containment building, and other associated structures remain on-site. In 2014, the remaining low-level radioactive waste that was stored on-site after decommissioning was shipped to Andrews, Texas for disposal. 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 SNF. The MP187 transportation cask (without impact limiters) is also stored on-site. The MP187 transportation cask is not certified for the transport of GTCC 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 2-91). Figure 2-92 shows the junction of the short track running adjacent to the ISFSI and the longer track running into the Rancho Seco site. Figure 2-93 shows the longer track running into the Rancho Seco site.

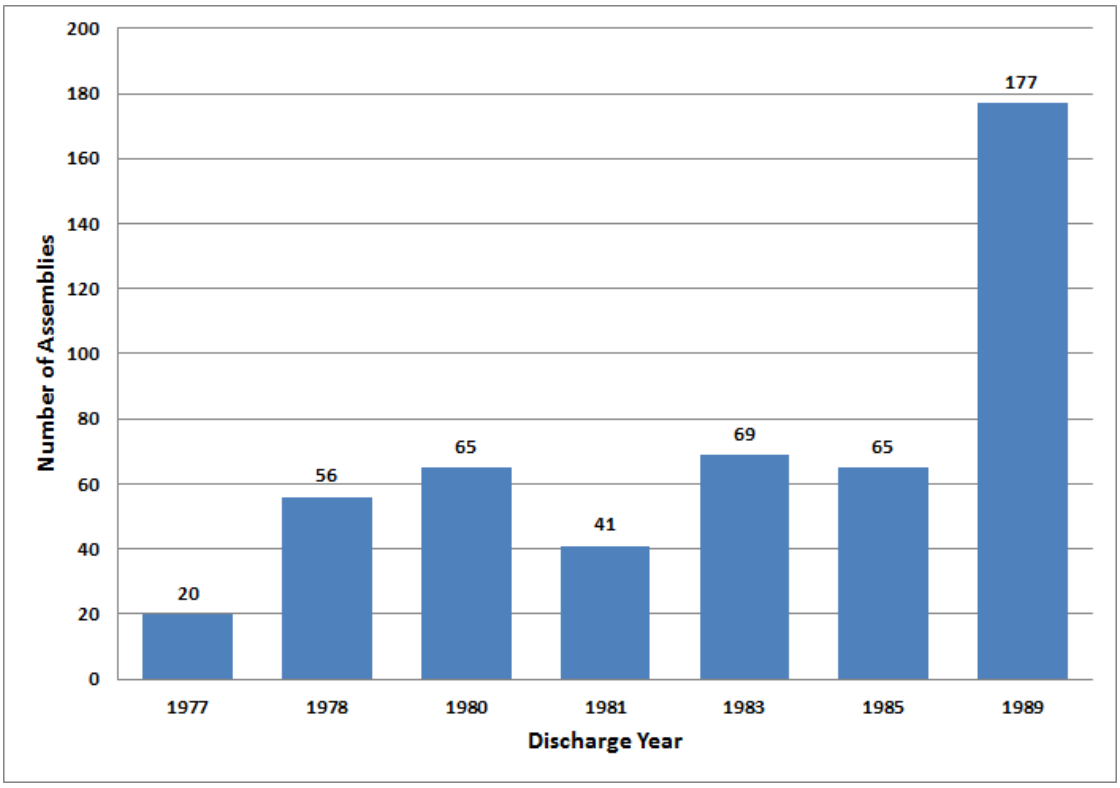


Figure 2-89. Rancho Seco Number of Assemblies versus Discharge Year (EIA 2013)

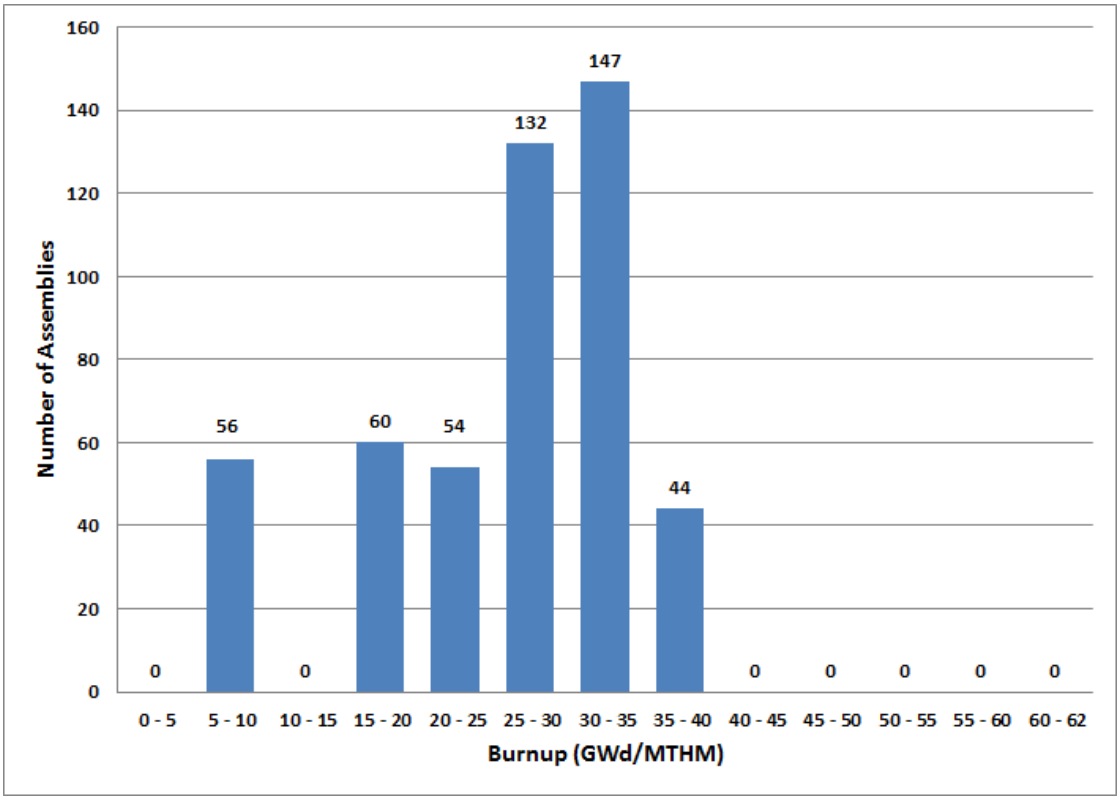


Figure 2-90. Rancho Seco Number of Assemblies versus Burnup (EIA 2013)

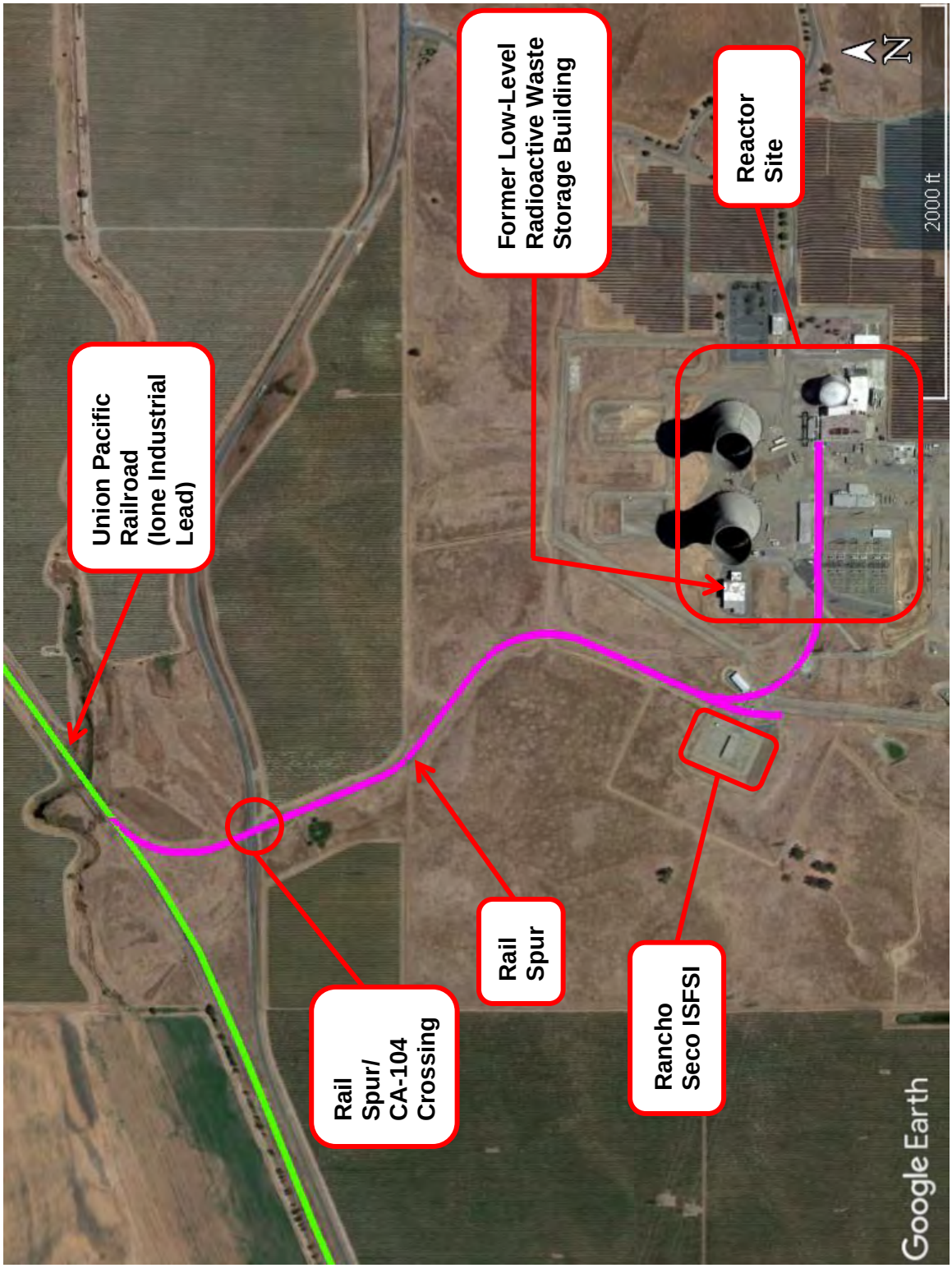


Figure 2-91. Aerial View of Rancho Seco Site (Google 2019)



Figure 2-92. 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 2-93. 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 2-94), 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 2-91). 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 2-95 and Figure 2-96 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.[18]

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 2-97). 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 2-98).

[18] 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.

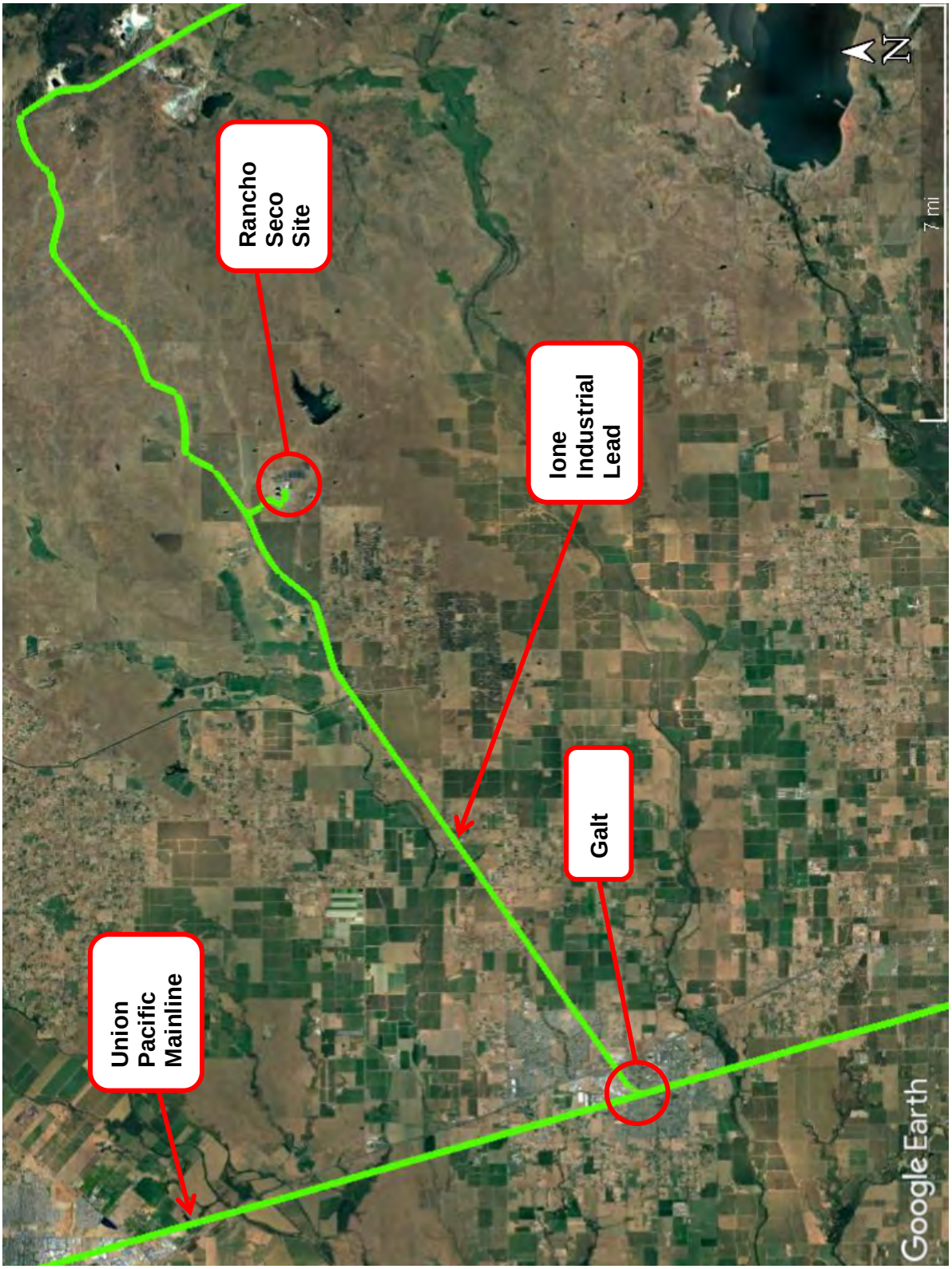


Figure 2-94. Aerial View of Ione Industrial Lead and Union Pacific Mainline (Google 2019)



Photo courtesy of Rancho Seco

Figure 2-95. Rancho Seco Pressurizer on Railcar (2004)



Photo courtesy of Rancho Seco

Figure 2-96. Rancho Seco Steam Generator Segments on Railcars



Photo courtesy of Rancho Seco

Figure 2-97. Rancho Seco Generator on Heavy Haul Truck Being Transported to the Port of Stockton, California (2002)



Photo courtesy of Rancho Seco

Figure 2-98. MP187 Cask Transported by Heavy Haul Truck

2.6.4 Future Information Needs

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 SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and no canisters of GTCC 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 2-99 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 SNF 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.



Photo courtesy of Trojan

Figure 2-99. Trojan Independent Spent Fuel Storage Installation

Figure 2-100 illustrates the number of SNF 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 2-101 illustrates the number of SNF assemblies at Trojan based on their burnup. The lowest burnup is 5.1 GWd/MTHM and the highest burnup is 41.9 GWd/MTHM. The median burnup is 33.5 GWd/MTHM. No high burnup SNF (burnup greater than 45 GWd/MTHM) is stored at Trojan.

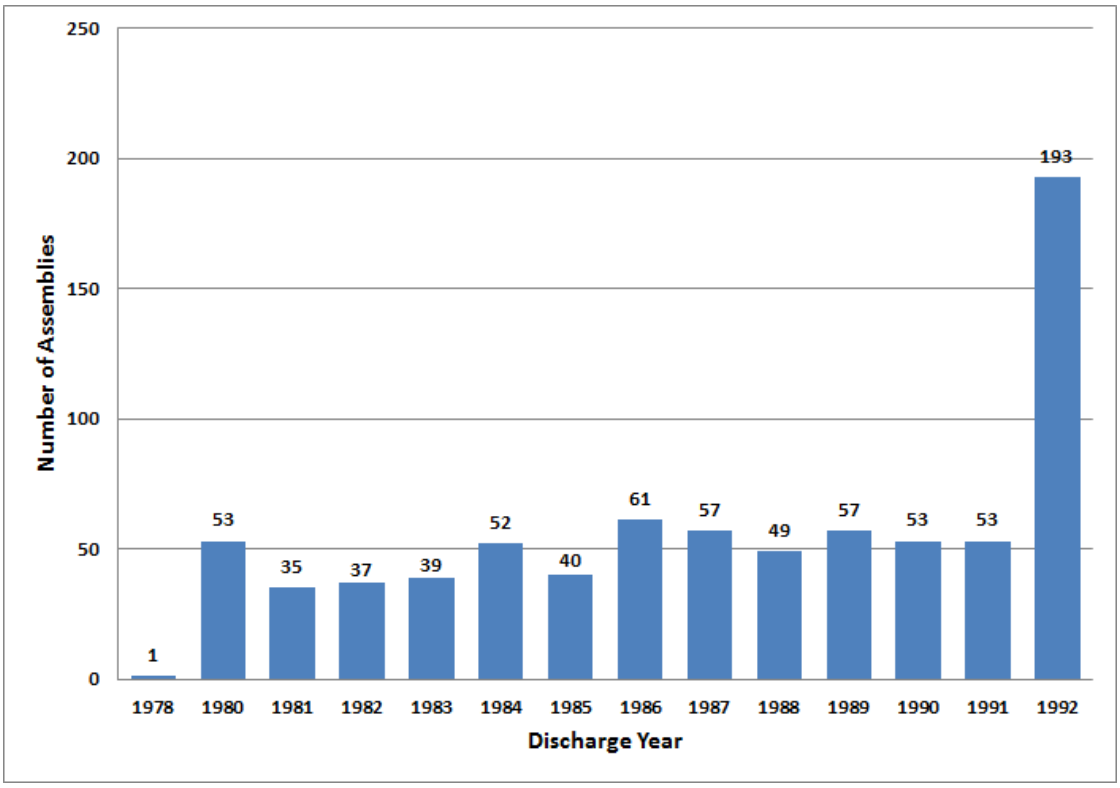


Figure 2-100. Trojan Number of Assemblies versus Discharge Year (EIA 2013)

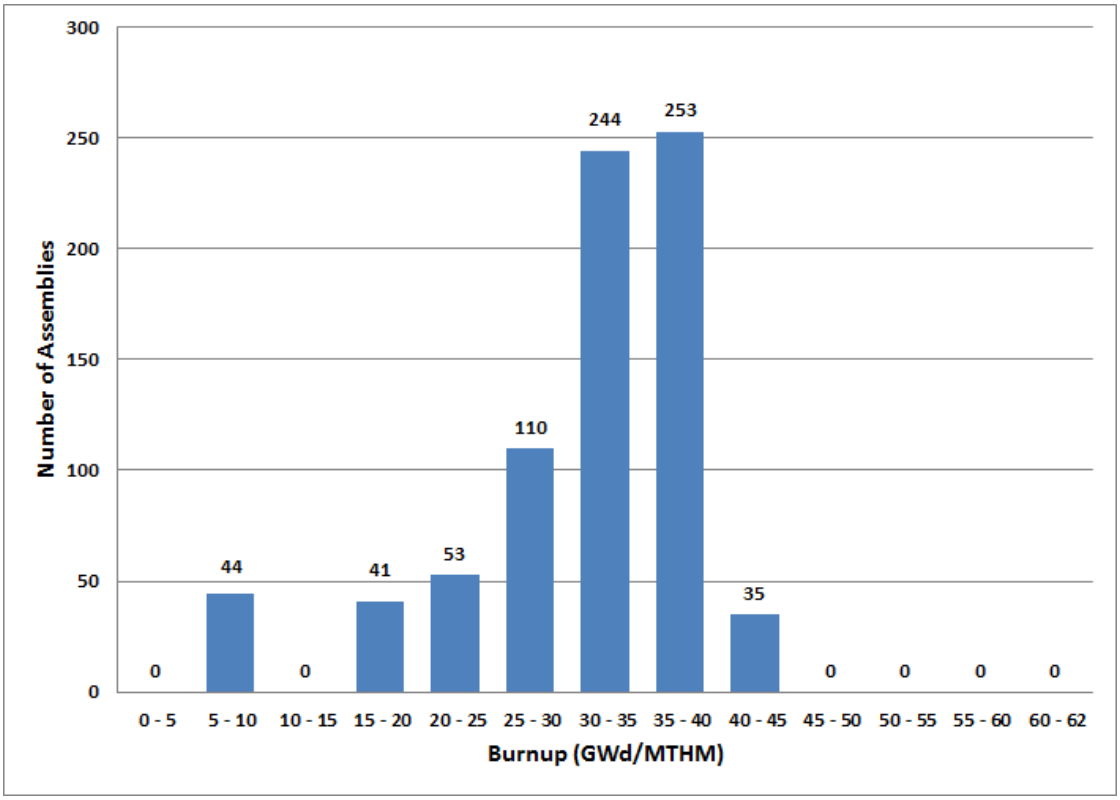


Figure 2-101. Trojan Number of Assemblies versus Burnup (EIA 2013)

2.7.2 Site Conditions

Figure 2-102 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 SNF 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 2-103 shows the transfer cask, Figure 2-104 shows the transfer station, Figure 2-105 shows the transfer station with the transfer cask and mobile crane, and Figure 2-106 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 SNF.[19]

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 2-107). 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 2-108 shows the Portland and Western Railroad in the vicinity of the Trojan site, Figure 2-109 shows the location of the former junction of the rail spur with the Portland and Western Railroad, and Figure 2-110 shows the railbed of the former rail spur. Remnants of this spur exist on-site (see Figure 2-111). 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 2-102 shows the location of the barge slip. Figure 2-112 shows the access road to the barge slip, and Figure 2-113 shows the condition of the barge slip in 2013.

[19] 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.

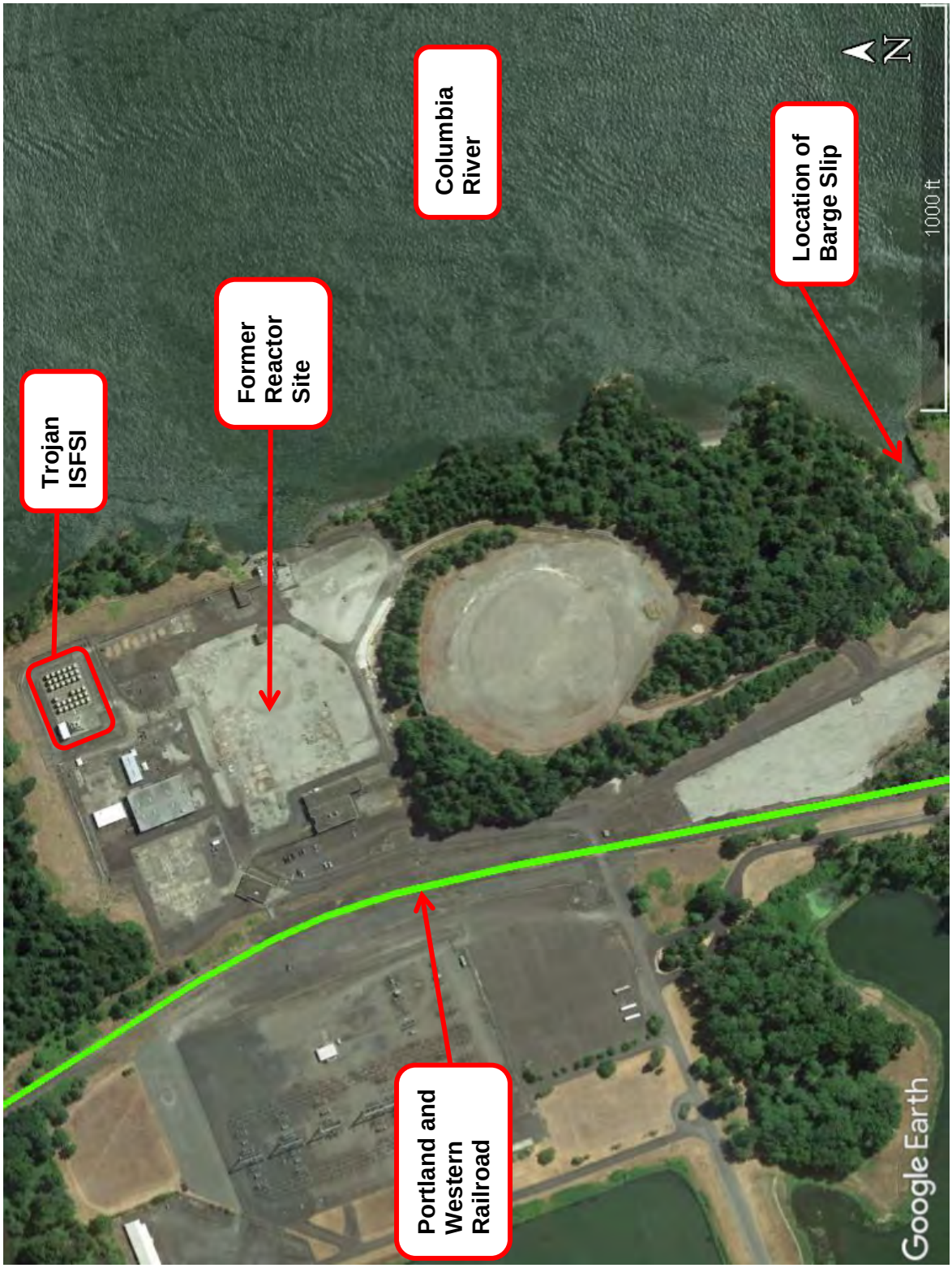


Figure 2-102. Aerial View of Trojan Site (Google 2019)



Photo courtesy of Trojan

Figure 2-103. Trojan Transfer Cask



Photo courtesy of Trojan

Figure 2-104. Trojan Transfer Station



Photo courtesy of Trojan

Figure 2-105. Trojan Transfer Station with Transfer Cask and Mobile Crane



Photo courtesy of Oregon Department of Energy

Figure 2-106. Trojan Transfer Station with Transfer Cask and TranStor Vertical Concrete Storage Overpack

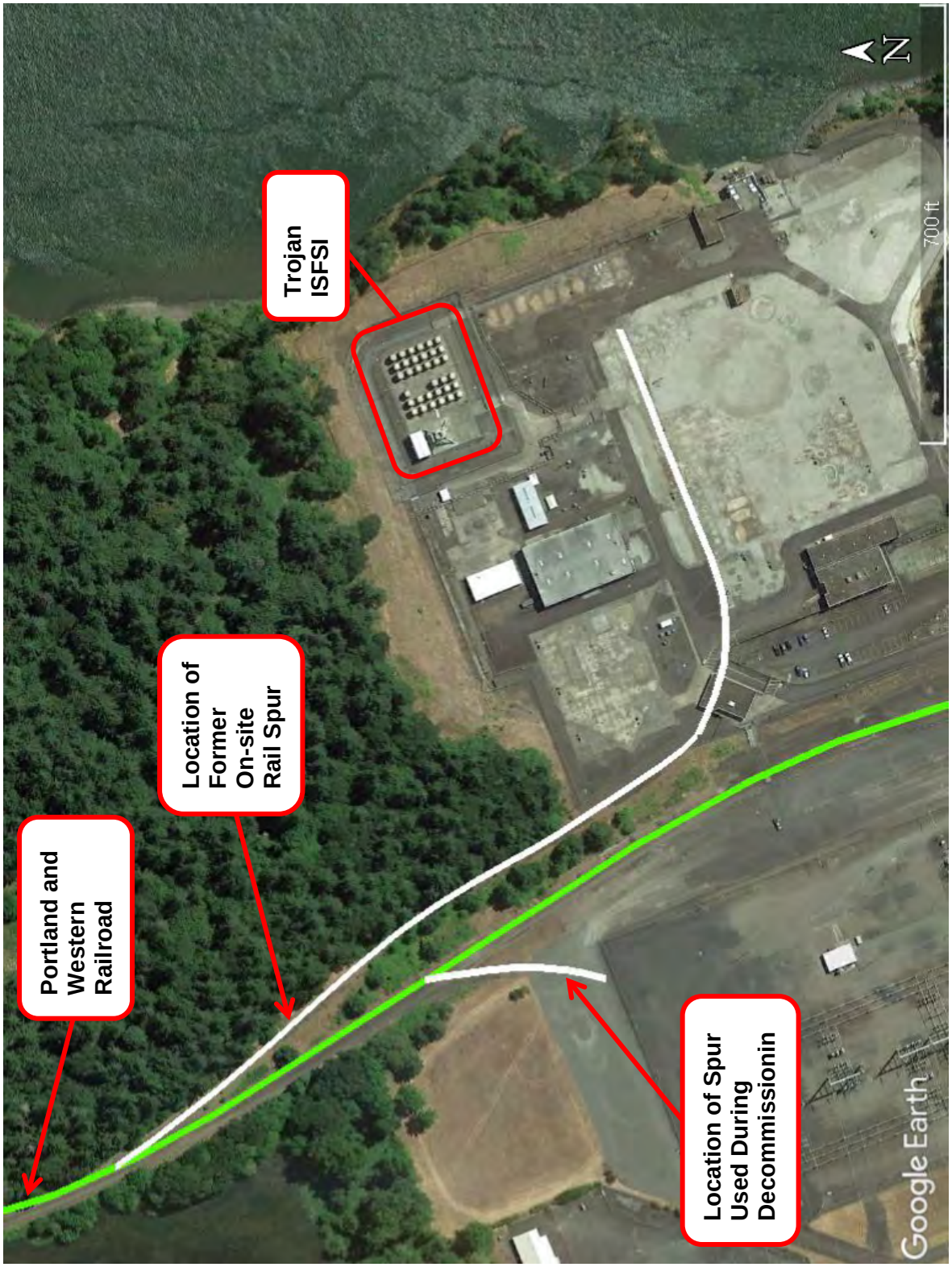


Figure 2-107. Rail Interface at Trojan (Google 2019)



Figure 2-108. Portland and Western Railroad in the Vicinity of the Trojan Site (2013)



Figure 2-109. Location of Former Junction of Portland and Western Railroad and Trojan Rail Spur (2013)



Figure 2-110. Former Trojan Rail Spur Railbed (2013)



Figure 2-111. Remnants of On-site Rail Spur at Trojan (2013)



Photo courtesy of Federal Railroad Administration

Figure 2-112. Trojan Barge Slip Access Road (2013)



Photo courtesy of Federal Railroad Administration

Figure 2-113. 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 by 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 by tides, so departure had to take place during high tide to have sufficient water depth to float the loaded barge (EPRI 2000).

Figure 2-114 through Figure 2-118 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 2-114. Trojan Steam Generator Being Loaded at Barge Slip (1995)



Photo courtesy of Oregon Department of Energy

Figure 2-115. Trojan Reactor Pressure Vessel on Transport Cradle (1999)



Photo courtesy of Trojan

Figure 2-116. Trojan Reactor Pressure Vessel Being Transported by Barge (1999)



Photo courtesy of Trojan

Figure 2-117. Trojan Reactor Pressure Vessel Passing Through Locks on the Columbia River (1999)



Photo courtesy of Trojan

Figure 2-118. Trojan Reactor Pressure Vessel Being Transported by Heavy Haul Truck (1999)

2.7.4 Future Information Needs

Both rail and barge modes are feasible for transporting SNF 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 SNF. 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 SNF transportation casks on barges.

2.8 La Crosse

This section describes the inventory of SNF, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies are stored at the La Crosse ISFSI (Docket No. 72-46). The five canisters contain 176 intact SNF assemblies, 157 damaged SNF 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 waste would not be generated.

Figure 2-119 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 SNF is the MPC-LACBWR. This canister holds 68 La Crosse boiling water reactor SNF 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. Six NAC-STC transportation casks have been fabricated for use in China.

Figure 2-120 illustrates the number of SNF 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 2-121 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) is stored at La Crosse.



Photo courtesy of La Crosse

Figure 2-119. La Crosse Independent Spent Fuel Storage Installation

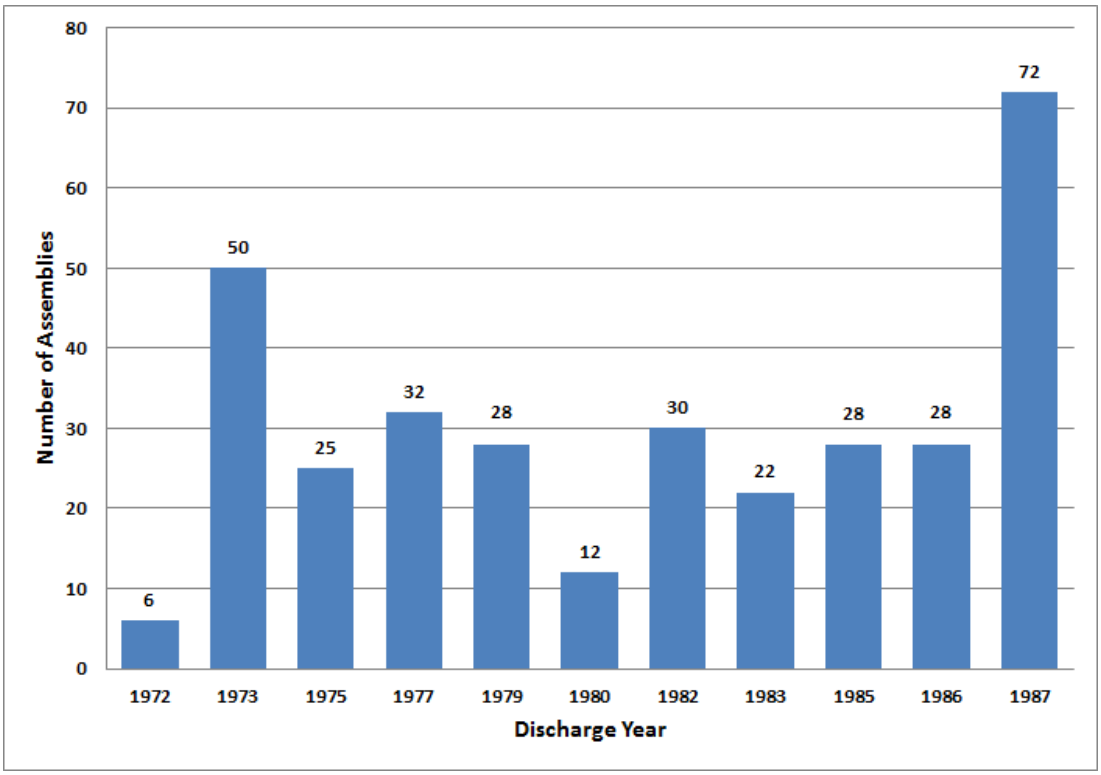


Figure 2-120. La Crosse Number of Assemblies versus Discharge Year (EIA 2013)

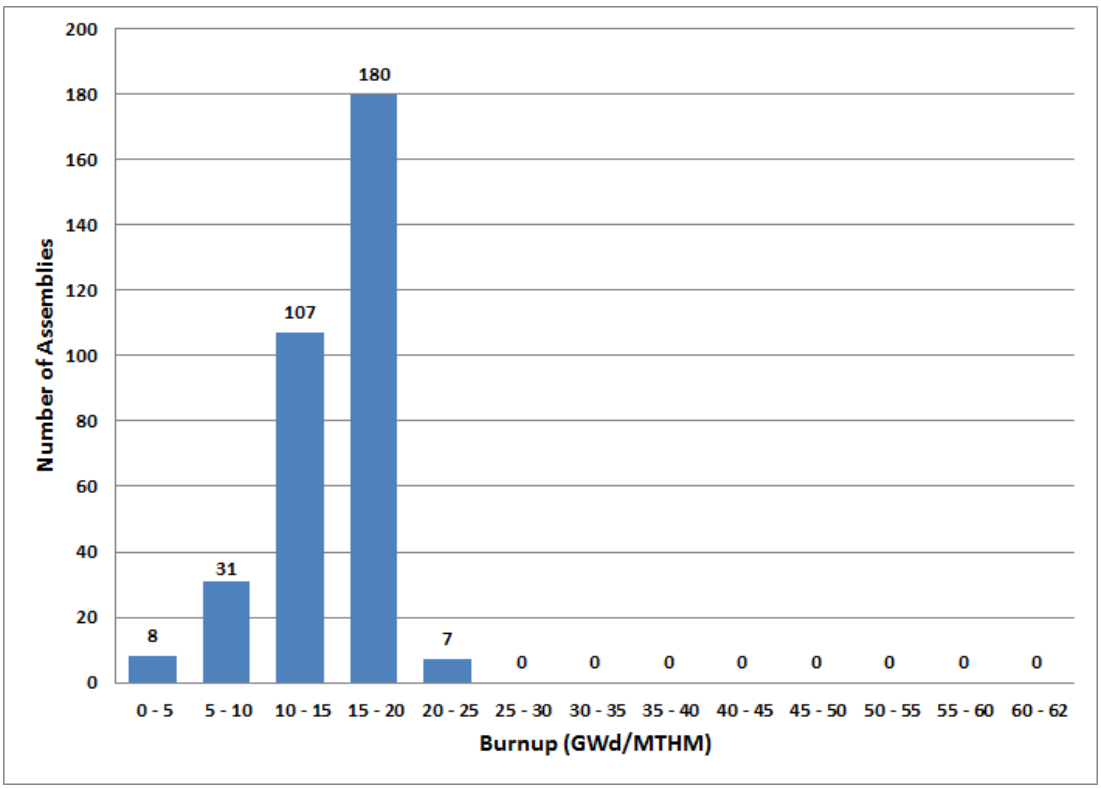


Figure 2-121. La Crosse Number of Assemblies versus Burnup (EIA 2013)

2.8.2 Site Conditions

Figure 2-122 through Figure 2-124 provide aerial views of the La Crosse site, barge facility and on-site rail spur, and ISFSI and boat ramp. As seen in Figure 2-122, 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 SNF 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. About 86 trains per day use this mainline and the rail line is designated as track class 4. La Crosse does not have an active on-site rail system;[20] however, remnants of an on-site rail system exist at the site (see Figure 2-125). There is a short on-site spur at the north end of the La Crosse site (see Figure 2-126). Figure 2-127 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 2-128). 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.

[20] 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.

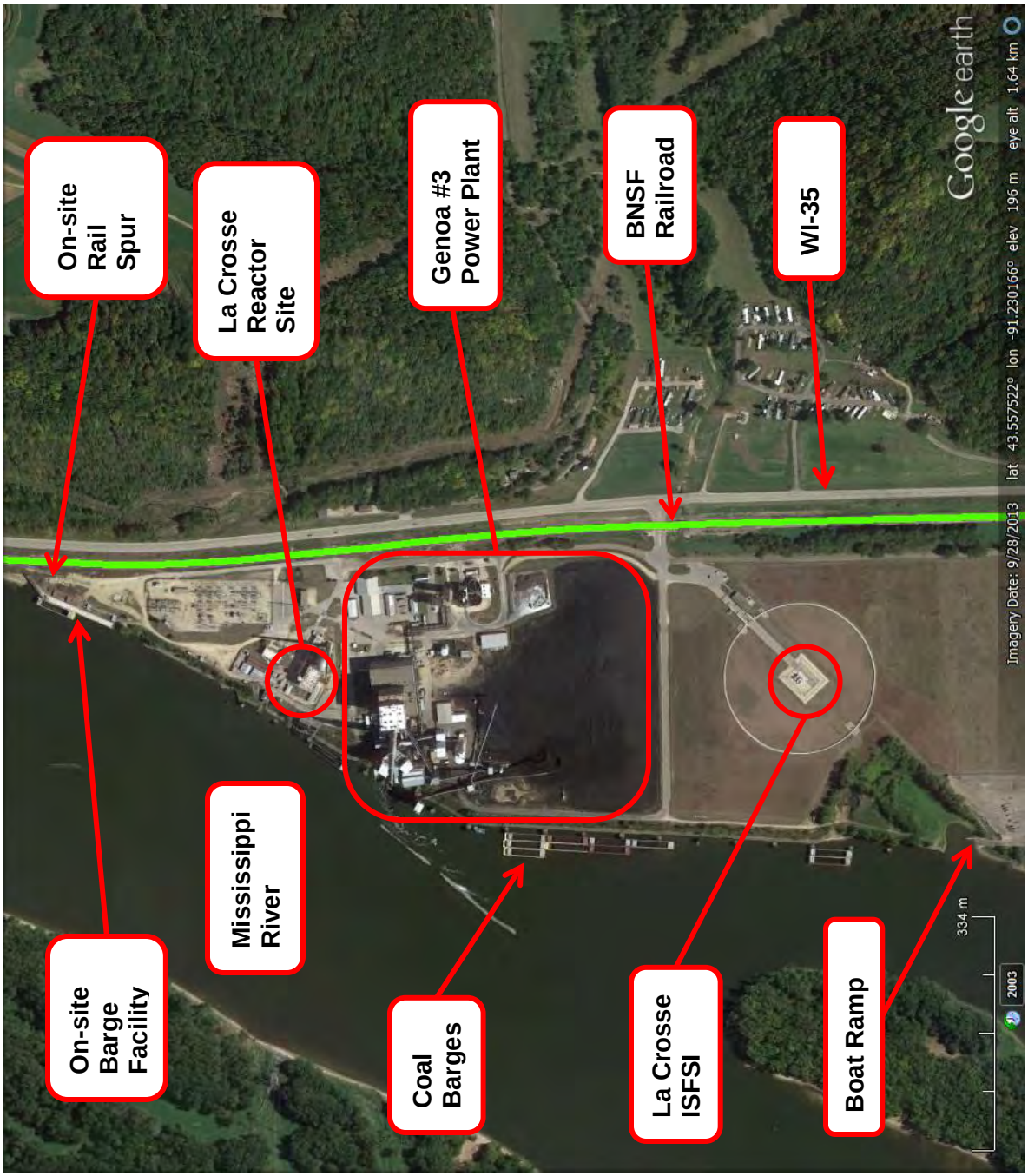


Figure 2-122. Aerial View of La Crosse Site (Google 2019)

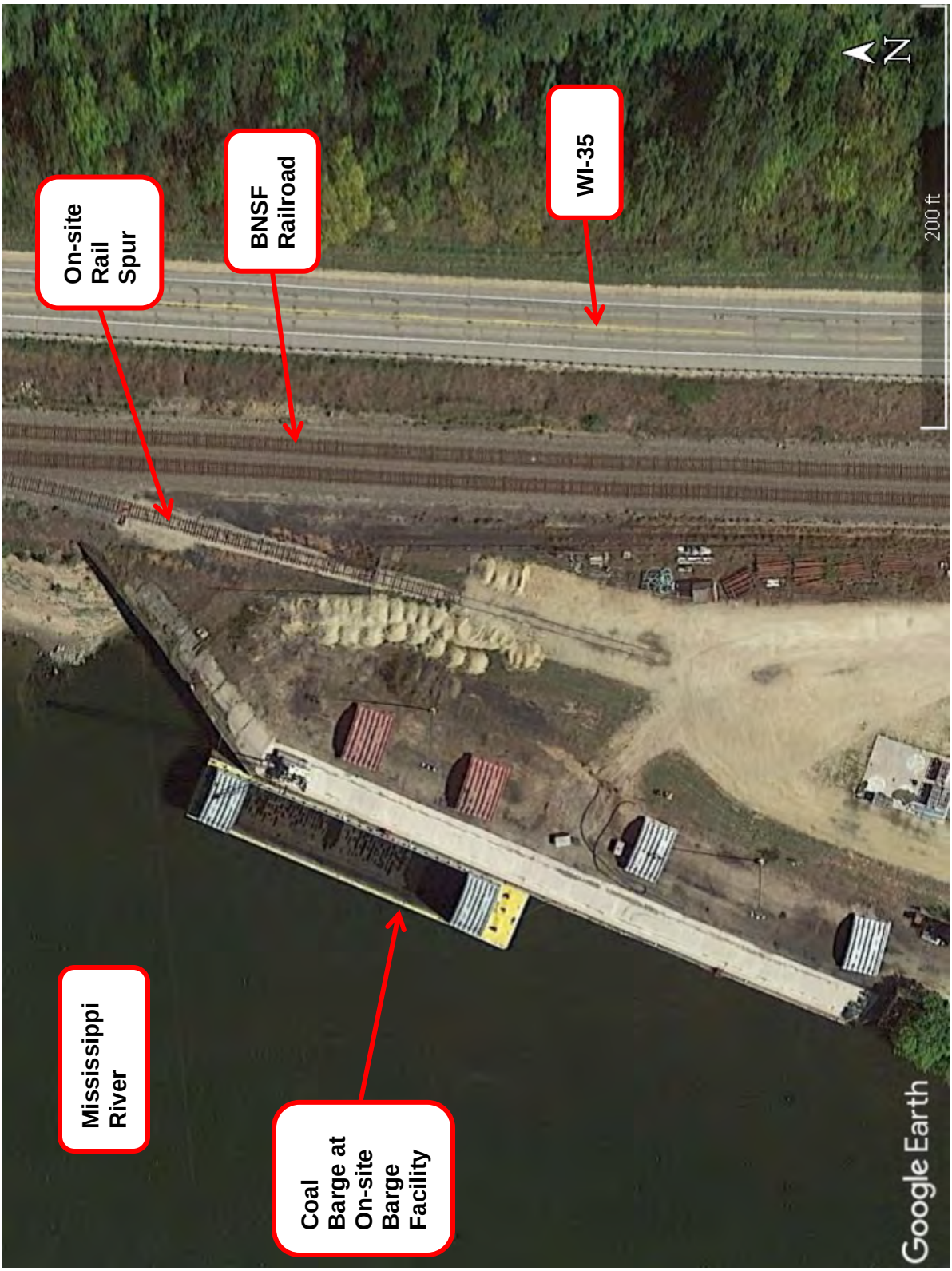


Figure 2-123. Aerial View of La Crosse Barge Facility and On-site Rail Spur (Google 2019)

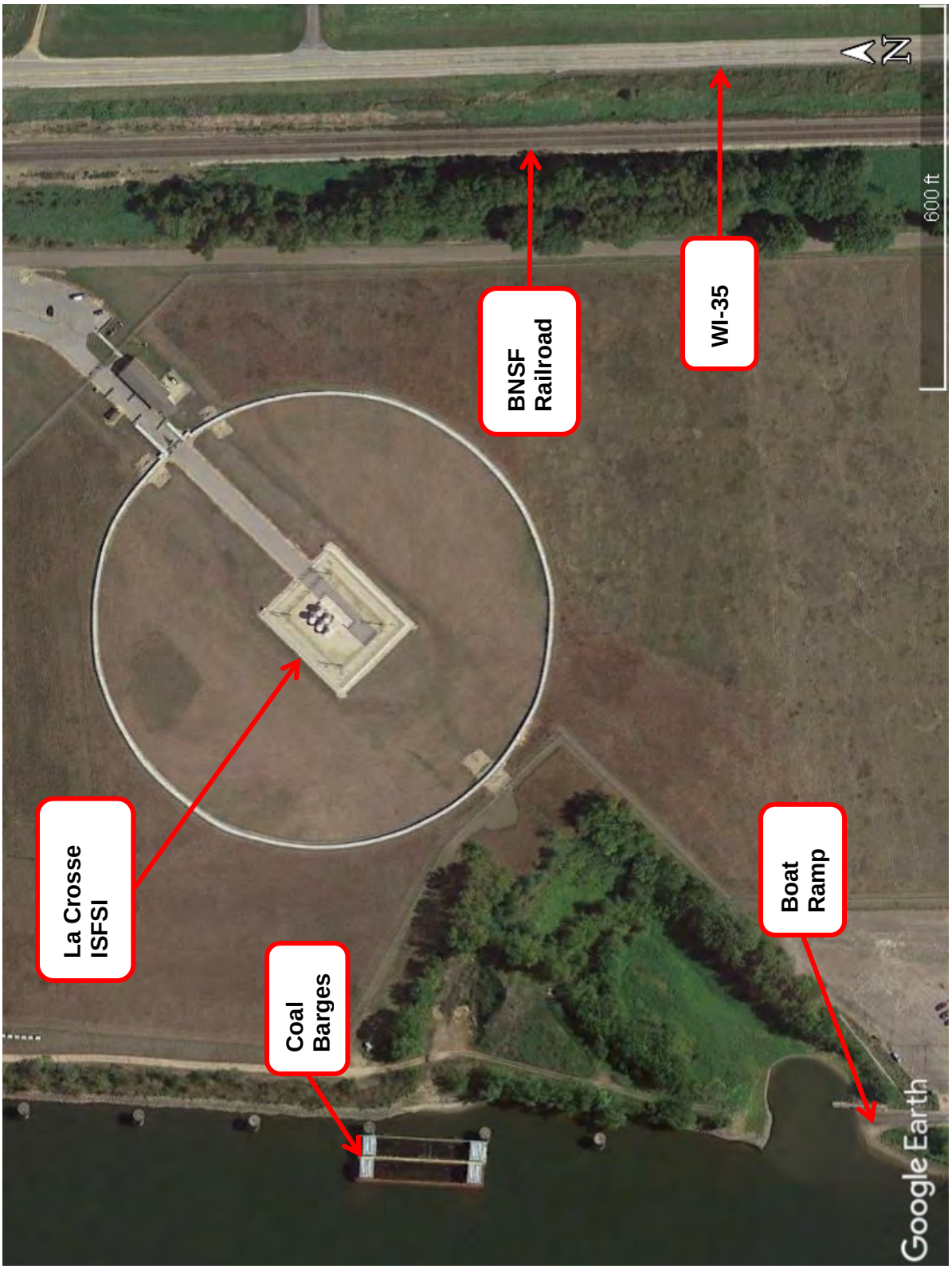


Figure 2-124. Aerial View of La Crosse Independent Spent Fuel Storage Installation and Boat Ramp (Google 2019)



Photo courtesy of La Crosse

Figure 2-125. Remnants of the On-site Rail System at La Crosse Site (2013)



Photo courtesy of La Crosse

Figure 2-126. On-site Rail Spur at Northern End of La Crosse Site (2013)



Photo courtesy of La Crosse

Figure 2-127. Junction of On-site Rail Spur with BNSF Railroad at La Crosse Site (2013)



Figure 2-128. 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 2-129 and Figure 2-130 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.

Lacrosse Solutions[21] has been transporting low-level radioactive waste in an estimated 1100 intermodal containers approximately 50 miles by truck to the Seven Rivers Intermodal Terminal in Winona, Minnesota. This is being done to avoid blockage of the BNSF mainline which runs along the eastern boundary of the La Crosse site. The intermodal containers will be transferred to approximately 200 flat cars and transported by rail to Clive, Utah for disposal.

2.8.4 Future Information Needs

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 SNF 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 SNF from the site.

[21] Lacrosse Solutions is the decommissioning contractor for the La Crosse site.



Photo courtesy of La Crosse

Figure 2-129. La Crosse Reactor Pressure Vessel on Rail Spur (2007)



Photo courtesy of La Crosse

Figure 2-130. La Crosse Reactor Pressure Vessel on BNSF Railroad (2007)

2.9 Zion

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF assemblies and four canisters of GTCC waste are stored at the Zion ISFSI (Docket No. 72-1037). The 61 canisters contain 2226 SNF assemblies that were discharged from the Zion 1 and Zion 2 reactors. Figure 2-131 shows the Zion ISFSI. The storage system used at Zion is the MAGNASTOR system (Docket No. 72-1031), which consists of a transportable storage canister (see Figure 2-132), a vertical concrete storage cask, and a transfer cask (see Figure 2-133). At Zion, the TSC-37[22] transportable storage canister is being used, which holds 37 pressurized water reactor SNF assemblies. Figure 2-134 shows the TSC-37 canister inside the transfer cask and Figure 2-135 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 certified to transport the SNF and GTCC waste at the Zion site is the MAGNATRAN (Docket No. 71-9356).



Photo courtesy of EnergySolutions

Figure 2-131. Zion Independent Spent Fuel Storage Installation

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

Figure 2-136 illustrates the number of SNF 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 2-137 illustrates the number of SNF assemblies at Zion based on their burnup. The lowest burnup is 14.2 GWd/MTHM and the highest burnup is 55.4 GWd/MTHM. The median burnup is 33.1 GWd/MTHM. There are 36 SNF assemblies at Zion with burnups greater than 45 GWd/MTHM. These 36 fuel assemblies are classified by the NRC as high burnup SNF. 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 SNF and was placed in a damaged fuel can.

In addition to the 37 SNF assemblies discussed above, 57 SNF assemblies identified as damaged, 2 loose fuel rod storage containers (ZFRSB1 and Y48B) holding 28 fuel rods, and 1 SNF 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).

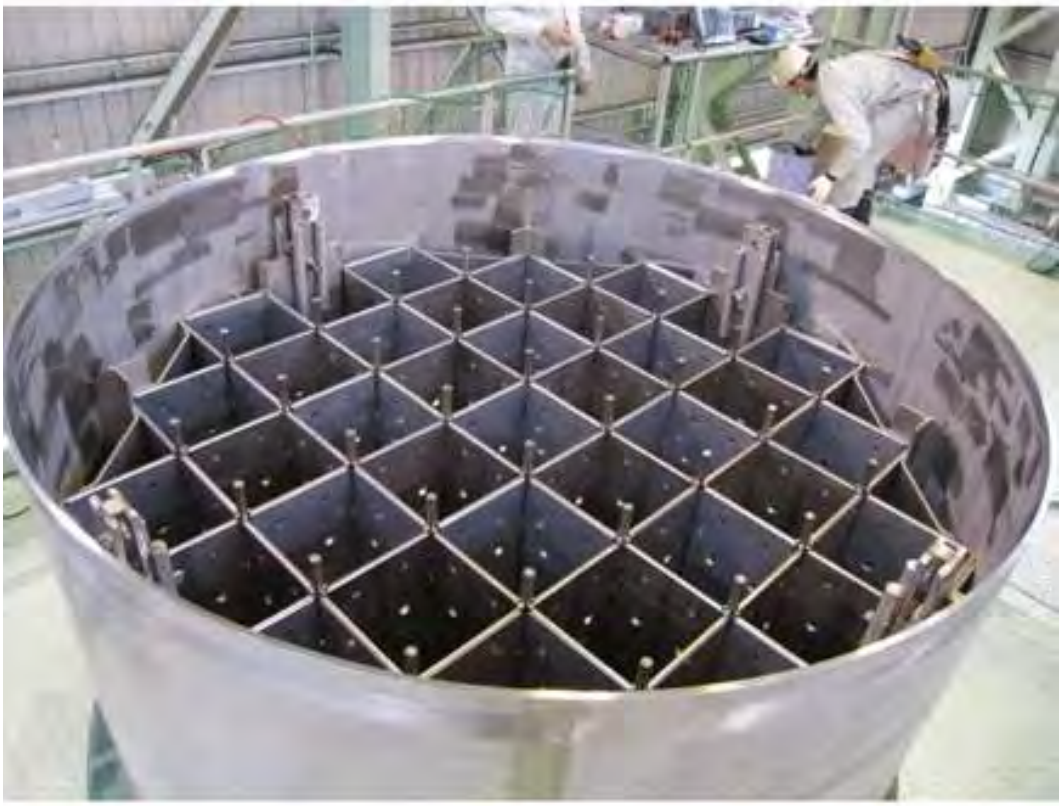


Photo courtesy of NAC International

Figure 2-132. TSC-37 Canister Showing Internal Baskets Which Hold Spent Nuclear Fuel Assemblies



Photo courtesy of ZionSolutions

Figure 2-133. Transfer Cask

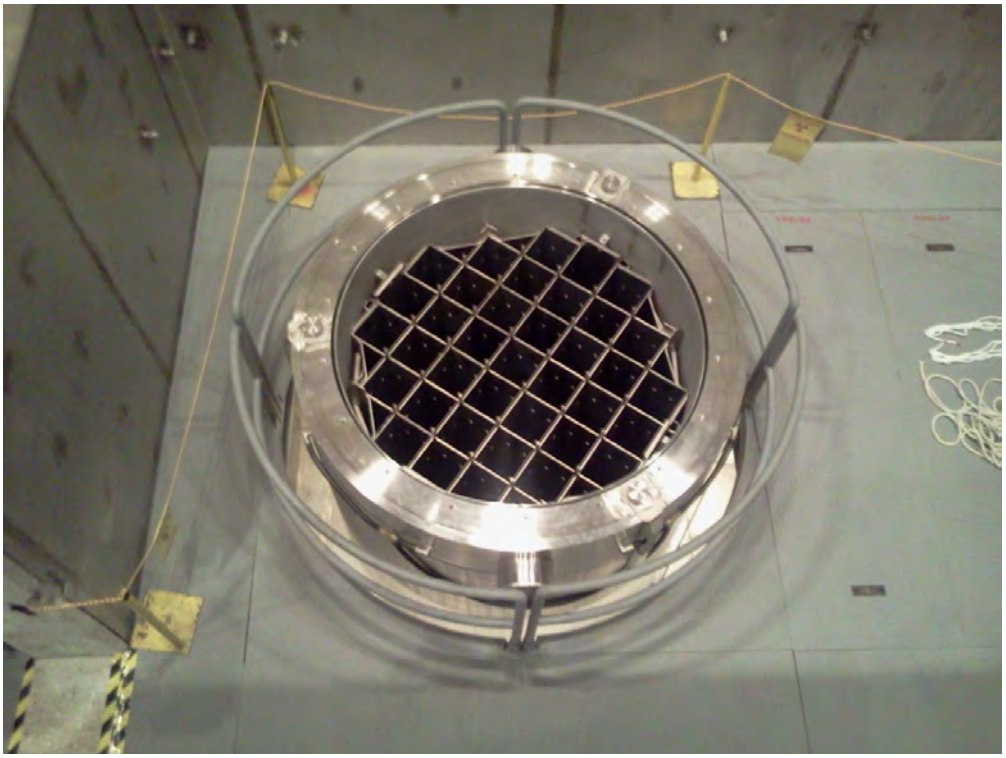


Photo courtesy of ZionSolutions

Figure 2-134. TSC-37 Canister Inside Transfer Cask



Photo courtesy of ZionSolutions

Figure 2-135. Damaged Fuel Can Being Installed in TSC-37 Canister

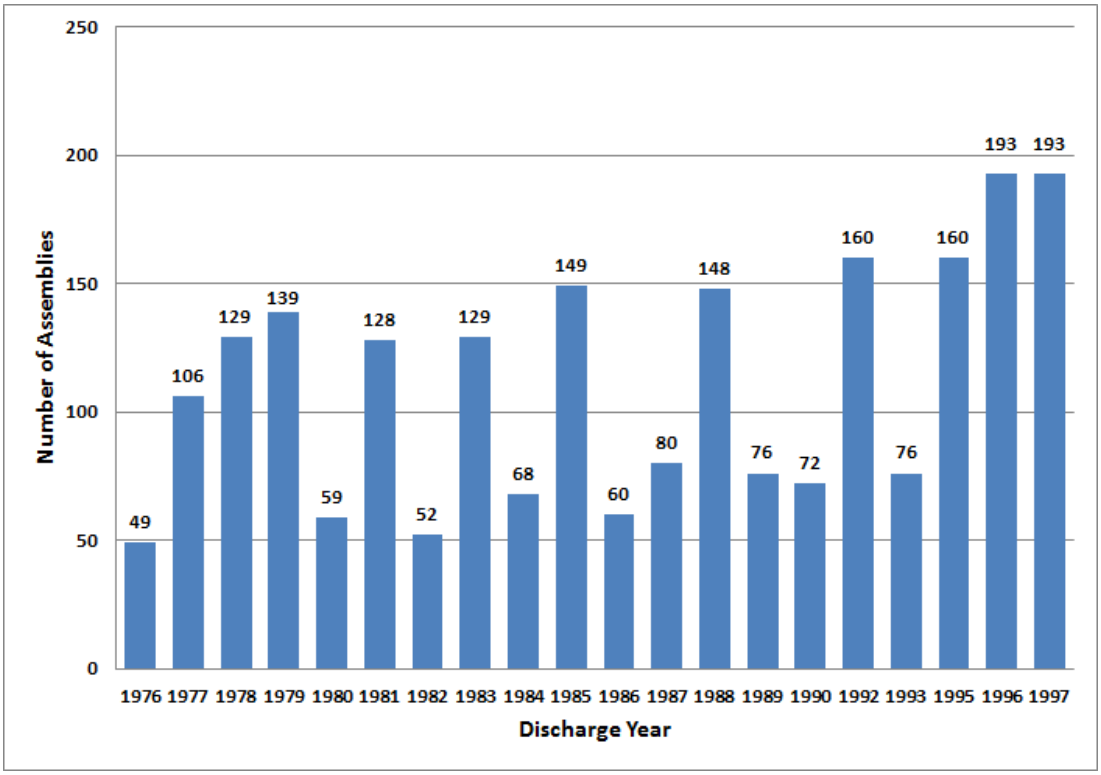


Figure 2-136. Zion Number of Assemblies versus Discharge Year (EIA 2013)

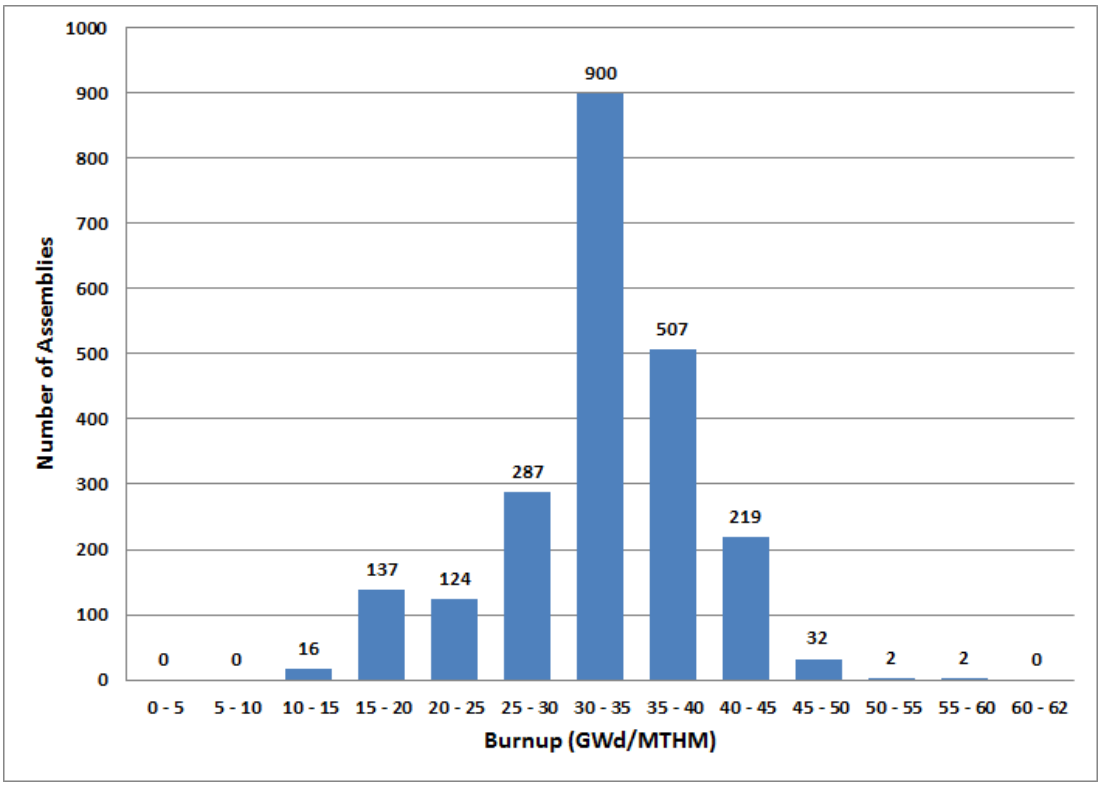


Figure 2-137. Zion Number of Assemblies versus Burnup (EIA 2013)

2.9.2 Site Conditions

Figure 2-138 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 2-139). At the northern end of the Zion site, 65 vertical concrete storage casks were staged prior to being loaded. Figure 2-140 provides a close-up view of these vertical concrete storage casks. Figure 2-141 shows the TSC-37 transportable storage canisters into which the SNF was placed. These canisters were then placed inside vertical concrete storage casks and moved to the Zion ISFSI. Figure 2-142 shows the transporter used to move the loaded vertical concrete storage casks to the ISFSI.

Figure 2-138 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 2-143). 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 2-144) remain and could be reused to refurbish the barge facility.

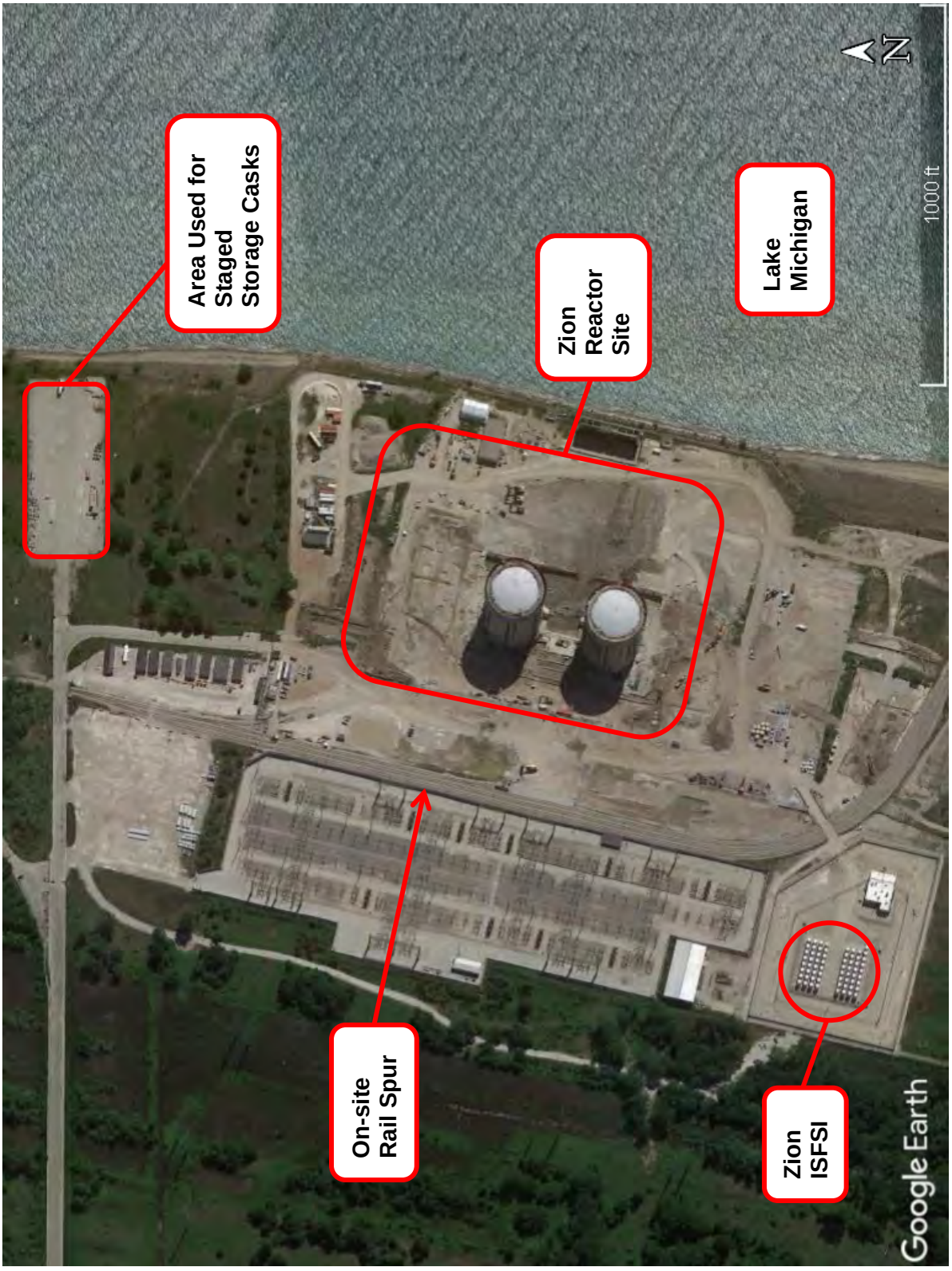


Figure 2-138. Aerial View of Zion Site (Google 2019)



Figure 2-139. Aerial View of Zion Independent Spent Fuel Storage Installation (Google 2019)



Figure 2-140. Vertical Concrete Storage Casks Staged at Zion (2013)



Figure 2-141. Spent Nuclear Fuel Transportable Storage Canisters Staged at Zion (2013)



Figure 2-142. Transporter Used to Move Vertical Concrete Storage Casks (2013)



Photo courtesy of ZionSolutions

Figure 2-143. Steam Generators Being Delivered to Zion Site by Barge during Construction



Figure 2-144. Barge Pilings at the North End of the Zion Site (Google 2019)

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 2-145). 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, at the junction of the Union Pacific mainline and the Zion site access road.

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 2-146 shows the Trackmobile that is being used to move railcars on-site. Figure 2-147 shows the rail spur entering the Zion site and Figure 2-148 shows the junction of the Zion on-site rail spur with the Union Pacific Railroad. Figure 2-148 also shows the concrete rail ties that were used in the reconstructing the curves of the on-site rail spur.

In 2016, eight steam generators were shipped by rail from the Zion site to Clive, Utah for disposal. The steam generators ranged in weight from 444,000 to 462,200 lb. and were shipped on 360-ton, 53-foot deck, 12-axle QTTX flat cars. Figure 2-149 shows a steam generator being

prepared for shipping and Figure 2-150 shows two steam generators awaiting departure from the Zion site.

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 2-151 shows the Zion reactor head on its heavy haul truck transporter.

2.9.4 Future Information Needs

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 SNF in 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.

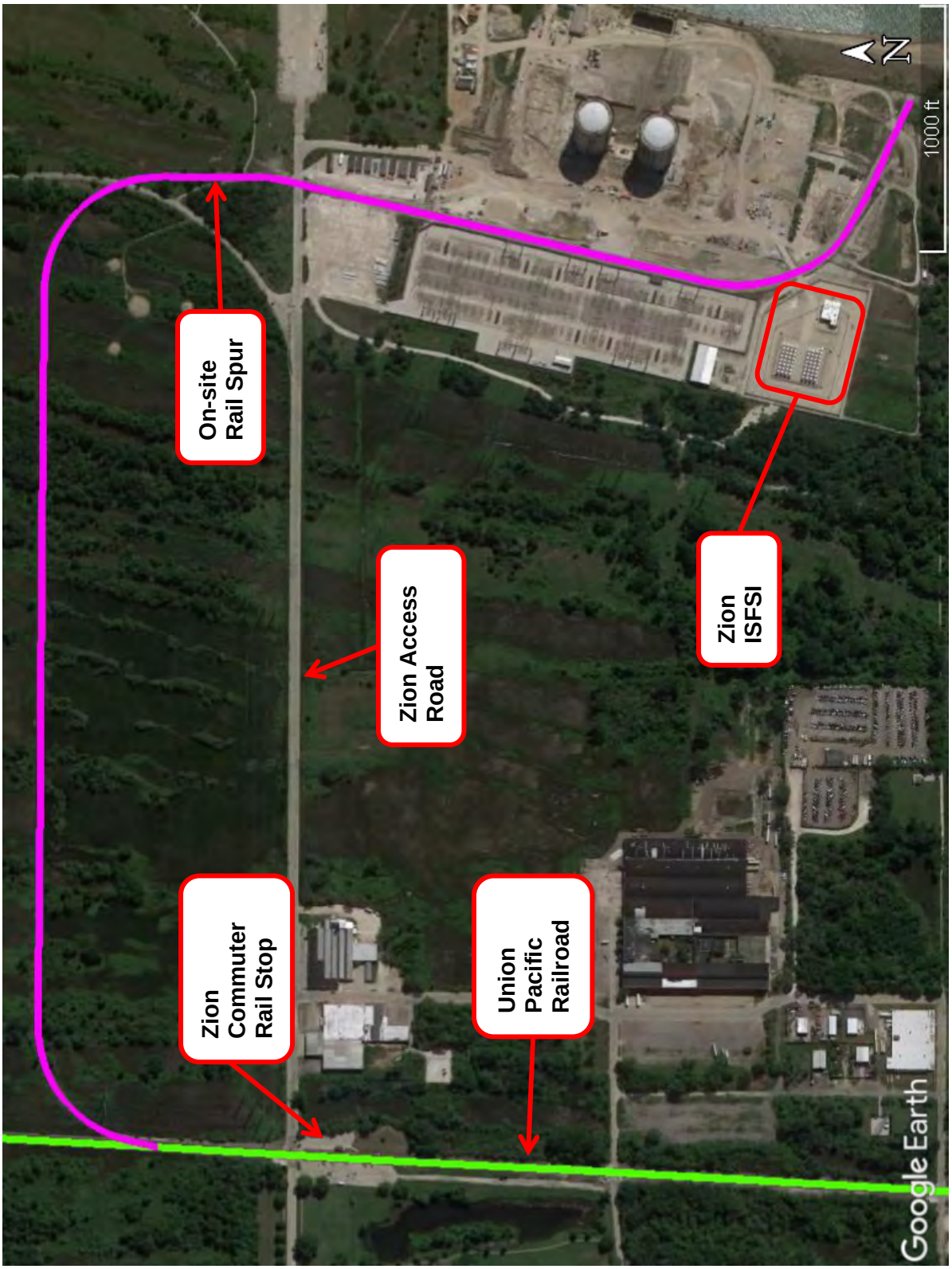


Figure 2-145. Rail Interface at Zion (Google 2019)



Figure 2-146. Trackmobile Used to Move Railcars On-site (2013)



Photo courtesy of Federal Railroad Administration

Figure 2-147. On-site Rail Spur Entering Zion Site (2013)



Figure 2-148. Junction of Zion On-site Rail Spur with Union Pacific Railroad Showing Concrete Rail Ties (2013)



Photo courtesy of ZionSolutions

Figure 2-149. Steam Generator Being Prepared for Shipping (2016)



Photo courtesy of ZionSolutions

Figure 2-150. Two Steam Generators Awaiting Departure from the Zion Site (2016)



Photo courtesy of ZionSolutions

Figure 2-151. Zion Reactor Head on Heavy Haul Truck Transporter (2011)

2.10 Crystal River

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF from the reactor vessel was completed on May 28, 2011 (Franke 2013). Removal of SNF from the Crystal River spent fuel pool was completed on January 15, 2018 (Hobbs 2018). There are 1244 pressurized water reactor SNF assemblies (582.2 MTHM) at the Crystal River site.[23] This total includes an assembly that was created by

[23] 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 were sold for reuse.

The fuel rods in the fuel assemblies are zirconium alloy-clad. Crystal River is using the Standardized NUHOMS System (Docket No. 72-1004) with the 32PTH1 dry shielded canister for dry storage of SNF at the Crystal River ISFSI (Docket No. 72-1035). This system consists of transportable 32PTH1 dry shielded canisters, reinforced concrete horizontal storage modules, and a transfer cask. Figure 2-152 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 SNF assemblies. Thirty-nine 32PTH1 canisters were required to store the 1244 SNF assemblies at Crystal River. Elnitsky (2013) estimated that 5 canisters containing GTCC waste would be generated during decommissioning.

The MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 32PTH1 canister and also canisters containing GTCC waste. In addition, the MP197HB transportation cask is certified to transport high burnup (> 45 GWd/MTHM) SNF in the 32PTH1 canister. An MP197HB transportation cask has been fabricated and is in use in the U.S.

Figure 2-153 illustrates the number of SNF assemblies at Crystal River, based on their discharge year. 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 2-154 illustrates the number of SNF assemblies at Crystal River based on their burnup. 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 SNF assemblies at Crystal River that have burnups greater than 45 GWd/MTHM. These 428 fuel assemblies are classified by the NRC as high burnup SNF.



Photo courtesy of AREVA TN

Figure 2-152. Transfer Cask Being Used to Load Canister into Horizontal Storage Module

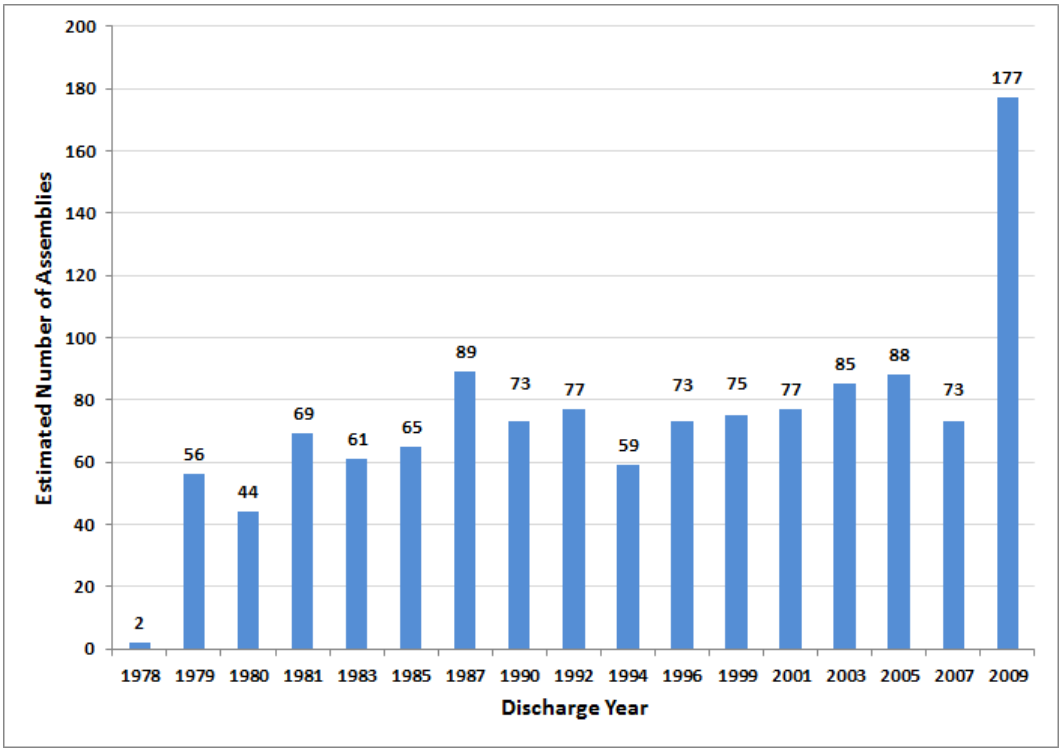


Figure 2-153. Crystal River Number of Assemblies versus Discharge Year (EIA 2013)

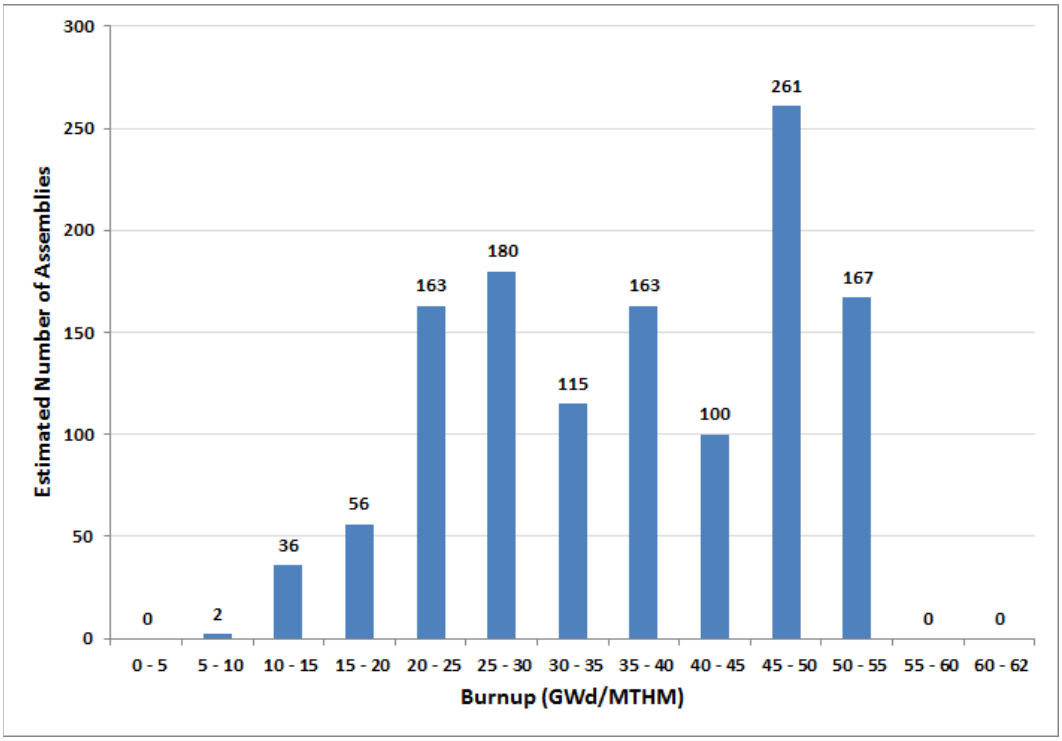


Figure 2-154. Crystal River Number of Assemblies versus Burnup (EIA 2013)

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 2-155 shows the site of the Crystal River ISFSI before construction. This area was built up approximately 20 feet to be above flood level. Figure 2-156 shows the Crystal River ISFSI after installation of the horizontal storage modules. Figure 2-157 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 2-158 shows the location of the 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 2-159 and Figure 2-160 show the nuclear spur and the junction of the on-site industrial spur and the nuclear spur. Figure 2-161 and Figure 2-162 show the on-site industrial spur in front

of the ISFSI site. Figure 2-163 and Figure 2-164 show the on-site 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 2-165). 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 2-166 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 2-167 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 2-155. Site of the Crystal River Independent Spent Fuel Storage Installation Before Construction (2015)



Photo courtesy of Crystal River

Figure 2-156. Crystal River Independent Spent Fuel Storage Installation with Horizontal Storage Modules Installed (2017)

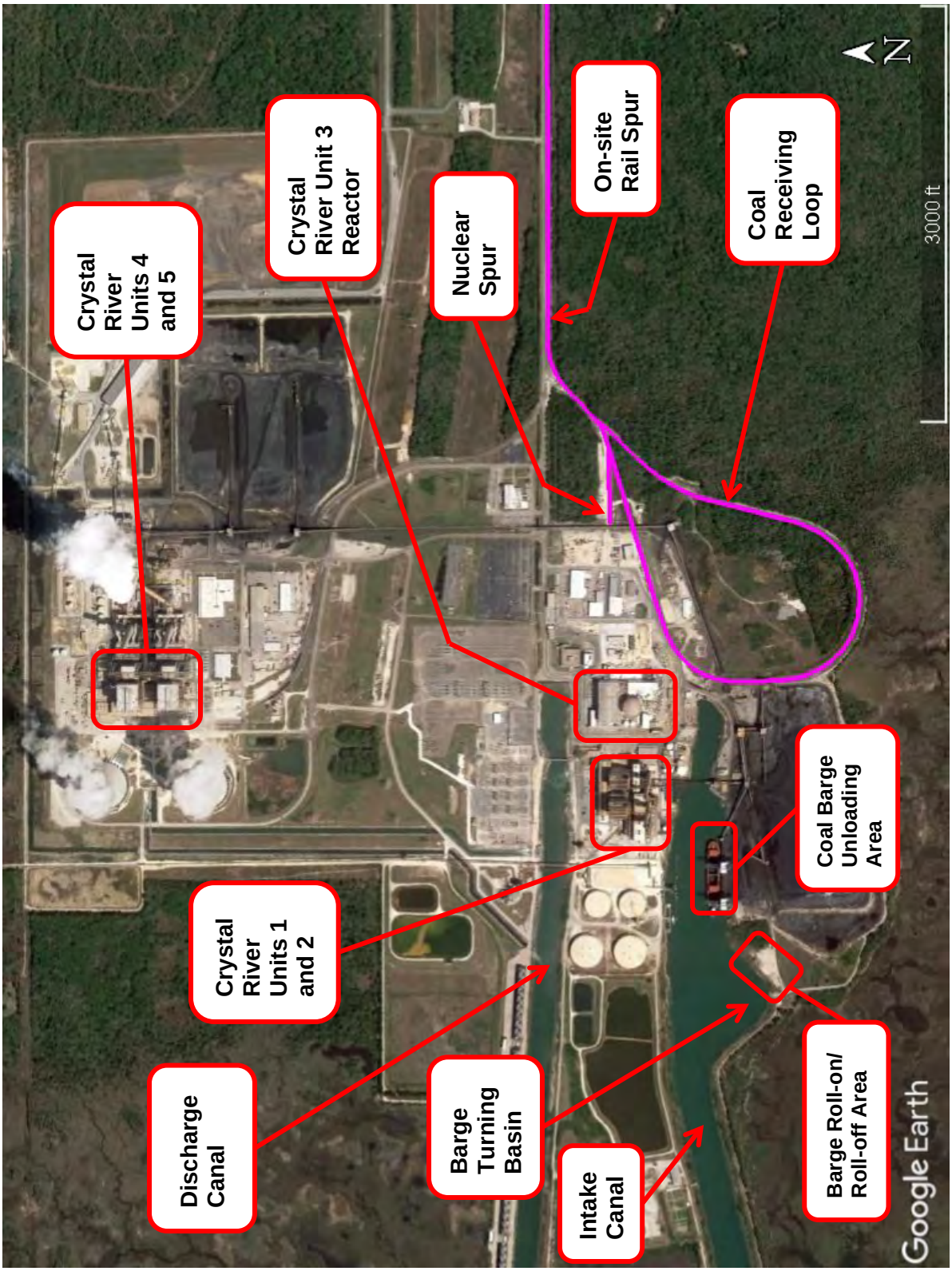


Figure 2-157. Aerial View of the Crystal River Energy Complex (Google 2019)

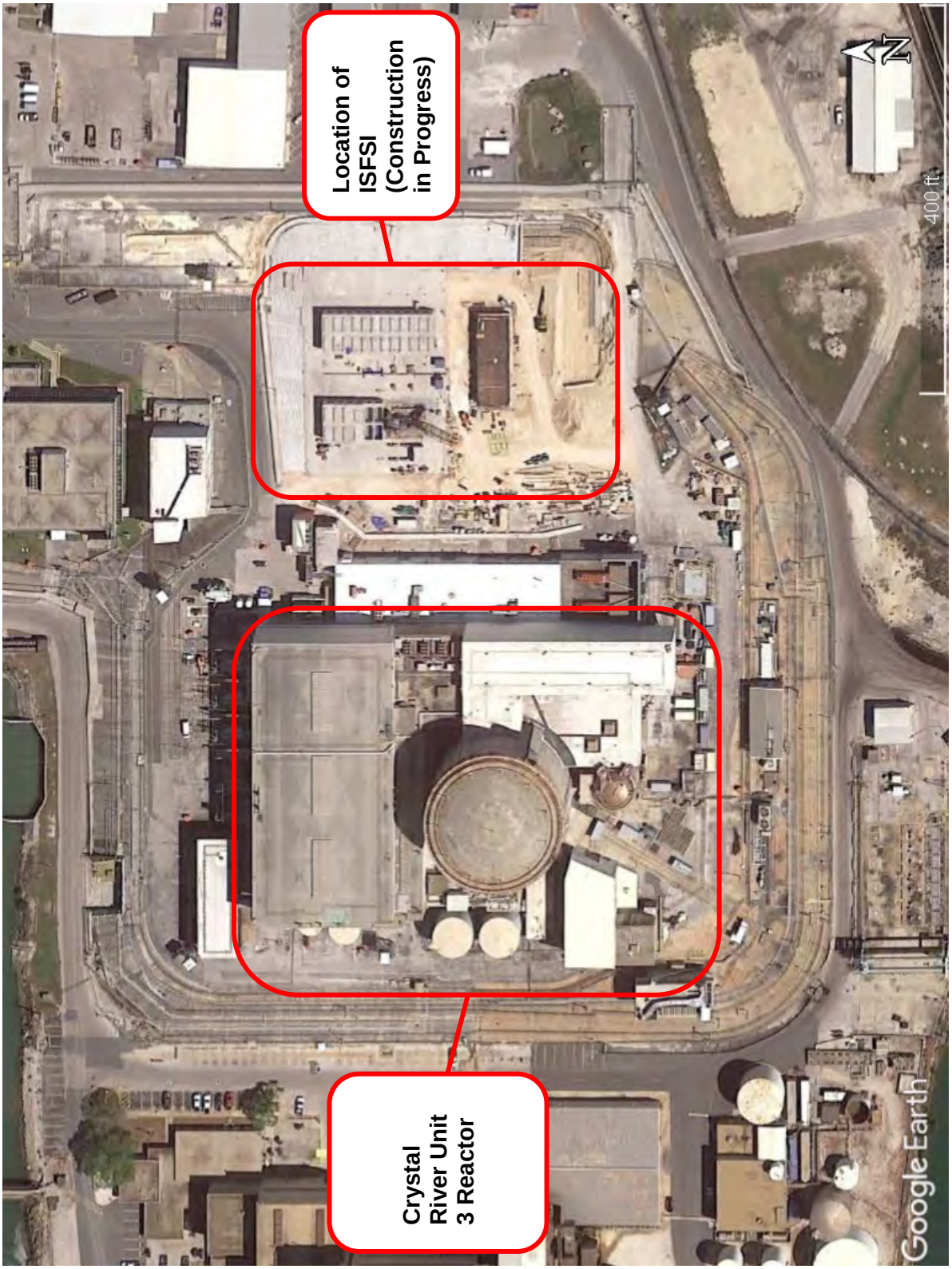


Figure 2-158. Location of Crystal River Independent Spent Fuel Storage Installation (Google 2019)



Figure 2-159. Nuclear Spur (2015)



Figure 2-160. Junction of On-site Industrial Spur (Left) and Nuclear Spur (Right) (2015)



Figure 2-161. On-site Industrial Rail Spur in Front of the Independent Spent Fuel Storage Installation Site (Looking East) (2015)



Figure 2-162. On-site Industrial Rail Spur in Front of the Independent Spent Fuel Storage Installation Site (Looking West) (2015)



Figure 2-163. On-site Industrial Rail Spur at the Coal Loop Junction (2015)



Figure 2-164. On-site Industrial Rail Spur Approaching U.S. Highway 19 from the West (2015)

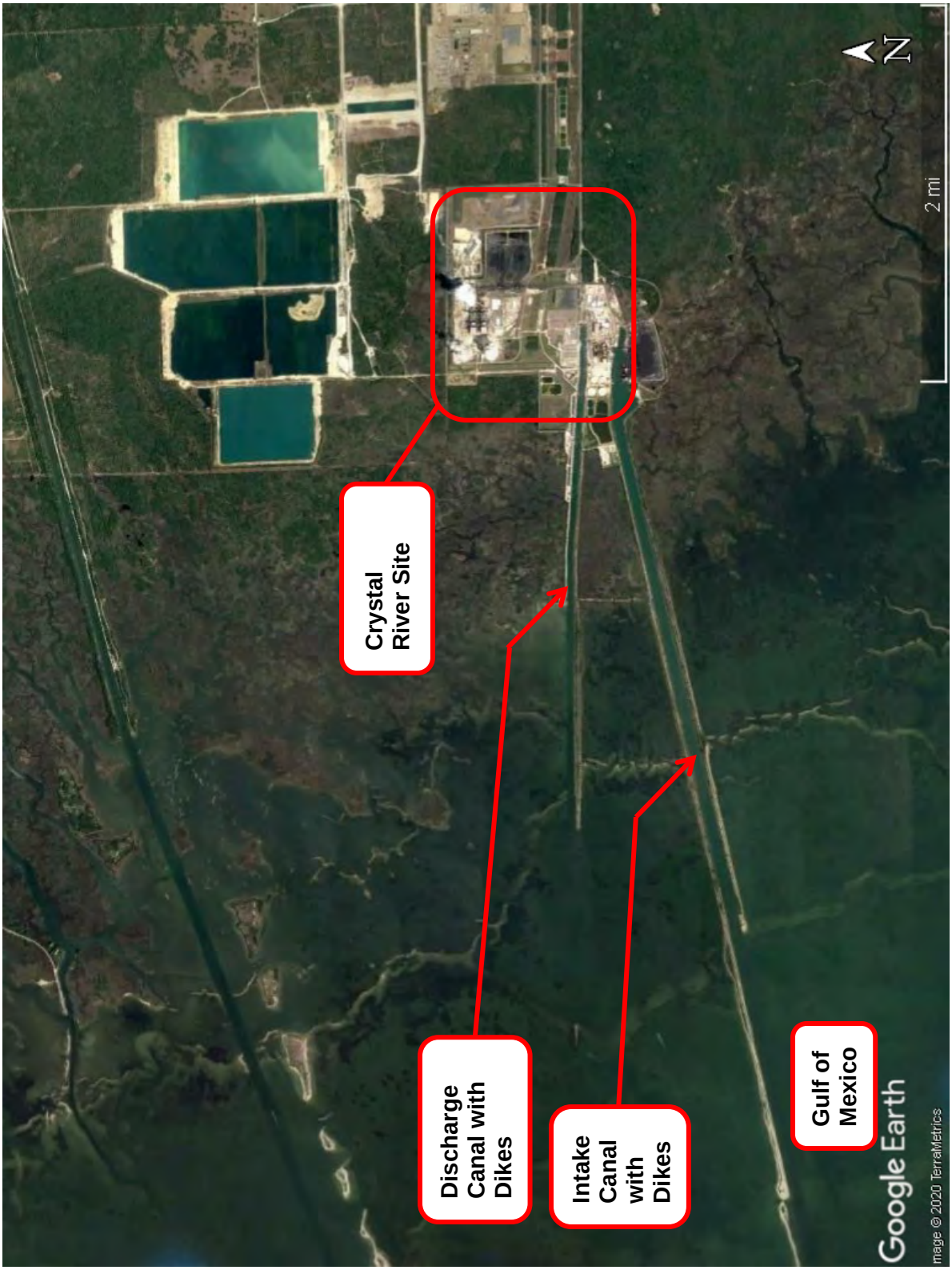


Figure 2-165. Aerial View of the Crystal River Intake and Discharge Canals (Google 2019)



Figure 2-166. Current Barge Area Used for Unloading Coal Barges (2015)



Figure 2-167. 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 2-168). 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 2-169 and Figure 2-170). 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 2-171 through Figure 2-174 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 2-175 through Figure 2-177 show wheel detectors, a hot bearing detector, and a dragging equipment detector on the Florida Northern Railroad at milepost 759.6. Figure 2-178 shows track maintenance equipment staged at the mine spur, just off the industrial spur, and Figure 2-179 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 2-180 and Figure 2-181). The generator rotor weighed 395,000 lb., and had a length of 50 feet and a diameter of 8 feet (see Figure 2-182 and Figure 2-183). 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 off-site by rail (see Figure 2-184 and Figure 2-185).

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 QTTX depressed center cars. 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 2-186 shows two horizontal storage modules loaded on railcars, Figure 2-187 shows a horizontal storage module staged for unloading, Figure 2-188 shows a horizontal storage module being unloaded from a railcar, and Figure 2-189 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 2-190), 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 2-191 through Figure 2-198 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 2-199). The high pressure turbine weighed 150,000 lb., and had a length of 28 feet and a diameter of 7 feet.

2.10.4 Future Information Needs

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 barge or heavy haul truck transport of SNF and GTCC waste would be unlikely from the Crystal River site. However, if the Crystal River site discontinues the use of coal, it is uncertain if the on-site rail spur would be maintained and barge or heavy haul truck transport could be become more likely.

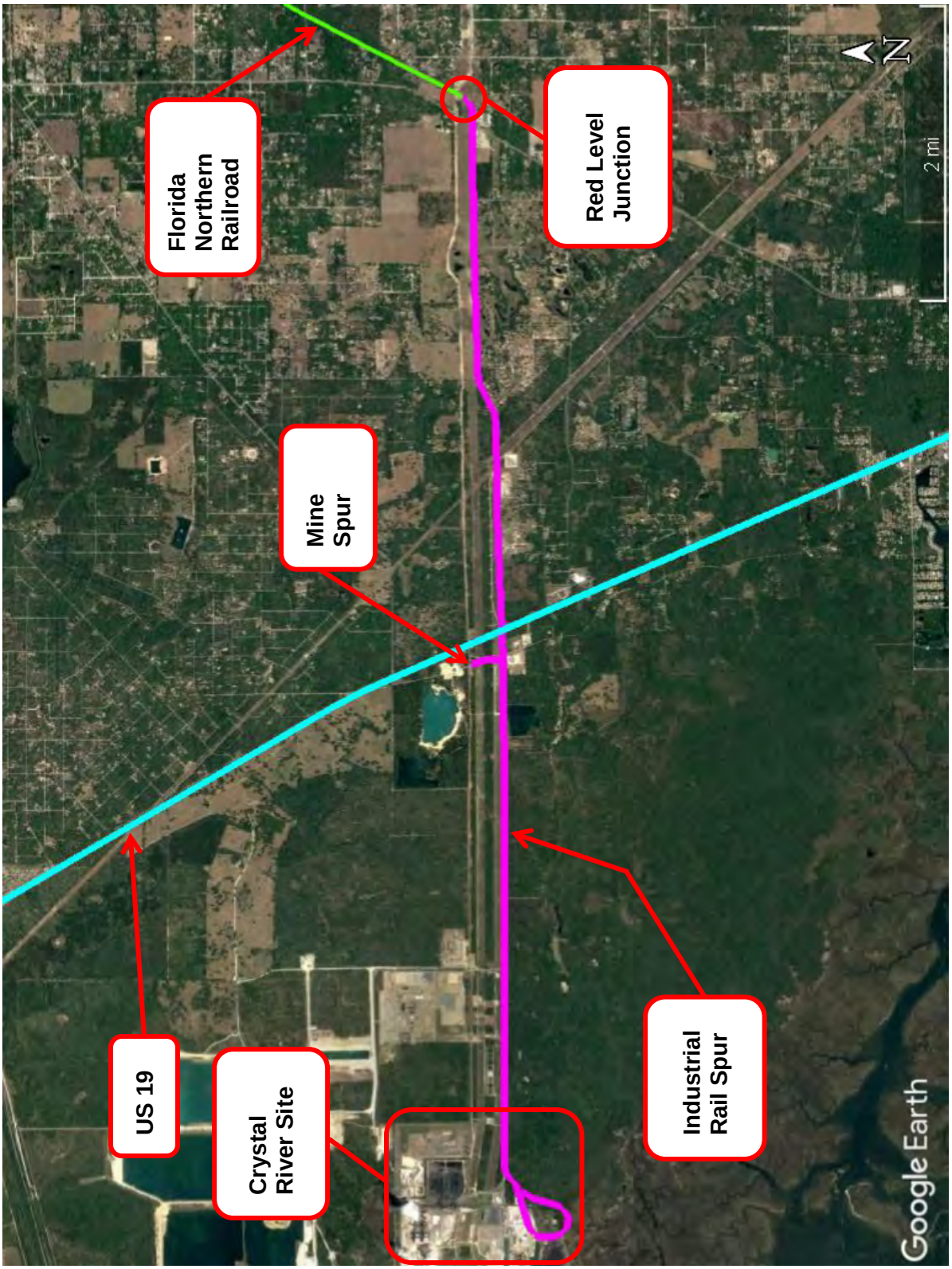


Figure 2-168. Aerial View of the Crystal River Industrial Rail Spur and Florida Northern Railroad (Google 2019)

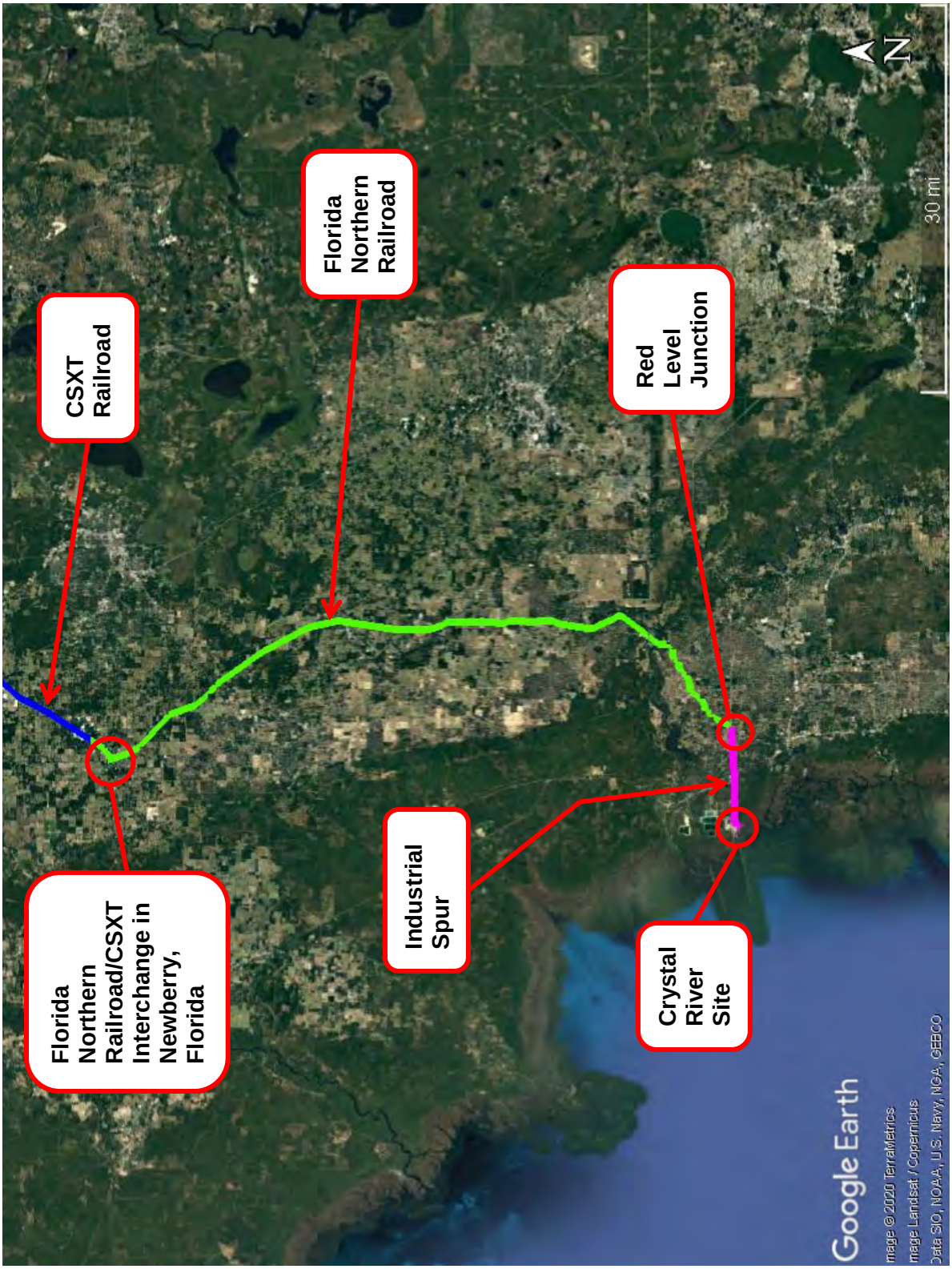


Figure 2-169. Aerial View of the Crystal River Industrial Rail Spur, Florida Northern Railroad, and CSXT Railroad (Google 2019)



Figure 2-170. Newberry Wye (Google 2019)



Figure 2-171. Florida Northern Railroad near Dunnellon, Florida (2015)



Figure 2-172. Highway Bridge over Florida Northern Railroad (2015)



Figure 2-173. Florida Northern Railroad Grade Crossing (2015)



Figure 2-174. Florida Northern Railroad Bridge (2015)



Figure 2-175. Wheel Detectors on Florida Northern Railroad (2015)



Figure 2-176. Hot Bearing Detector on Florida Northern Railroad (2015)



Figure 2-177. Dragging Equipment Detector on Florida Northern Railroad (2015)



Figure 2-178. Track Maintenance Equipment Staged at the Mine Spur (2015)



Figure 2-179. Hi-Rail Vehicle Used for Track Inspections (2015)



Photo courtesy of Crystal River

Figure 2-180. Moisture Separator Reheaters Being Shipped by Rail to the Crystal River Site (2009)



Photo courtesy of Crystal River

Figure 2-181. Moisture Separator Reheaters Being Unloaded at the Crystal River Site (2009)



Photo courtesy of Crystal River

Figure 2-182. Generator Rotor Being Shipped by Rail to the Crystal River Site (2009)



Photo courtesy of Crystal River

Figure 2-183. Generator Rotor Being Unloaded at the Crystal River Site (2009)



Photo courtesy of Crystal River

Figure 2-184. Old Moisture Separator Reheaters Being Shipped Off-site by Rail (2009)



Photo courtesy of Crystal River

Figure 2-185. Locomotive Picking Up Old Moisture Separator Reheaters (2009)



Photo courtesy of Crystal River

Figure 2-186. Two Horizontal Storage Modules Loaded on Railcars (2015)



Photo courtesy of Crystal River

Figure 2-187. Horizontal Storage Module Staged for Unloading (2015)



Photo courtesy of Crystal River

Figure 2-188. Horizontal Storage Module Being Unloaded from Railcar (2015)



Photo courtesy of Crystal River

Figure 2-189. Horizontal Storage Modules at Nuclear Spur after Unloading (2015)

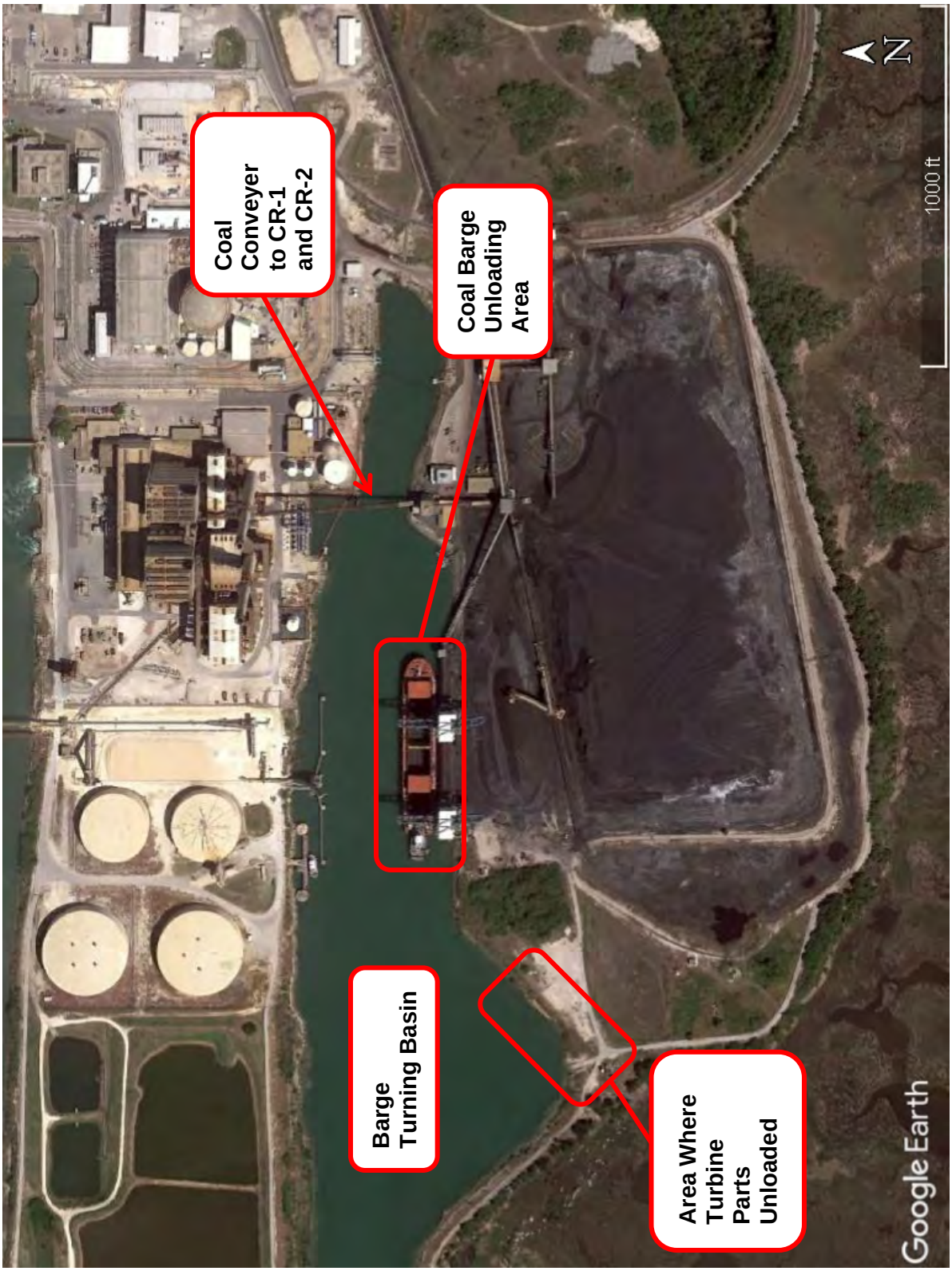


Figure 2-190. Crystal River Site Barge Area (Google 2019)



Photo courtesy of Crystal River

Figure 2-191. Crystal River Turbine Components on Barge (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-192. Barge with Turbine Components Approaching Ramp (2012)



Photo courtesy of Crystal River

Figure 2-193. Barge with Turbine Components Just Before Grounding at Ramp (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-194. Barge with Turbine Components Grounded at Ramp (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-195. Turbine Components Being Unloaded Using Self-Propelled Modular Transporter (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-196. Turbine Components Driving Off of Unloading Ramp (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-197. Turbine Components Fully Unloaded from Barge (2012)



Photo courtesy of Argonautics Marine Engineering, Inc.

Figure 2-198. Self-Propelled Modular Transporter Turning with Turbine Components (2012)



Photo courtesy of Crystal River

Figure 2-199. High Pressure Turbine Rotor Delivered to Crystal River Site by Heavy Haul Truck (2011)

2.11 Kewaunee

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF from the reactor vessel was completed on May 14, 2013 (Stoddard 2013a, 2013b). Removal of SNF from the Kewaunee spent fuel pool was completed on June 15, 2017. A total of 1335 SNF assemblies (518.7 MTHM) are stored at Kewaunee (Sartain 2014a). The fuel rods in the fuel assemblies are zirconium alloy-clad.

Kewaunee uses the Standardized NUHOMS System (Docket No. 72-1004) and the MAGNASTOR System (Docket No. 72-1031) for dry storage of SNF. The Standardized NUHOMS System consists of transportable dry shielded canisters, reinforced concrete horizontal storage modules, and a transfer cask. There are 448 pressurized water reactor SNF assemblies

(170.3 MTHM) stored in 14 32PT dry shielded canisters at the Kewaunee ISFSI (Docket No. 72-64) in Standardized NUHOMS Systems. The 32PT dry shielded canister holds 32 pressurized water reactor SNF assemblies.

There are a total of 16 horizontal storage modules at the Kewaunee ISFSI. The two horizontal storage modules that are not being used for storing SNF are currently empty. These horizontal storage modules will be used for storing GTCC waste.

The MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 32PT canister and also canisters containing GTCC waste. An MP197HB transportation cask has been fabricated and is in use in the U.S.

The MAGNASTOR System consists of transportable storage canisters, vertical concrete storage casks, and a transfer cask. There are 887 pressurized water reactor SNF assemblies (348.4 MTHM) stored in 24 TSC-37 transportable storage canisters. The TSC-37 transportable storage canister holds 37 pressurized water reactor SNF assemblies. The transportation cask certified to transport the TSC-37 canister is the MAGNATRAN (Docket No. 71-9356).

Three damaged fuel assemblies (A15, C02, and N11) have been identified at the Kewaunee site. These assemblies were placed in damaged fuel cans (Ridder 2016). In addition, 241 assemblies were identified as susceptible to bulge joint corrosion of the top nozzle sleeves and were repaired to allow inspection and movement into dry storage (Ridder 2016).

At the Kewaunee site, a total of 38 canisters containing SNF and an estimated 2 canisters containing GTCC waste will be stored. Sartain (2014b) states that GTCC waste would not be packaged until 2070.

Figure 2-200 illustrates the number of SNF 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 2-201 illustrates the number of SNF 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 SNF assemblies at Kewaunee that have burnups greater than 45 GWd/MTHM. These 264 fuel assemblies are classified by the NRC as high burnup SNF.

As mentioned previously, Kewaunee has 448 SNF assemblies stored in 14 32PT dry storage canisters. Figure 2-202 and Figure 2-203 illustrate the number of these fuel assemblies based on their discharge year and burnup. The oldest fuel was discharged in 1982 and the last fuel was discharged in 2004. The median discharge year of the 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 fuel assemblies at Kewaunee stored in 32PT canisters that have burnups greater than 45 GWd/MTHM.

Figure 2-204 and Figure 2-205 illustrate the number of fuel assemblies based on their discharge year and burnup for the 887 fuel assemblies that are stored in TSC-37 dry storage canisters. The oldest fuel was discharged in 1976 and the last fuel was discharged in 2013. The median

discharge year of the 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 fuel assemblies at Kewaunee that are stored in TSC-37 canisters that have burnups greater than 45 GWd/MTHM. These assemblies were not placed in damaged fuel cans (Ridder 2016).

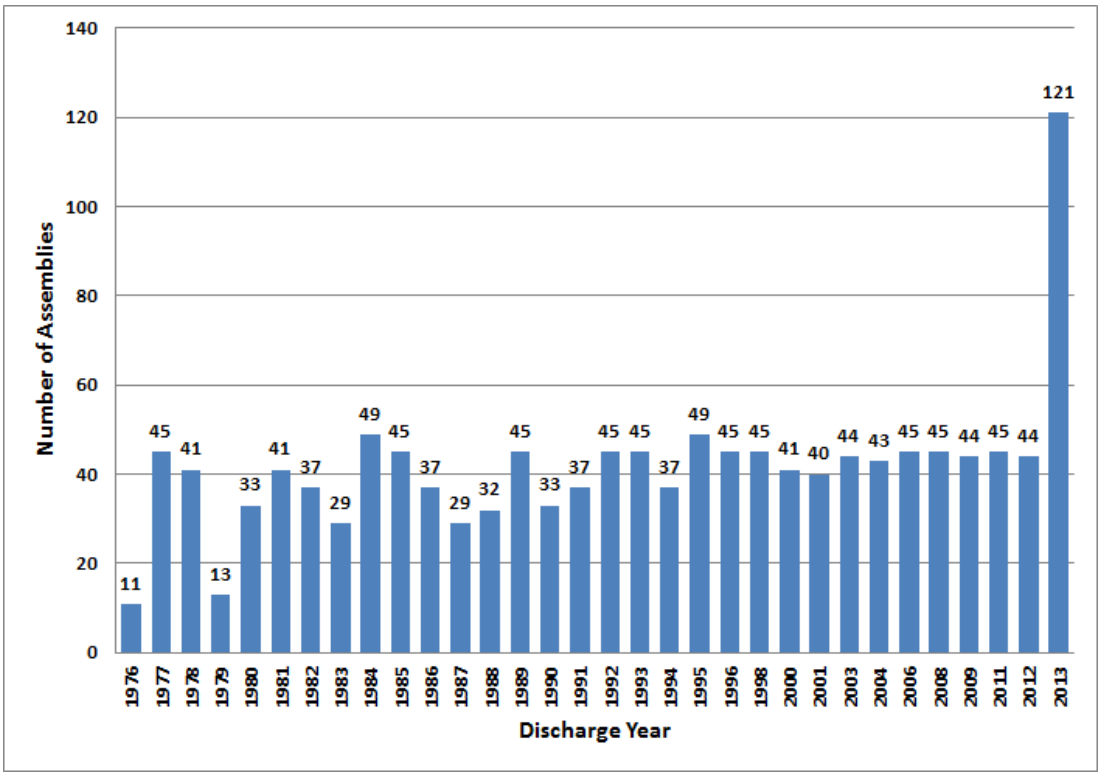


Figure 2-200. Kewaunee Number of Assemblies versus Discharge Year (EIA 2013)

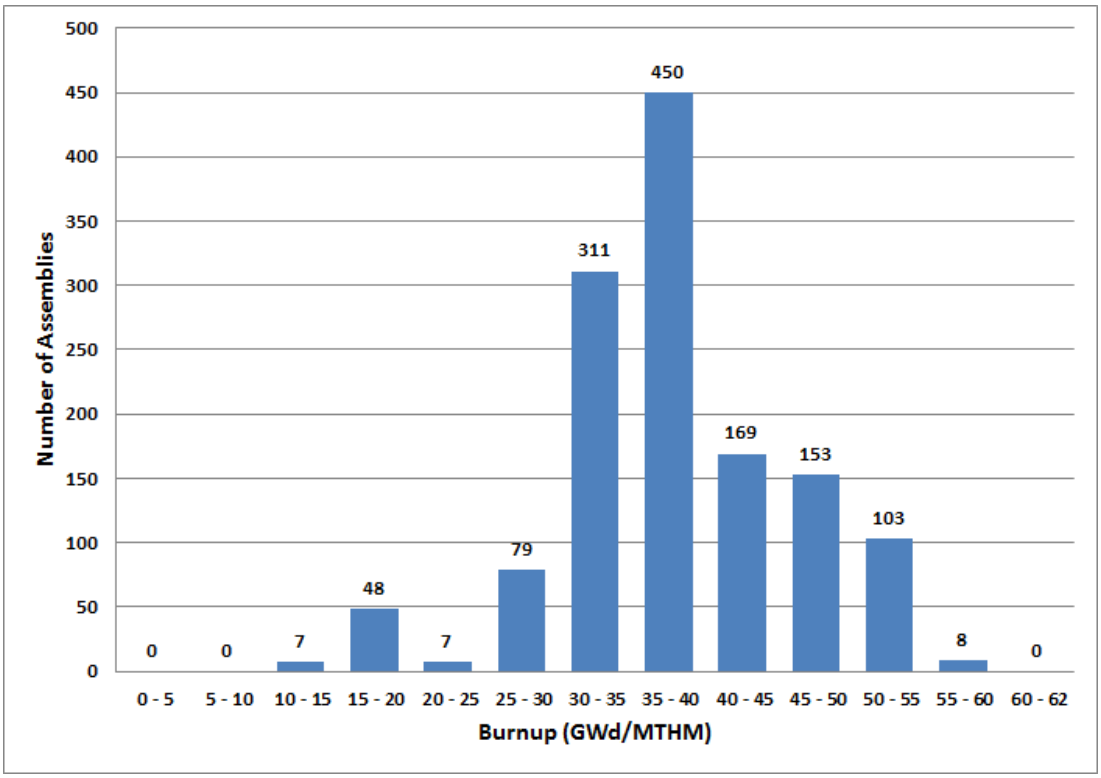


Figure 2-201. Kewaunee Number of Assemblies versus Burnup (EIA 2013)

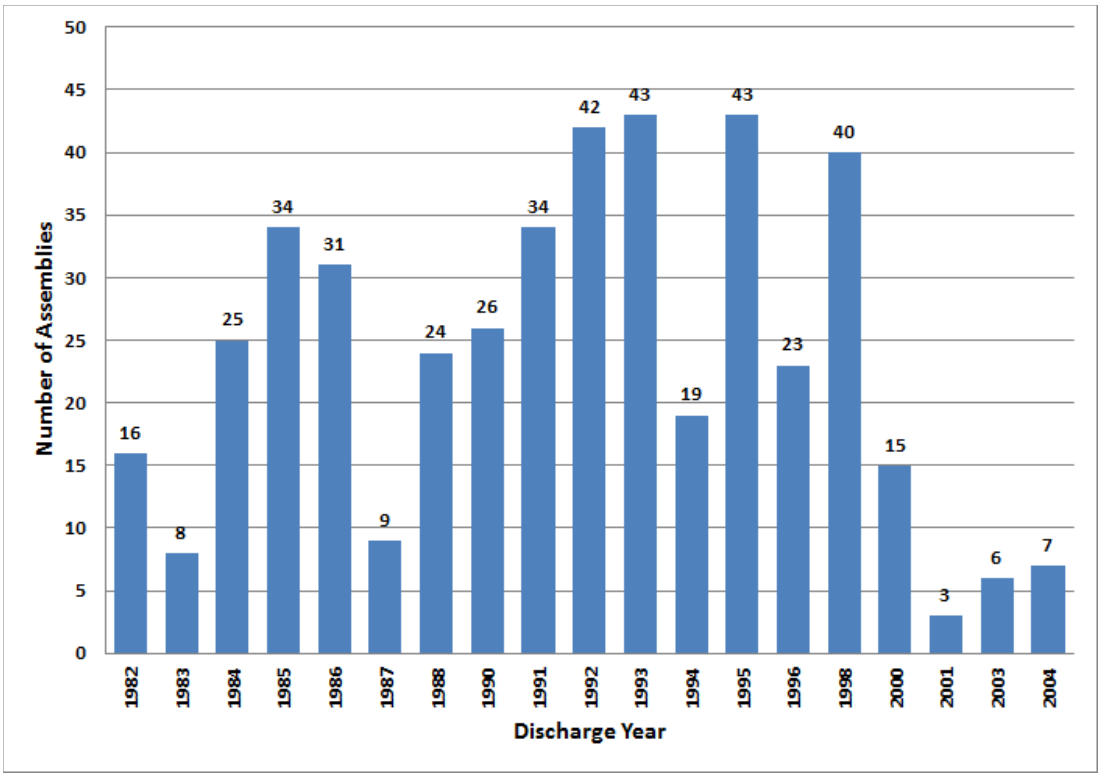


Figure 2-202. Kewaunee Number of Assemblies Stored in 32PT Canisters versus Discharge Year (EIA 2013)

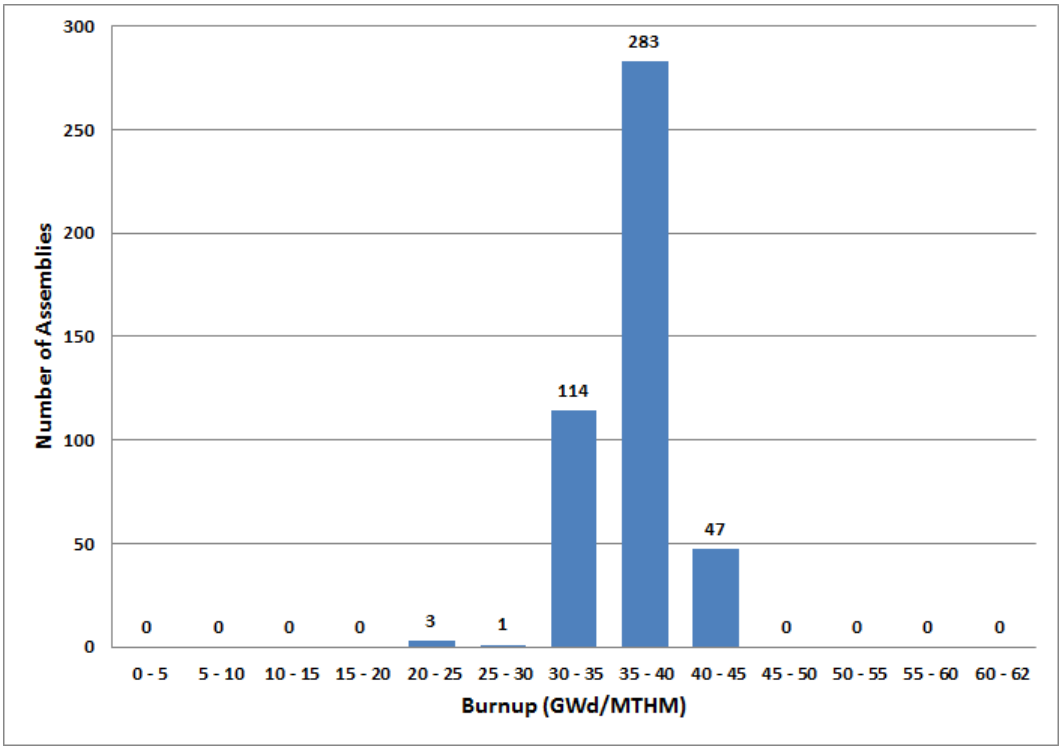


Figure 2-203. Kewaunee Number of Assemblies Stored in 32PT Canisters versus Burnup (EIA 2013)

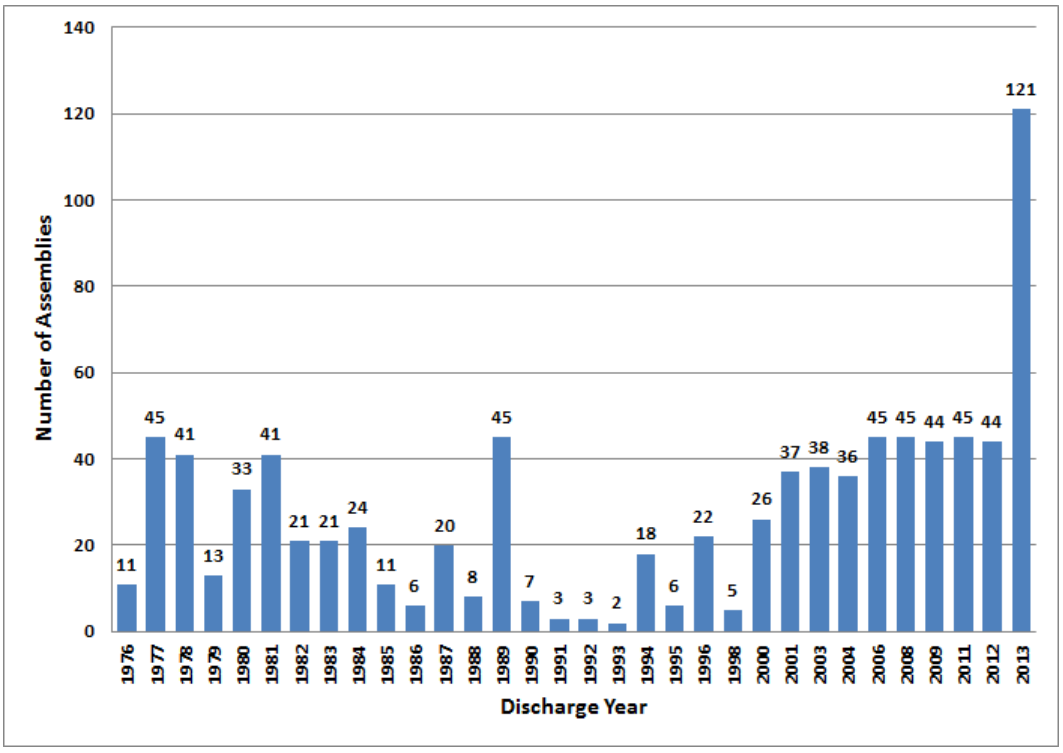


Figure 2-204. Kewaunee Number of Assemblies Stored in TSC-37 Canisters versus Discharge Year (EIA 2013)

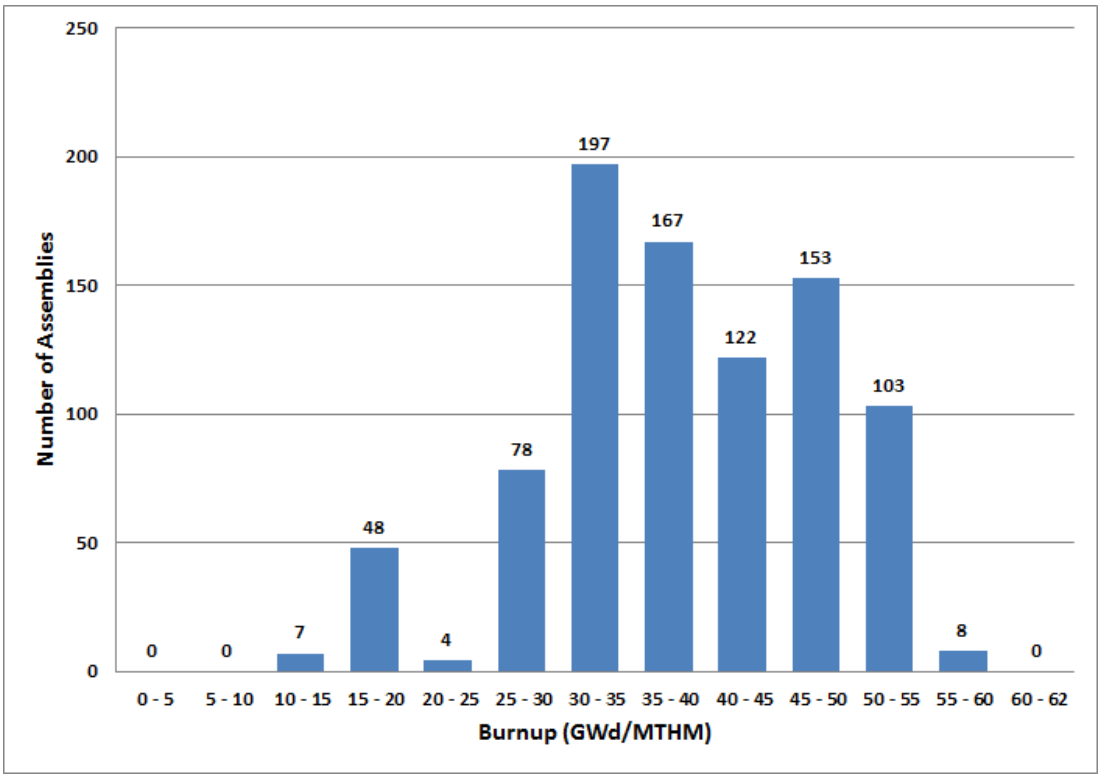


Figure 2-205. Kewaunee Number of Assemblies Stored in TSC-37 Canisters versus Burnup (EIA 2013)

2.11.2 Site Conditions

The Kewaunee site is located on the western shore of Lake Michigan and the Kewaunee ISFSI (see Figure 2-206) is located at the northern end of the site (see Figure 2-207). 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 2-206. Kewaunee Independent Spent Fuel Storage Installation

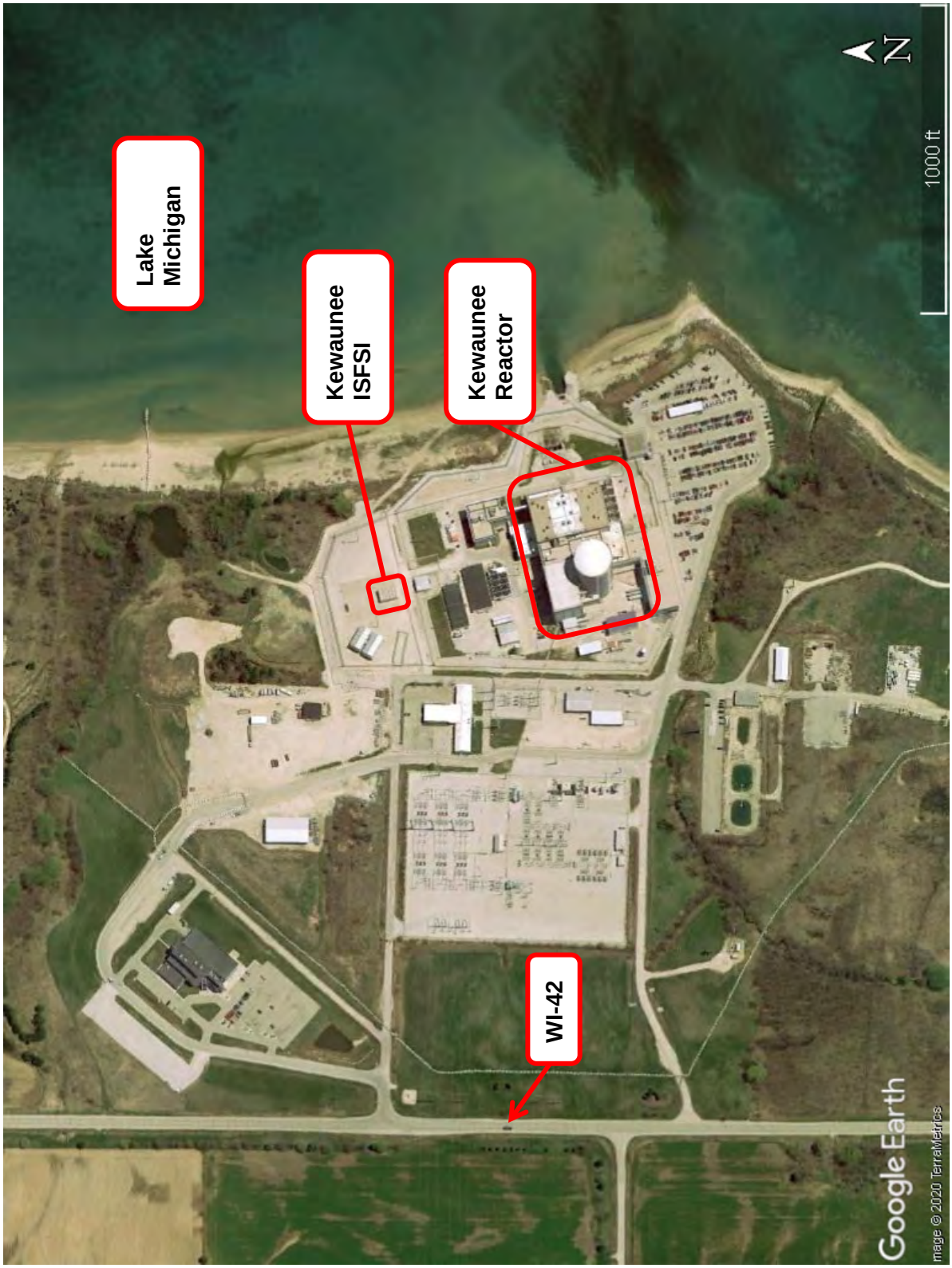


Figure 2-207. Aerial View of Kewaunee Site (Google 2019)

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 SNF 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 2-208). Figure 2-208 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 North
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 WI-42 West
Manitowoc (waterfront area)	21.3	WI-42 South

Figure 2-209 shows an aerial view of a potential transload location at Luxemburg, Wisconsin, and Figure 2-210 shows a potential heavy haul truck route from the Kewaunee site to the Luxemburg transload location. Figure 2-211 through Figure 2-213 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 2-214 shows the gantry system used to transfer the transformers from the railcars to Goldhofer trailer and Figure 2-215 shows a transformer on a heavy haul truck being moved from Luxemburg to the Kewaunee site.

Figure 2-216 shows an aerial view of a potential transload location at Bellevue, Wisconsin, and Figure 2-217 shows a potential heavy haul truck route from the Kewaunee site to the Bellevue transload location. Figure 2-218 through Figure 2-221 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 2-222 shows horizontal storage modules on railcars and Figure 2-223 shows a horizontal storage module on a heavy haul truck being moved from Bellevue to the Kewaunee site.

Figure 2-224 shows an aerial view of a potential transload location at Denmark, Wisconsin, and Figure 2-225 shows a potential heavy haul truck route from the Kewaunee site to the potential Denmark transload location. Figure 2-226 through Figure 2-229 show the current condition of the potential Denmark transload location.

Figure 2-230 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 2-231 shows potential heavy haul truck routes from the Kewaunee site to the potential Rockwood Spur and WI-310 transload location. Figure 2-232 through Figure 2-235 show the current condition of the potential Rockwood Spur and WI-310 transload location. Figure 2-236 shows a traffic circle on WI-310 that a transportation cask would have to pass through to approach the potential transload location from the east.

Figure 2-237 shows an aerial view of a potential transload location on the Rockwood Spur near the Manitowoc, Wisconsin airport, and Figure 2-238 shows a potential heavy haul truck route from the Kewaunee site to the Rockwood Spur near the Manitowoc, Wisconsin airport. Figure 2-239 through Figure 2-241 show the current condition of this potential transload location.

Figure 2-242 shows an aerial view of a potential transload location in Manitowoc, Wisconsin, and Figure 2-243 shows potential heavy haul truck routes from the Kewaunee site to the potential Manitowoc transload location. Figure 2-244 through Figure 2-246 show the current condition of the potential Manitowoc transload location.

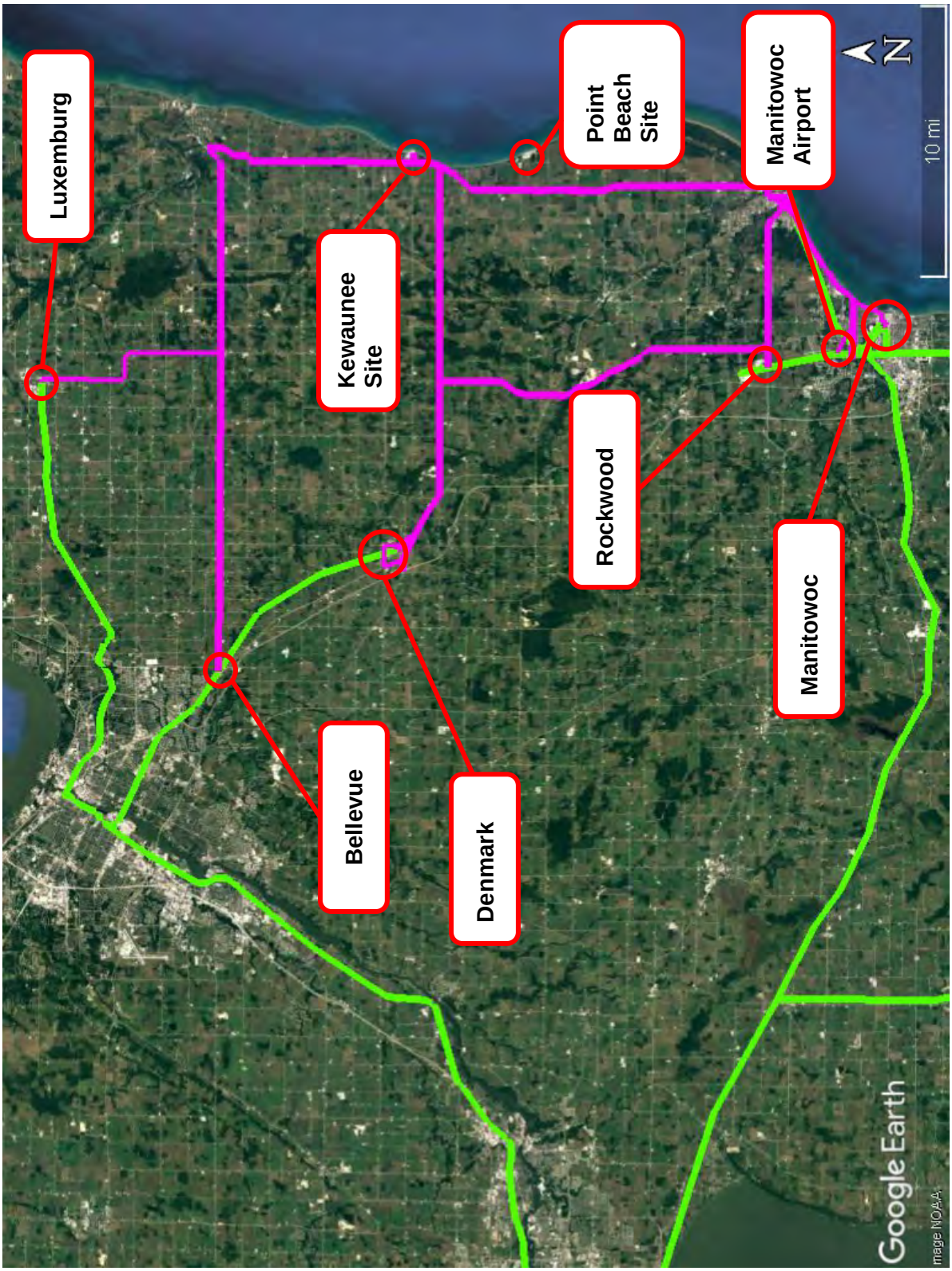


Figure 2-208. Potential Rail Transload Locations and Heavy Haul Truck Routes for the Kewaunee Site (Google 2019)



Figure 2-209. Potential Luxemburg Transload Location (Google 2019)

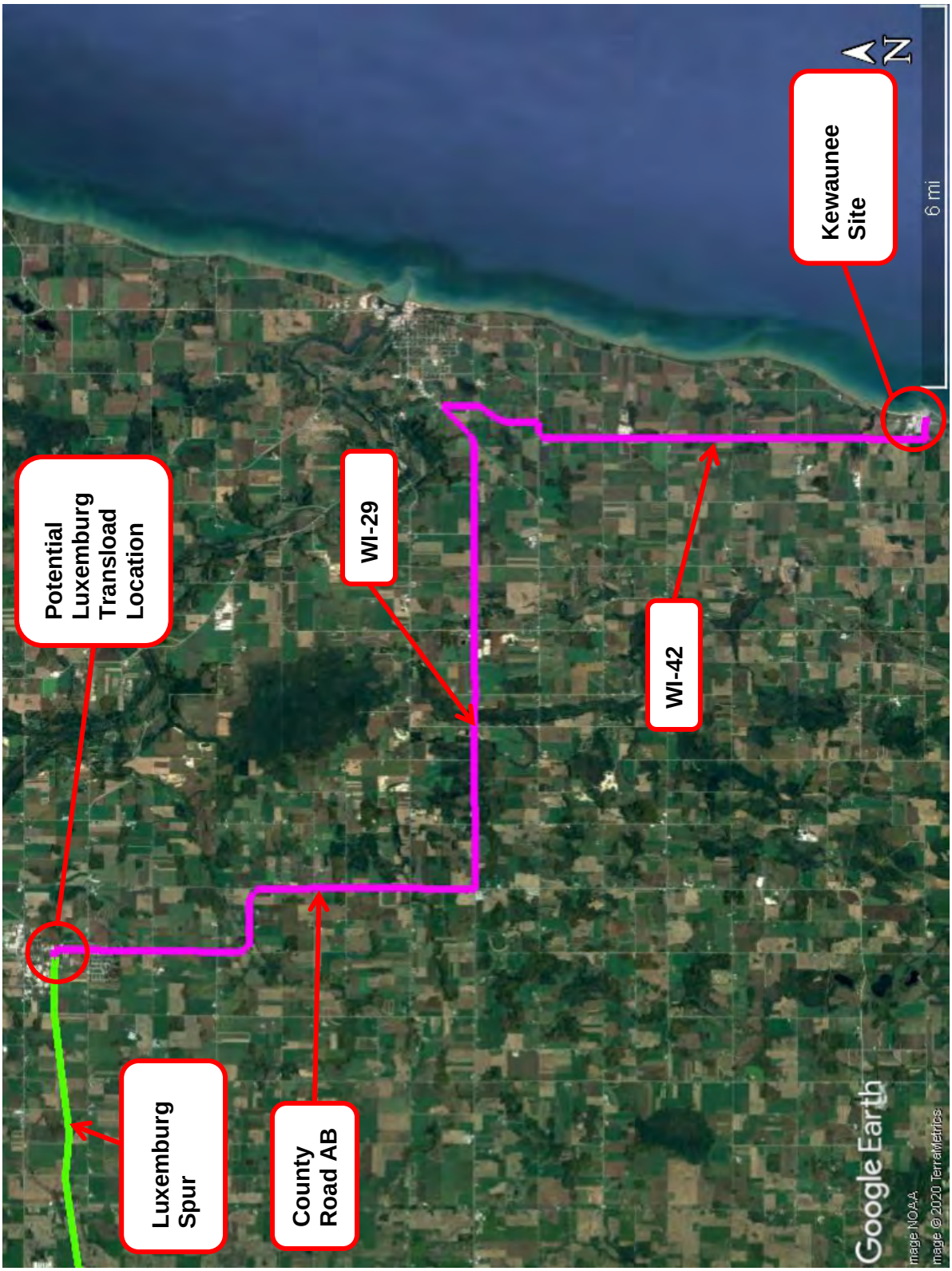


Figure 2-210. Potential Luxemburg Heavy Haul Route (Google 2019)



Figure 2-211. Potential Luxemburg Transload Location (Looking West) (2014)



Figure 2-212. Potential Luxemburg Transload Location Further Down Track (Looking West) (2014)



Figure 2-213. Potential Luxemburg Transload Location (Looking East) (2014)



Photo courtesy of Kewaunee

Figure 2-214. Gantry System Used to Transfer Transformers from Railcars to Goldhofer Trailers (2008)



Photo courtesy of Kewaunee

Figure 2-215. Transformer on 15-axle Goldhofer Trailer (2008)

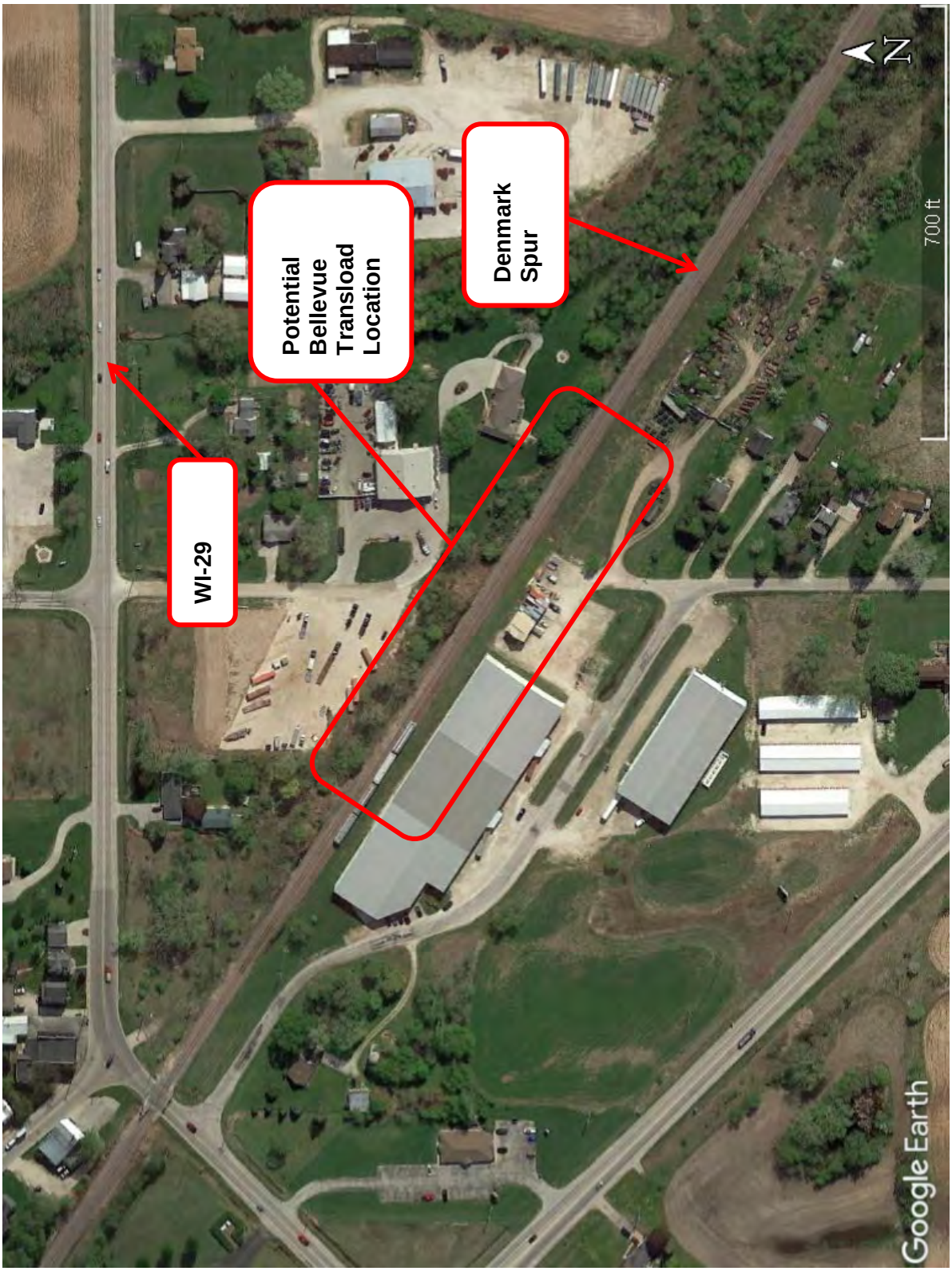


Figure 2-216. Potential Bellevue Transload Location (Google 2019)

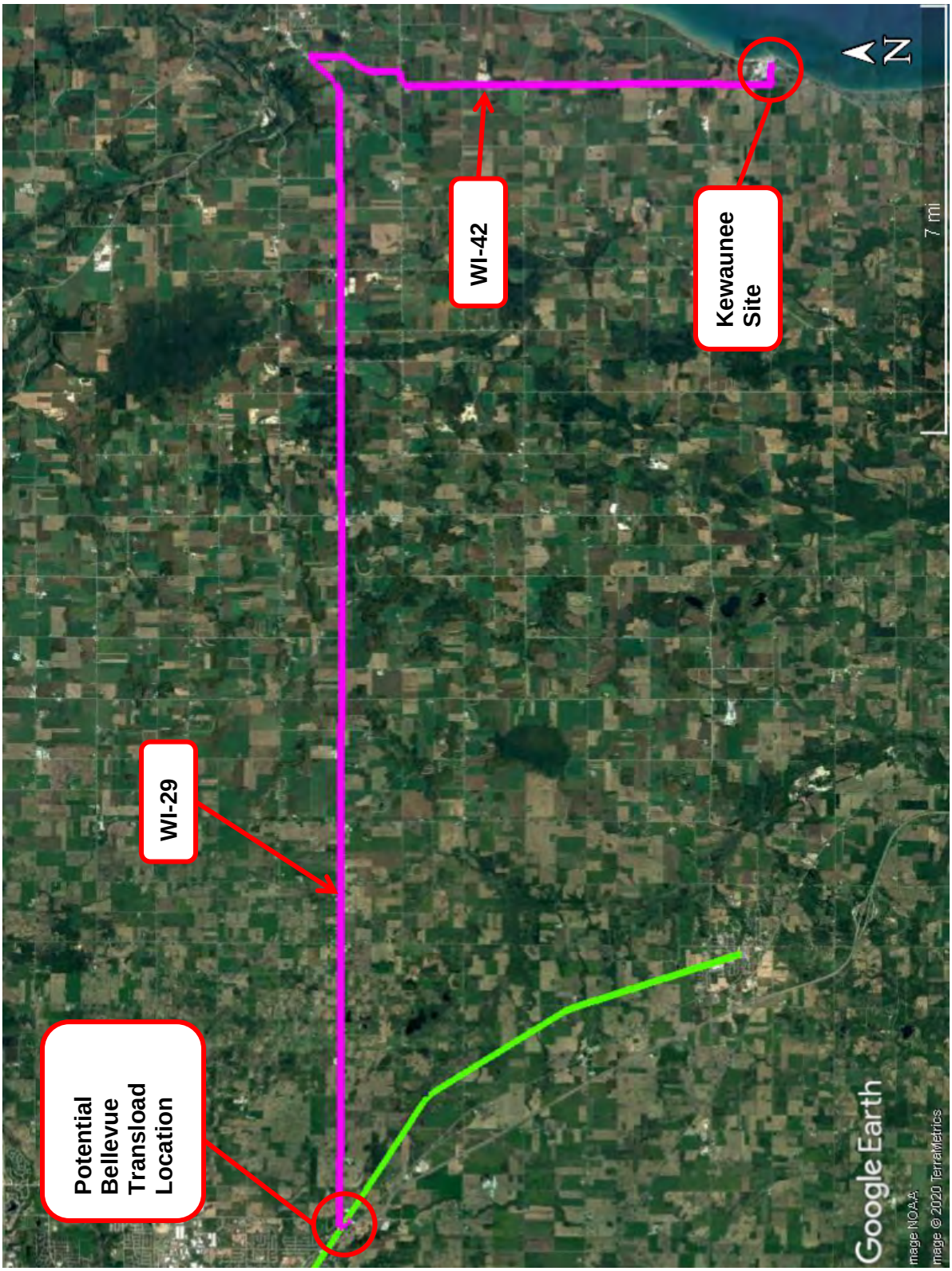


Figure 2-217. Potential Bellevue Heavy Haul Route (Google 2019)



Figure 2-218. Potential Bellevue Transload Location (Looking North) (2014)



Figure 2-219. Potential Bellevue Transload Location (Looking South) (2014)



Figure 2-220. Potential Bellevue Transload Location at WI-29 (2014)



Figure 2-221. Approaching Potential Bellevue Transload Location on WI-29 (Looking West) (2014)



Photo courtesy of Kewaunee

Figure 2-222. Horizontal Storage Module Transloading at Bellevue Location (2008)



Photo courtesy of Kewaunee

Figure 2-223. Horizontal Storage Module on 6-axle Goldhofer Trailer (2008)

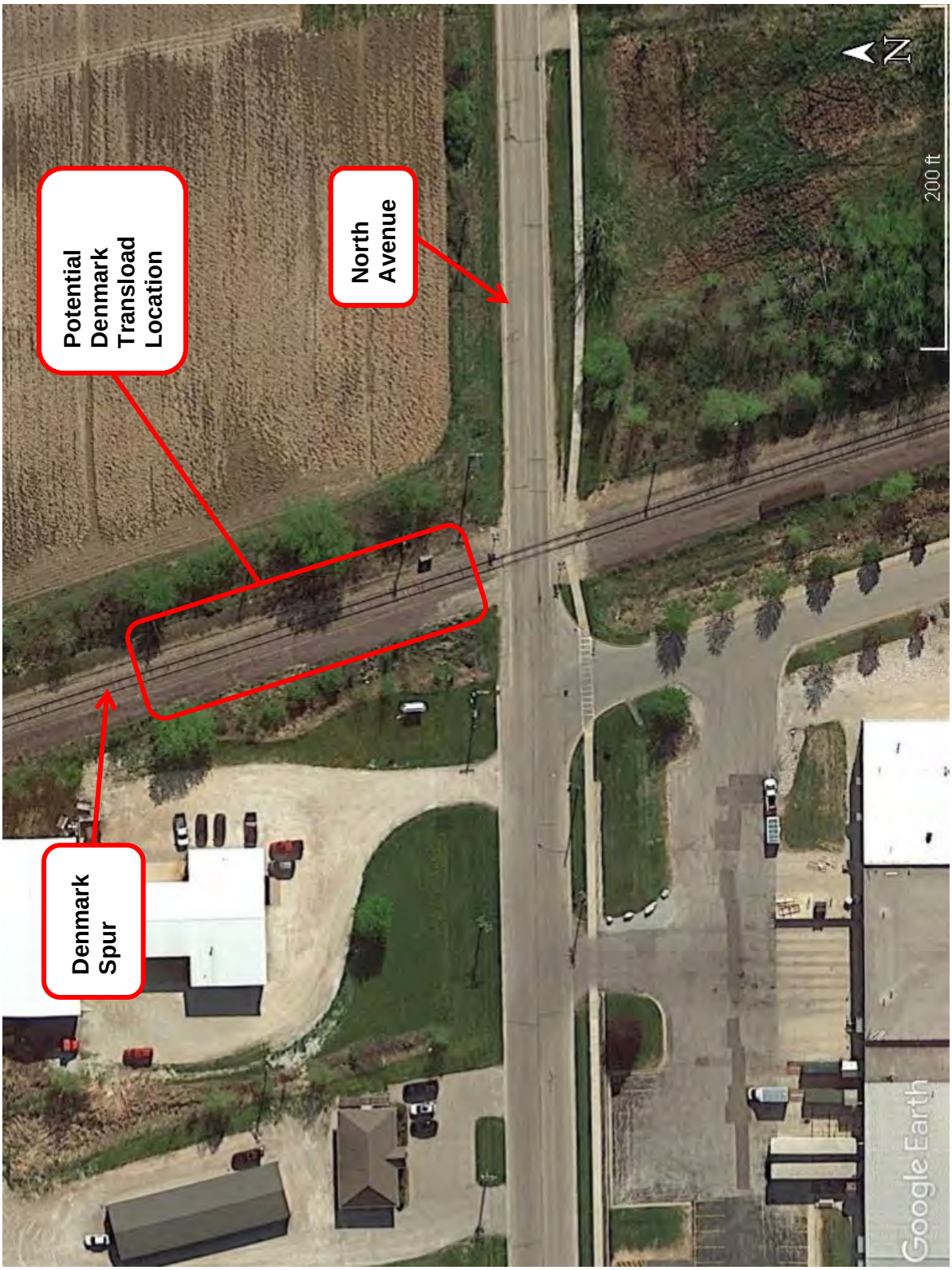


Figure 2-224. Potential Denmark Transload Location (Google 2019)

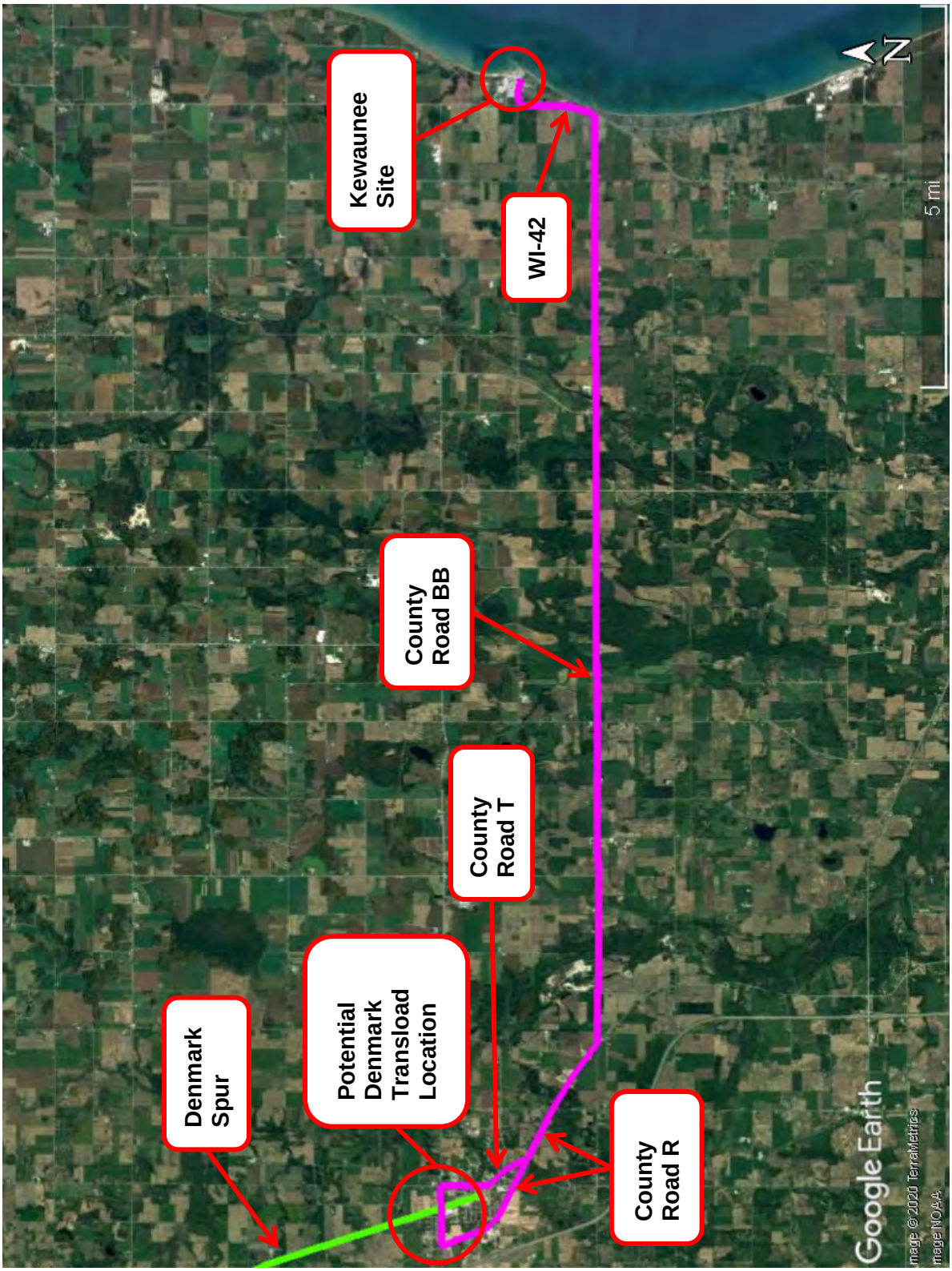


Figure 2-225. Potential Denmark Heavy Haul Route (Google 2019)



Figure 2-226. Potential Denmark Transload Location (Looking South) (2014)



Figure 2-227. Potential Denmark Transload Location (Looking North) (2014)



Figure 2-228. Potential Denmark Transload Location (Looking West) (2014)



Figure 2-229. Potential Denmark Transload Location (Looking East) (2014)



Figure 2-230. Potential Rockwood Spur at WI-310 Transload Location (Google 2019)

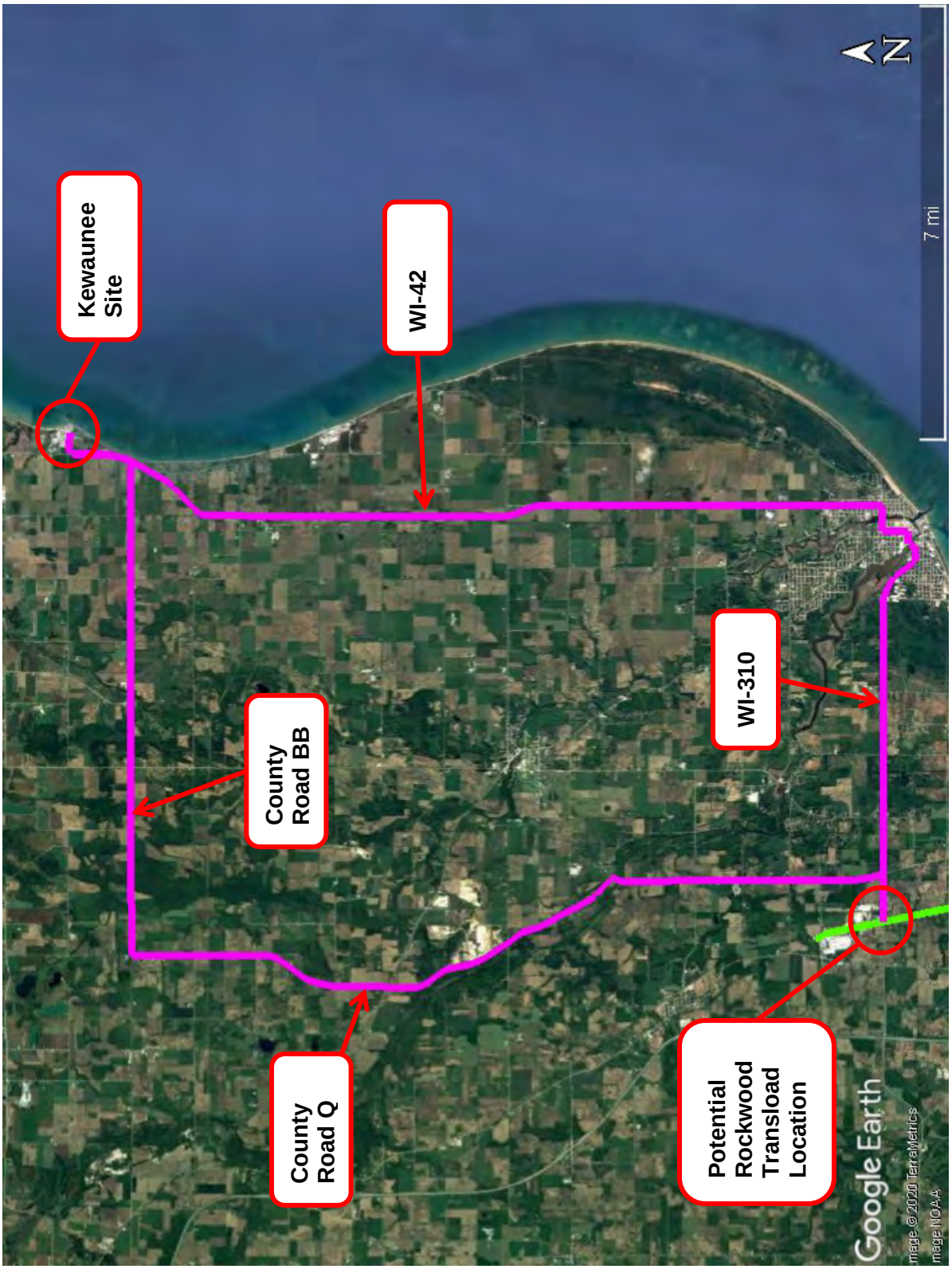


Figure 2-231. Potential Rockwood Spur at WI-310 Heavy Haul Routes (Google 2019)



Figure 2-232. Potential Rockwood Spur at WI-310 Transload Location (Looking North) (2014)



Figure 2-233. Potential Rockwood Spur at WI-310 Transload Location (Looking South) (2014)



Figure 2-234. Approaching Rockwood Spur at WI-310 from the East (2014)



Figure 2-235. Turning into Parking Lot at Rockwood Spur at WI-310 (2014)



Figure 2-236. Traffic Circle on WI-310 (Looking East) (2014)

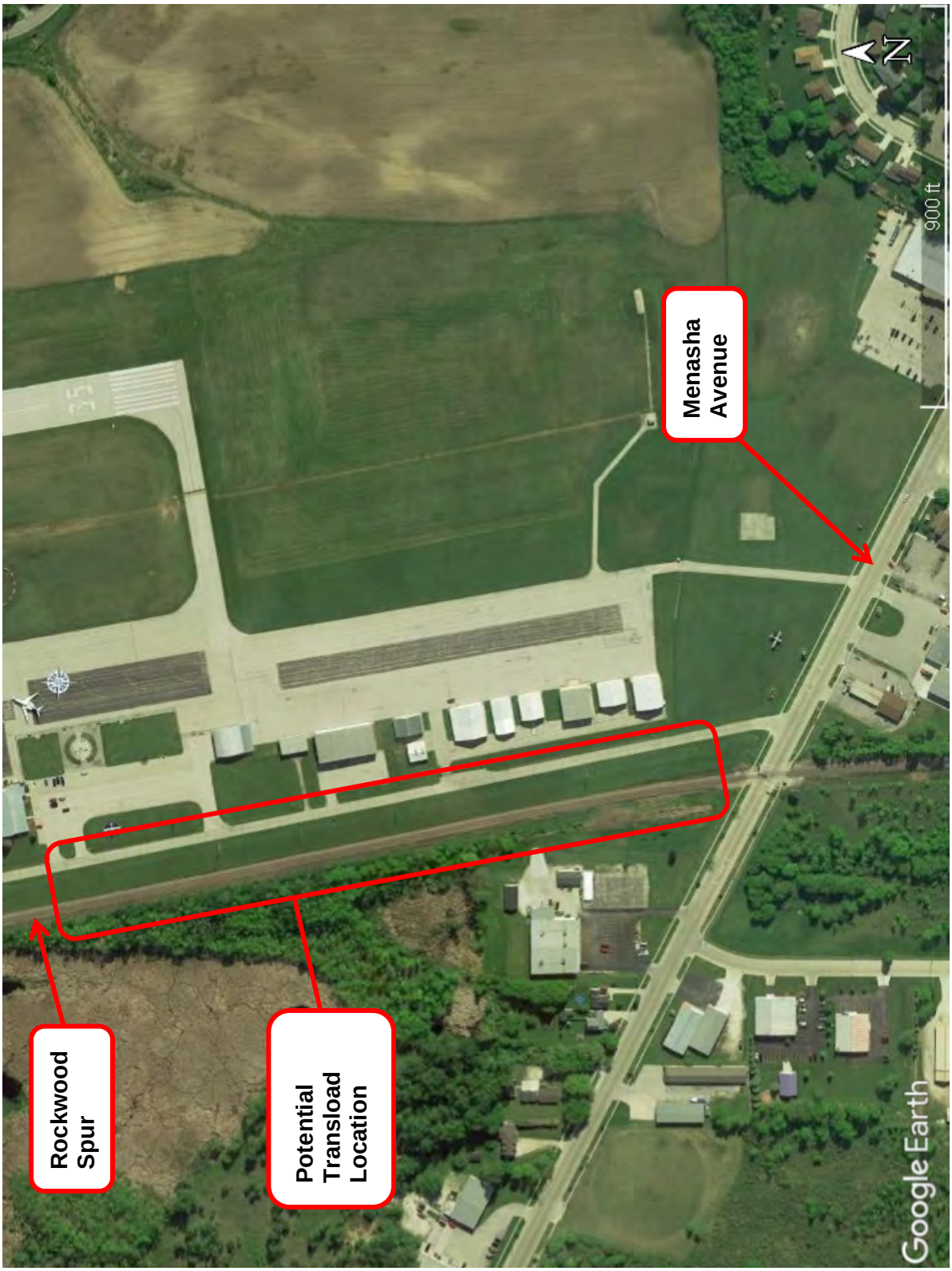


Figure 2-237. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Google 2019)



Figure 2-238. Potential Rockwood Spur at the Manitowoc Airport Heavy Haul Route (Google 2019)



Figure 2-239. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) (2014)



Figure 2-240. Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking South) (2014)



Figure 2-241. Access Road at Potential Rockwood Spur at the Manitowoc Airport Transload Location (Looking North) (2014)

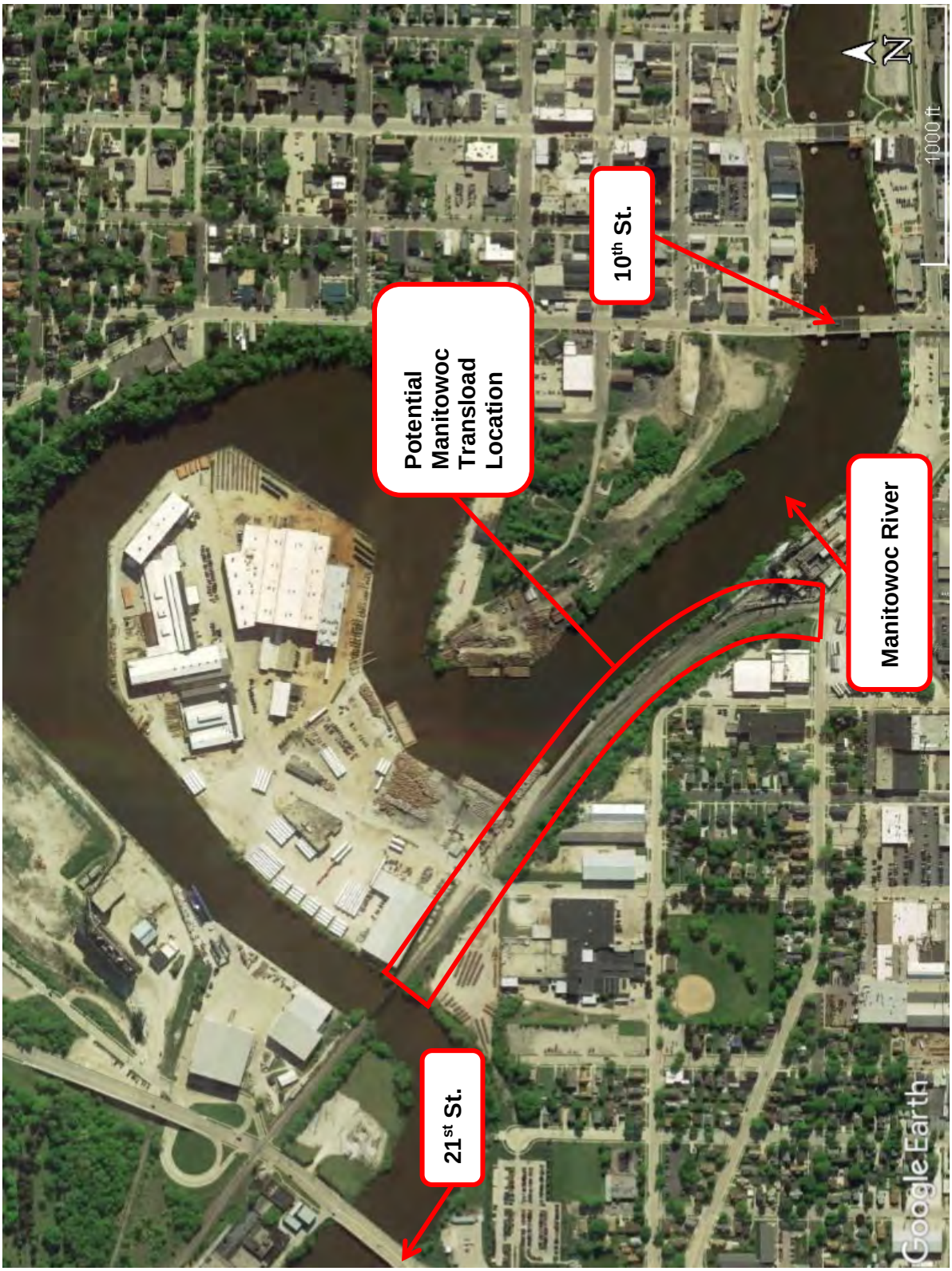


Figure 2-242. Potential Manitowoc Transload Location (Google 2019)



Figure 2-243. Potential Manitowoc Heavy Haul Routes (Google 2019)



Figure 2-244. Potential Manitowoc Transload Location (Looking Northwest) (2014)



Figure 2-245. Potential Manitowoc Transload Location (Looking Southeast) (2014)



Figure 2-246. 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 2-247 shows an aerial view of a potential barge transload location in the city of Kewaunee. Figure 2-248 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 2-249 and Figure 2-250 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 2-251 shows horizontal storage modules being unloaded from a barge and Figure 2-252 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 (Posivak 2016). The steam generators were transported from the Point Beach site using Goldhofer trailers (see Figure 2-253) and transloaded onto a barge at the Kewaunee barge transload location (see Figure 2-254 through Figure 2-257). 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 2-258) and transported through Texas to the Waste Control Specialists low-level radioactive waste disposal facility in Andrews, Texas (see Figure 2-259).

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 2-260), and the old Kewaunee site reactor pressure vessel head was shipped to Clive, Utah for disposal using a heavy haul truck (see Figure 2-261).



Figure 2-247. Aerial View of Potential Kewaunee Barge Transload Location (Google 2019)

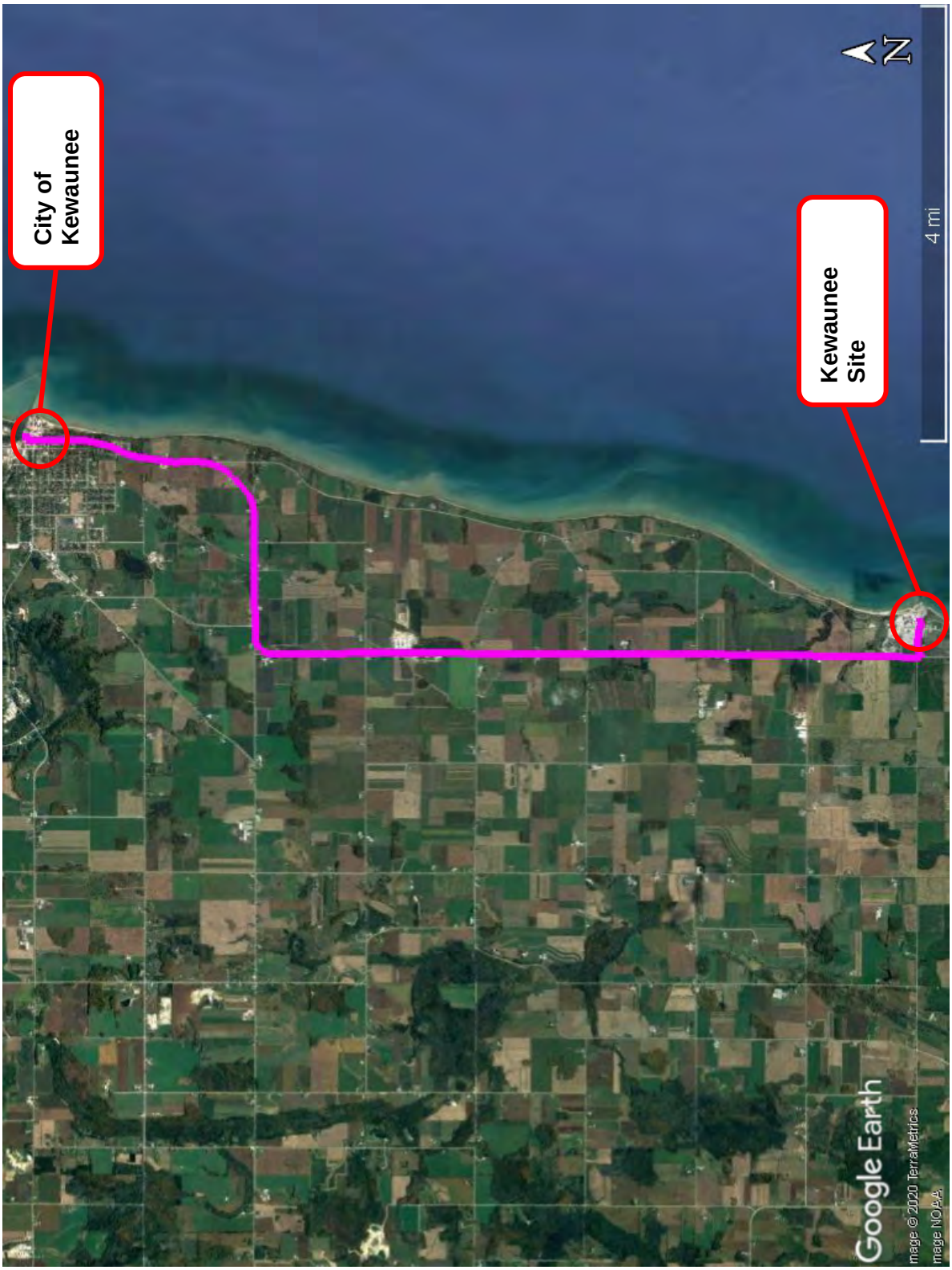


Figure 2-248. Potential Heavy Haul Truck Route to City Of Kewaunee Dock Facilities (Google 2019)



Figure 2-249. Potential Kewaunee Barge Transload Location Parking Lot (2014)



Figure 2-250. Potential Kewaunee Barge Transload Location Water Front (2014)



Photo courtesy of Kewaunee

Figure 2-251. Horizontal Storage Modules Being Unloaded from a Barge (2013)



Photo courtesy of Kewaunee

Figure 2-252. Horizontal Storage Module on 6-axle Goldhofer Trailer (2013)



Photo courtesy of Point Beach

Figure 2-253. Steam Generator on Goldhofer Trailer (2014)



Photo courtesy of Point Beach

Figure 2-254. First Steam Generator on Goldhofer Trailer Moving onto Barge (2014)



Photo courtesy of Point Beach

Figure 2-255. Barge with Two Steam Generators at Kewaunee Barge Transload Location (2014)



Photo courtesy of Point Beach

Figure 2-256. Fourth Steam Generator Moving onto Barge (2014)



Photo courtesy of Point Beach

Figure 2-257. Barge with Four Steam Generators at Kewaunee Barge Transload Location (2014)



Photo courtesy of Point Beach

Figure 2-258. Transloading of Steam Generator from Barge to Railcar in Houston, Texas (2014)



Photo courtesy of Point Beach

Figure 2-259. Steam Generators Arriving at Waste Control Specialists Low-Level Radioactive Waste Disposal Facility (2014)



Photo courtesy of Kewaunee

Figure 2-260. Replacement Reactor Pressure Vessel Head on Heavy Haul Truck (2004)



Photo courtesy of Kewaunee

Figure 2-261. Old Reactor Pressure Vessel Head on Heavy Haul Truck (2004)

2.11.4 Future Information Needs

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) SNF 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. The certificate of compliance for the MAGNATRAN transportation cask allows for transport of high burnup SNF in damaged fuel cans; however, the undamaged high

burnup SNF stored in TSC-37 canisters at Kewaunee is not contained in damaged fuel cans and a revision to the certificate of compliance would be required for this SNF to be transportable.

2.12 San Onofre

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 2019).

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 SNF from the San Onofre-2 reactor vessel was completed on July 18, 2013 (Dietrich 2013b). Final removal of SNF from the San Onofre-3 reactor vessel was completed on October 5, 2012 (Dietrich 2013c). Removal of SNF from the San Onofre-2 and -3 spent fuel pools was completed on August 7, 2020 (Bauder 2020).

San Onofre uses the Standardized Advanced NUHOMS System (Docket No. 72-1029) and the HI-STORM UMAX System (Docket No. 72-1040) for dry storage of SNF. The Standardized Advanced NUHOMS 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 SNF assemblies. The MP187 transportation cask (Docket No. 71-9255) is certified to transport the 24PT1 canister and the MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 24PT4 canister.

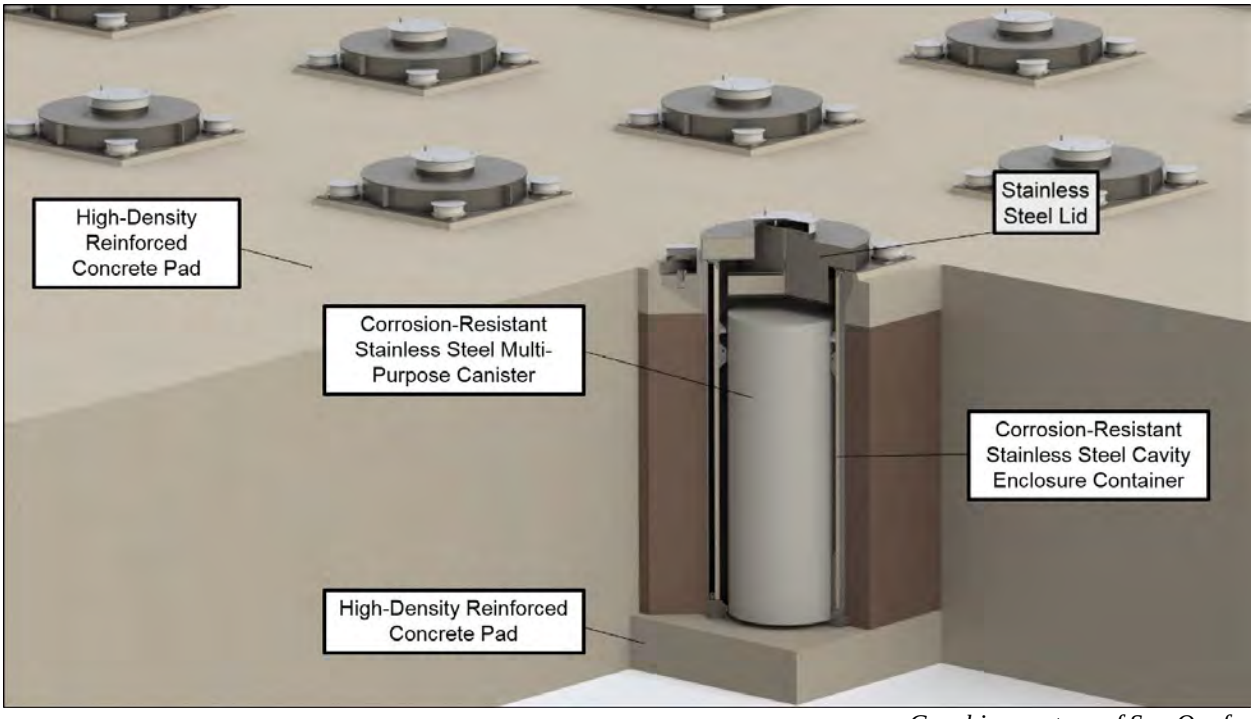
HI-STORM UMAX System consists of transportable multipurpose canisters, which contain the fuel; underground vertical ventilated modules, which contain the multipurpose canisters during storage; and a transfer cask (HI-TRAC VW), which contains the multipurpose canister during loading, unloading and transfer operations. The multipurpose canister (MPC-37) stores up to 37 pressurized water reactor SNF assemblies. The HI-STAR 190 transportation cask (Docket No. 71-9373) is certified to transport the MPC-37 canister. Figure 2-262 shows a cutaway view of the HI-STORM UMAX dry storage system.

There are also 12 additional unused 24PT4 dry shielded canisters, nine of which have been shipped off-site, and 12 unused NUHOMS reinforced concrete horizontal storage modules on the ISFSI pad, and eight additional reinforced concrete horizontal storage modules stored at the site. There were six 32PTH2 dry shielded canisters at the San Onofre site; however, these canisters have been shipped off-site. Figure 2-263 through Figure 2-266 show 24PT4 and 32PTH2 dry storage canisters, a transfer cask, and horizontal storage modules, respectively. Two of the 24PT4 dry storage canisters will be used for GTCC waste and one of the 24PT4 dry storage canisters will be used in San Onofre's Aging Management Program. Ten Radioactive Waste Containers (RWC) are being designed and fabricated to store GTCC waste from San Onofre-2

and -3 reactor vessel segmentation. The RWCs are designed to be processed similarly to a 24PT4 dry shielded canister, and will be stored in unused NUHOMS horizontal storage modules.

There are 395 pressurized water reactor SNF 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 SNF assemblies. There is also one 24PT1 dry shielded canister containing GTCC 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 is certified to ship SNF in the 24PT1 canister. However, the MP187 transportation cask is not certified for the transport of GTCC 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 SNF or GTCC 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 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 waste using the MP197HB transportation cask.



Graphic courtesy of San Onofre

Figure 2-262. Cutaway View of the HI-STORM UMAX Dry Storage System



Photo courtesy of San Onofre

Figure 2-263. 24PT4 Dry Storage Canisters



Figure 2-264. 32PTH2 Dry Storage Canisters (On Left) (2015)



Figure 2-265. Transfer Cask for 32PTH2 Canisters (2015)



Figure 2-266. Horizontal Storage Modules (2015)

There are also 792 pressurized water reactor SNF assemblies in 33 24PT4 dry shielded canisters from San Onofre-2 and -3 stored at the San Onofre site. The MP197HB transportation cask is certified to ship SNF in the 24PT4 canister. The MP197HB is also certified to ship GTCC waste. An MP197HB transportation cask has been fabricated and is in use in the U.S.

The fuel rods in 391 of the 395 SNF assemblies (146.2 MTHM) from San Onofre-1 stored at the San Onofre site are stainless steel-clad. The four mixed oxide SNF assemblies from San Onofre-1 (D049, D050, D051, and D052) are zirconium alloy-clad. There are also an additional 270 stainless steel-clad SNF assemblies from San Onofre-1 that are stored at the Morris, Illinois ISFSI. Figure 2-267 illustrates the number of SNF 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 2-268 illustrates the number of SNF 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 SNF (burnup greater than 45 GWd/MTHM) from San Onofre-1 is stored at the San Onofre site.

There are a total of 3460 SNF assemblies (1462.6 MTHM) from San Onofre-2 and -3 stored at the San Onofre site. This total includes the 792 assemblies (330.4 MTHM) in dry storage in Standardized Advanced NUHOMS Systems and 2668 assemblies (1132.2 MTHM) in dry storage in HI-STORM UMAX Systems. The fuel rods in these fuel assemblies are zirconium alloy-clad. There are also two rod storage baskets containing rods from reconstituted fuel assemblies from San Onofre -2 and -3 in dry storage. The 2668 SNF assemblies 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.

All SNF at San Onofre has been moved to dry storage. All of the 395 San Onofre-1 fuel assemblies are stored in 24PT1 dry shielded canisters, and 792 of the San Onofre-2 and -3 fuel assemblies are stored in 24PT4 dry shielded canisters. The remaining 2668 San Onofre-2 and -3 fuel assemblies are stored in 73 MPC-37 canisters. The San Onofre site also estimates that 12 canisters would be required to store the GTCC waste from decommissioning of San Onofre-2 and -3. At the San Onofre site, a total of 123 canisters contain SNF from San Onofre-1, -2, and -3. The San Onofre site estimates that 13 canisters would be required to store GTCC waste generated during decommissioning.

High burnup SNF stored in 24PT4 canisters and MPC-37 canisters at San Onofre would be transportable in the MP197HB and HI-STAR 190 transportation casks, respectively.

There are 94 damaged SNF assemblies from San Onofre-1, -2, and -3 stored in 24PT1 and 24PT4 dry storage canisters. There are 27 damaged assemblies from San Onofre-1 stored in 9 canisters, 46 damaged assemblies from San Onofre-2 stored in 4 canisters, and 21 damaged assemblies from San Onofre-3 stored in 2 canisters. These assemblies are packaged in damaged fuel cans. There are 34 damaged assemblies from San Onofre-2 and 29 damaged assemblies from San Onofre-3 stored in MPC-37 canisters. These assemblies are packaged in damaged fuel cans. Two rods storage baskets (one each from San Onofre-2 and -3) and two fuel debris containers (one each from San Onofre-2 and -3) are stored in damaged fuel cans. An additional

two fuel assemblies (one each from San Onofre-2 and -3) are stored in damaged fuel cans due to the presence of foreign material, for a total of 69 damaged fuel cans within 28 MPC-37 canisters.

Figure 2-269 illustrates the number of SNF 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 2-270 illustrates the number of SNF 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 SNF 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 SNF.

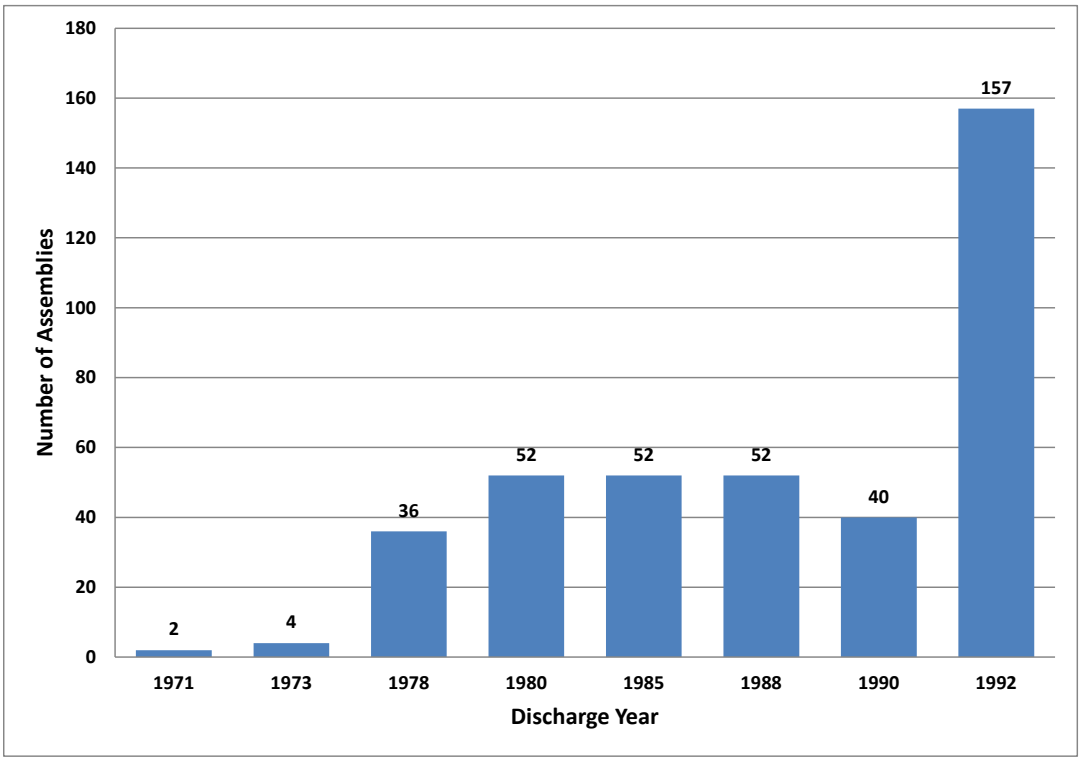


Figure 2-267. San Onofre-1 Number of On-site Assemblies versus Discharge Year (EIA 2013)

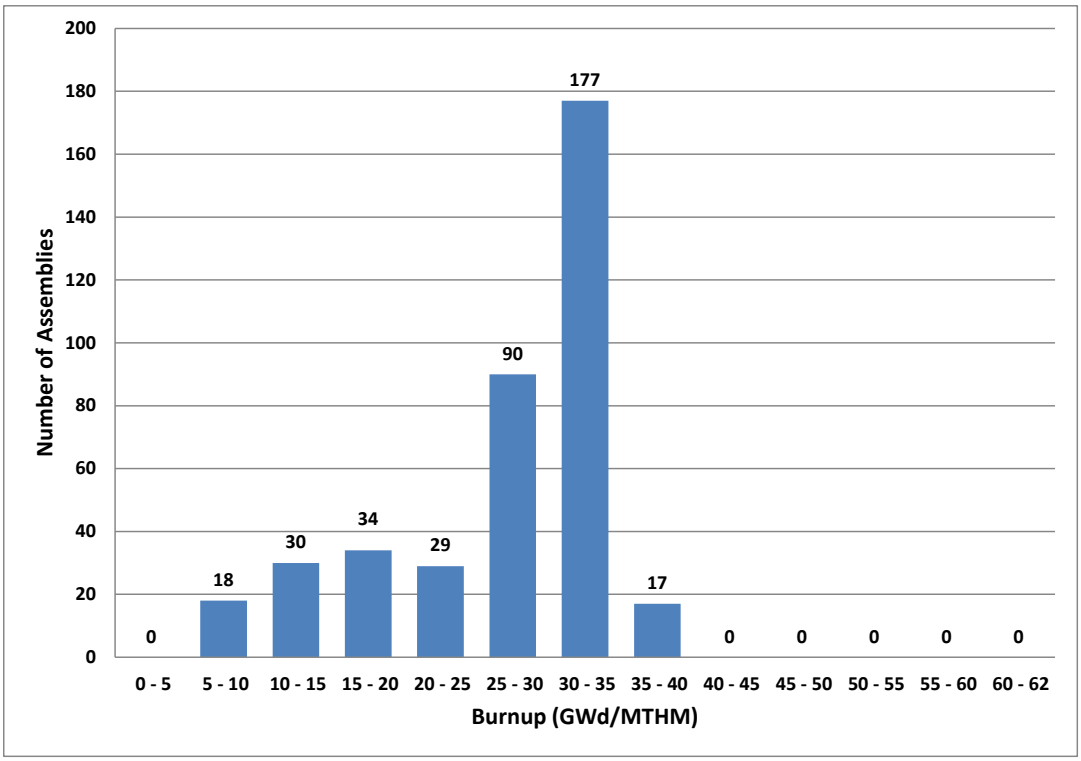


Figure 2-268. San Onofre-1 Number of On-site Assemblies versus Burnup (EIA 2013)

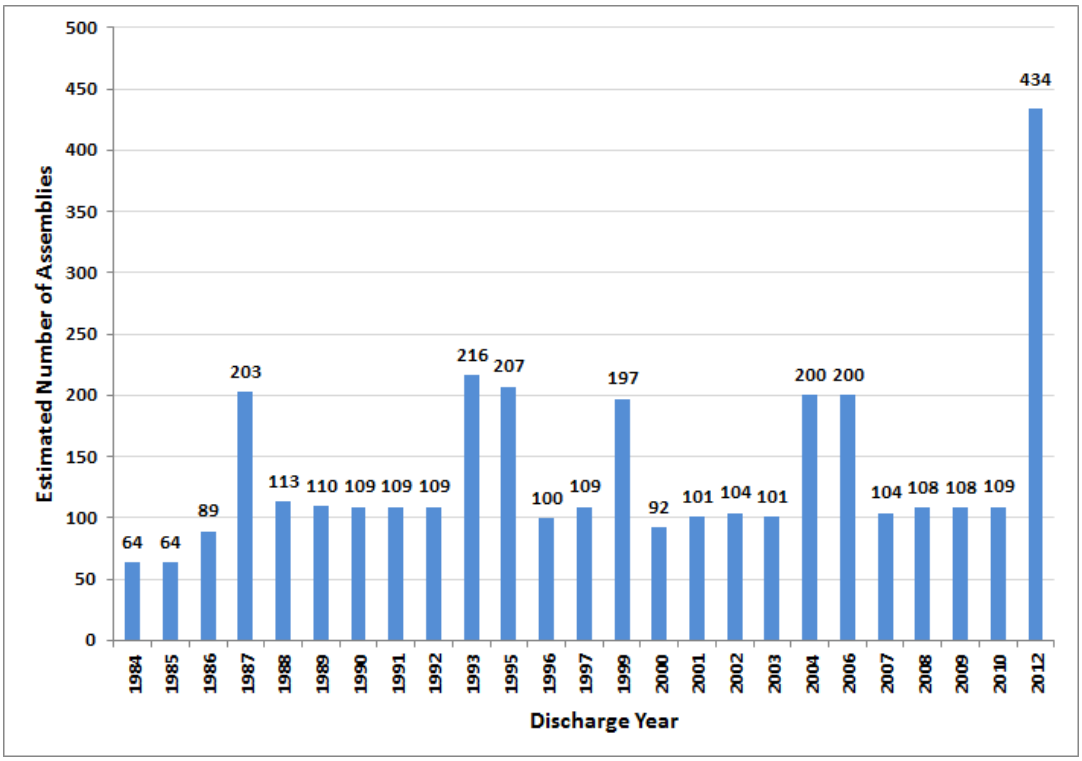


Figure 2-269. San Onofre-2 and San Onofre-3 Number of Assemblies versus Discharge Year (EIA 2013)

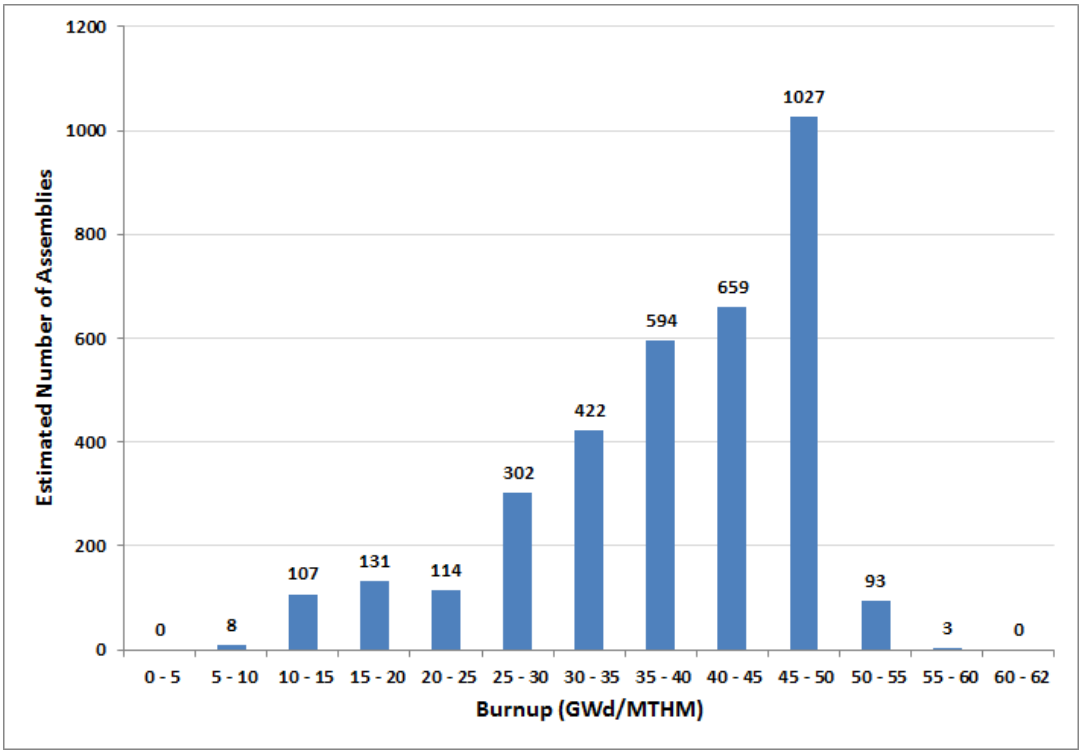


Figure 2-270. San Onofre-2 and San Onofre-3 Number of Assemblies versus Burnup (EIA 2013)

As mentioned previously, there are 792 SNF assemblies from San Onofre-2 and -3 stored in 33 24PT4 dry storage canisters. Figure 2-271 and Figure 2-272 illustrate the number of fuel assemblies stored in 24PT4 canisters based on their discharge year and burnup. The oldest fuel was discharged in 1984 and the last fuel was discharged in 2004. The median discharge year of the 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 fuel assemblies from San Onofre-2 and -3 stored in 24PT4 canisters that have burnups greater than 45 GWd/MTHM. These 8 assemblies are not packaged in damaged fuel cans.

Figure 2-273 and Figure 2-274 illustrate the number of fuel assemblies based on their discharge year and burnup for the 2668 fuel assemblies from San Onofre-2 and -3 that are stored in MPC-37 dry storage canisters. The oldest fuel was discharged in 1984 and the last fuel was discharged in 2012. The median discharge year of the 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. These 1115 assemblies are not packaged in damaged fuel cans.

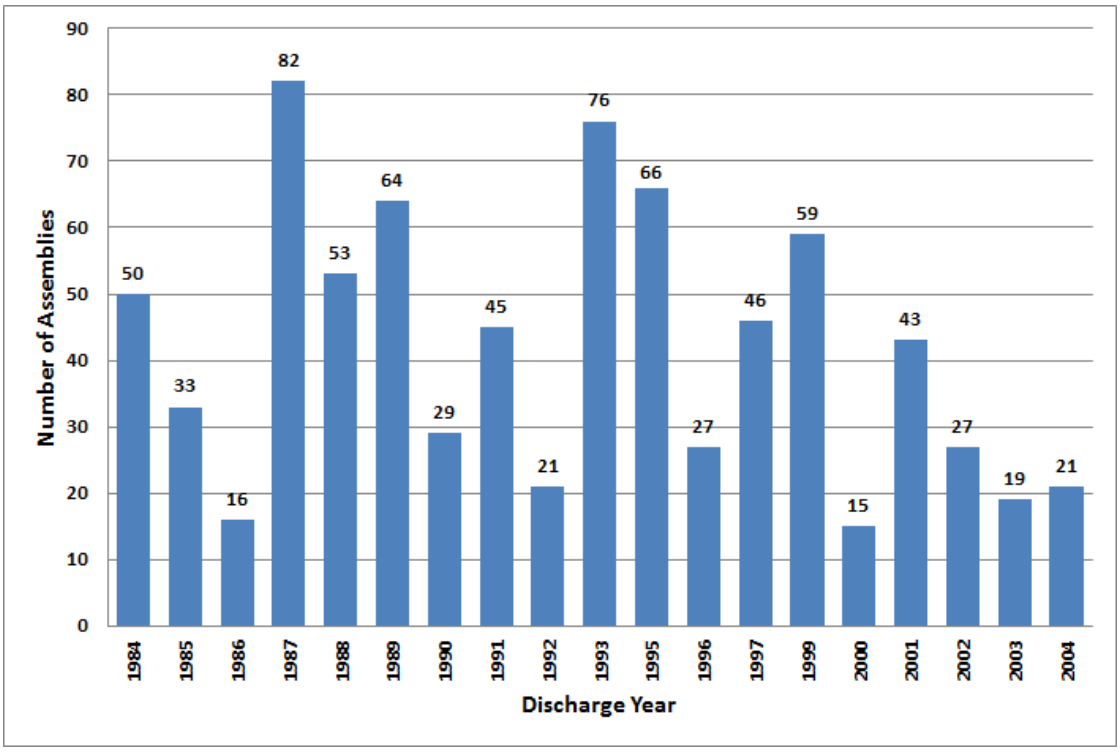


Figure 2-271. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in 24PT4 Canisters versus Discharge Year (EIA 2013)

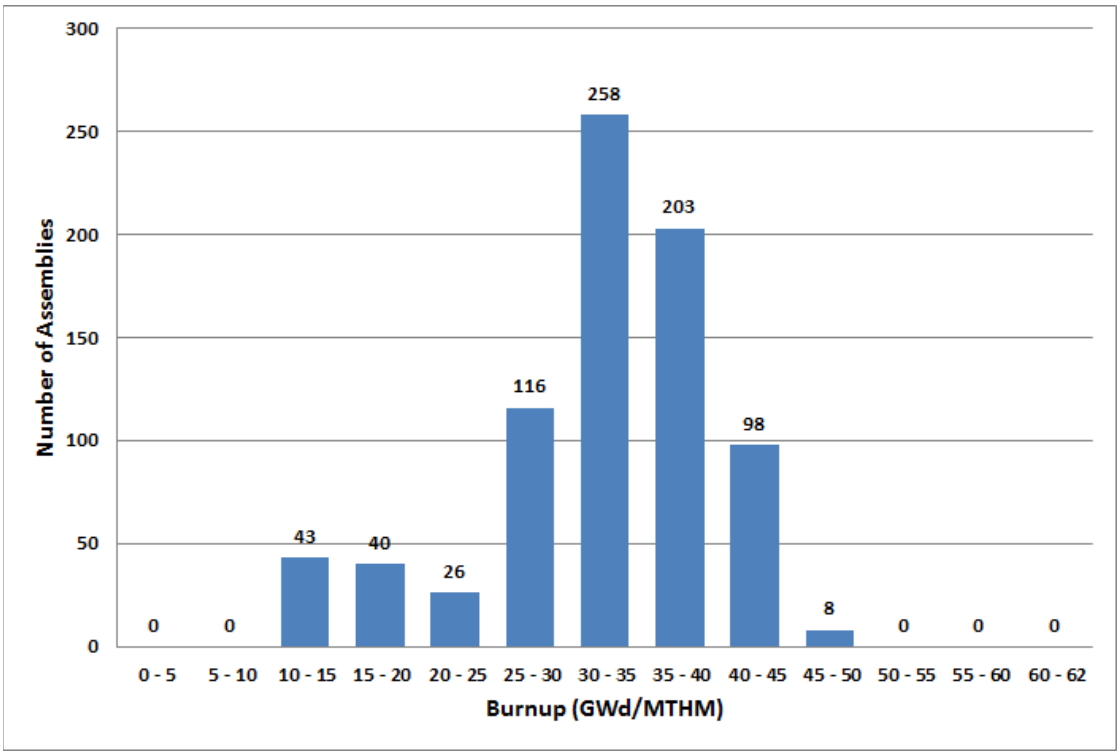


Figure 2-272. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in 24PT4 Canisters versus Burnup (EIA 2013)

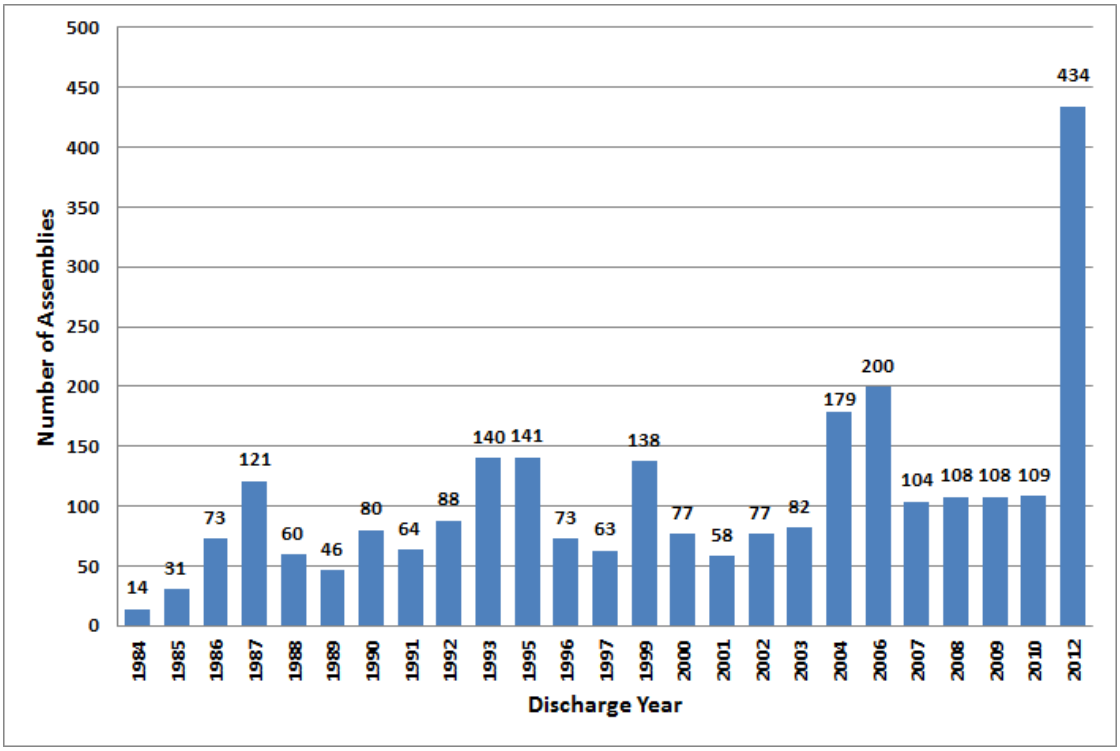


Figure 2-273. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in MPC-37 Canisters versus Discharge Year (EIA 2013)

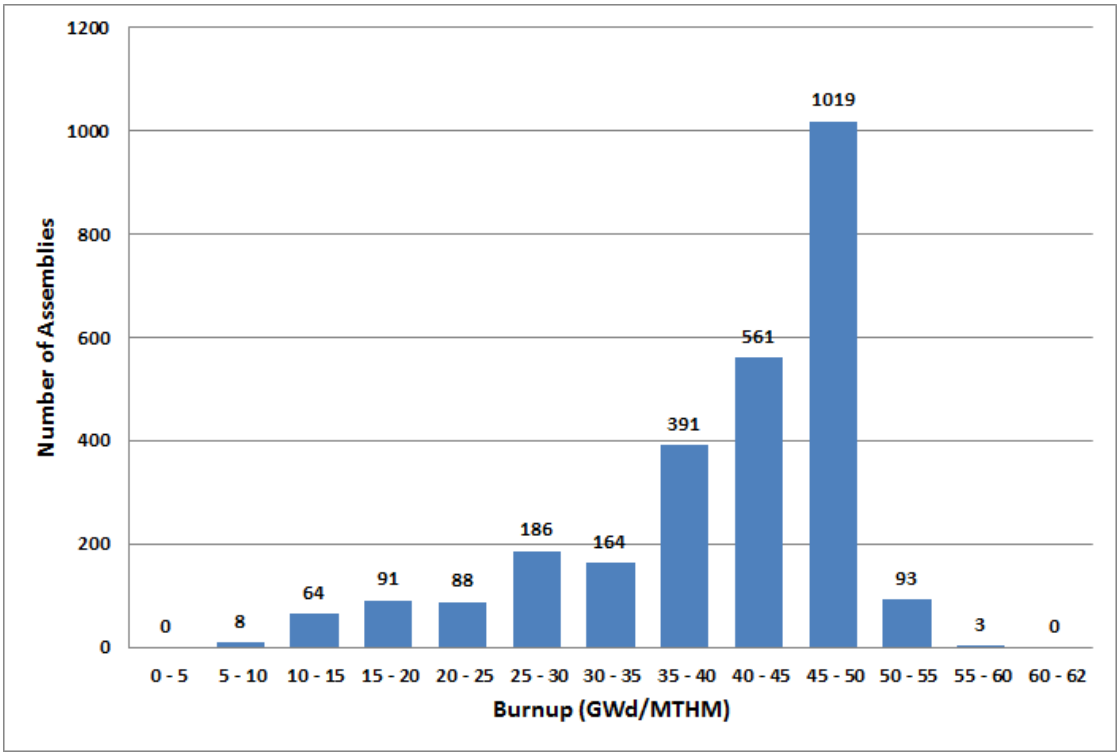


Figure 2-274. San Onofre-2 and San Onofre-3 Number of Assemblies Stored in MPC-37 Canisters versus Burnup (EIA 2013)

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) is located at the northwestern end of the site. San Onofre uses two systems to store SNF. The original ISFSI uses the Standardized Advanced NUHOMS System and expanded ISFSI uses the HI-STORM UMAX System. Figure 2-275 and Figure 2-276 show the original ISFSI and Figure 2-277 shows the expanded ISFSI.

Figure 2-278 provides an aerial view of the San Onofre site and Figure 2-279 provides an aerial view of the original ISFSI and the expanded ISFSI. The expansion was required to accommodate additional dry storage in HI-STORM UMAX underground vertical storage modules. The expanded ISFSI is located in an area adjacent to the original ISFSI (see Figure 2-279). Figure 2-280 shows this area before the expansion of the ISFSI. This area was excavated to a depth of approximately 12 feet to install the underground vertical storage modules. Following installation of the modules, the area was built up approximately 12 feet from the current ground level.

The San Onofre site is served by the BNSF 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 BNSF 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 2-281 through Figure 2-285 show the on-site rail system at San Onofre, the on-site spur, and the junction of the rail spur with the mainline. The on-site rail spur was refurbished to support shipping of the San Onofre-1 reactor pressure vessel in 2020. The rail spur will be further modified to support decommissioning and will be relocated to the northeast in the vicinity of the existing Administrative, Warehouse and Shop Building (see Figure 2-286).

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.

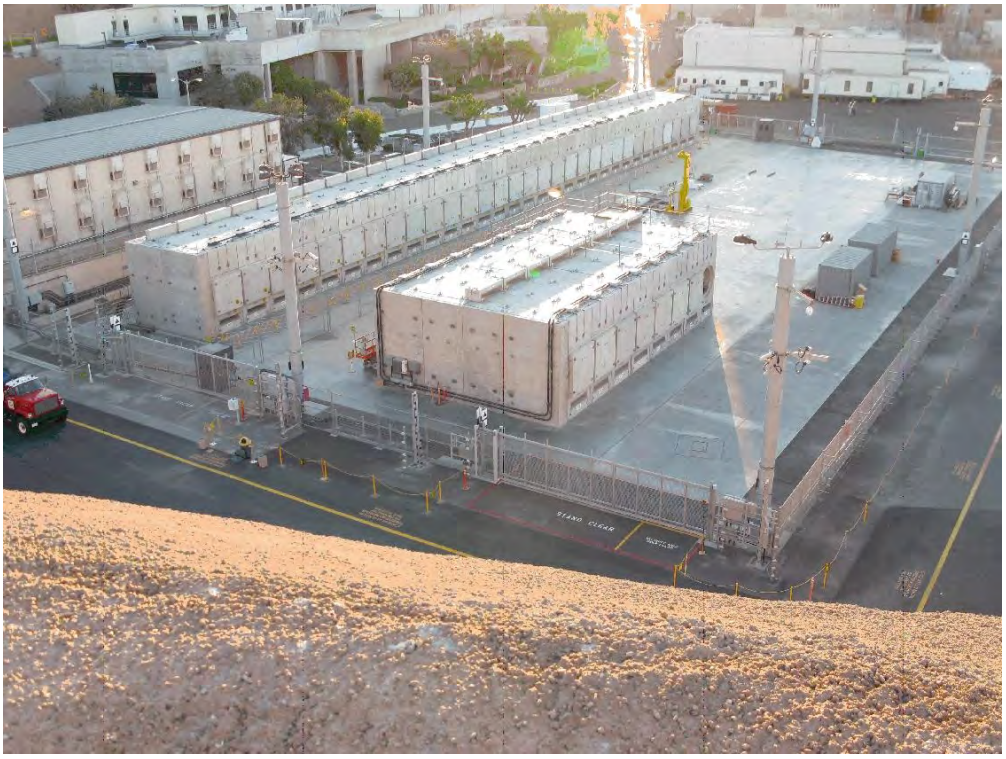


Photo courtesy of San Onofre

Figure 2-275. Original San Onofre Independent Spent Fuel Storage Installation (2009)



Figure 2-276. Close-up View of Original San Onofre Independent Spent Fuel Storage Installation (2018)



Photo courtesy of San Onofre

Figure 2-277. Expanded San Onofre Independent Spent Fuel Storage Installation (2020)



Figure 2-278. Aerial View of San Onofre Site (Google 2019)

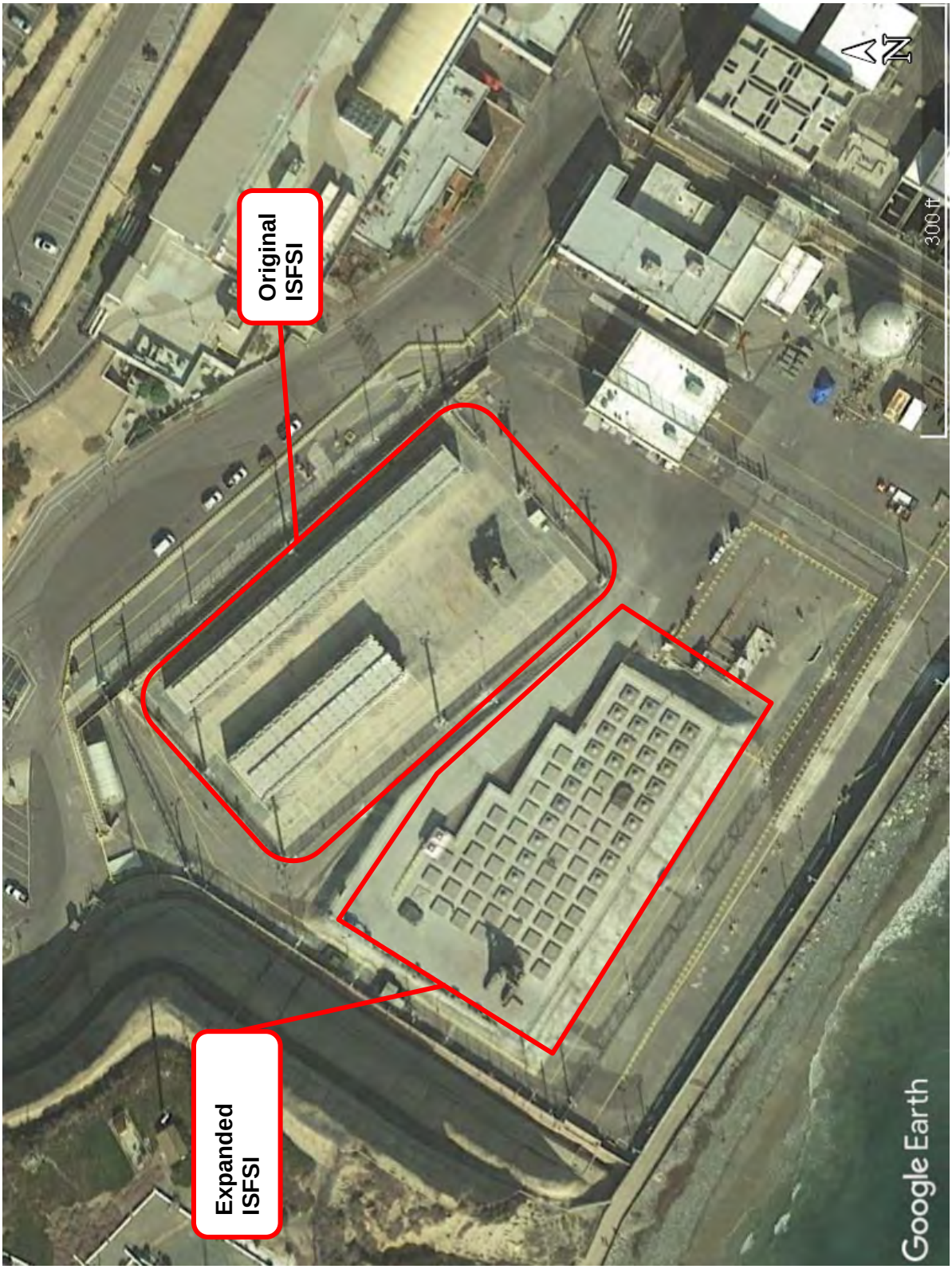


Figure 2-279. Aerial View of the San Onofre Original and Expanded Independent Spent Fuel Storage Installation (Google 2019)



Figure 2-280. Expanded San Onofre Independent Spent Fuel Storage Installation Location (2015)



Figure 2-281. On-site Rail System at San Onofre Site (2015)



Figure 2-282. On-site Rail System near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Southwest) (2015)



Figure 2-283. On-site Rail System and Vehicle Barrier near Independent Spent Fuel Storage Installation at San Onofre Site (Looking Northeast) (2015)



Figure 2-284. On-site Rail Spur at San Onofre Site (2018)



Figure 2-285. Junction of On-site Rail Spur with Mainline at San Onofre Site (2015)

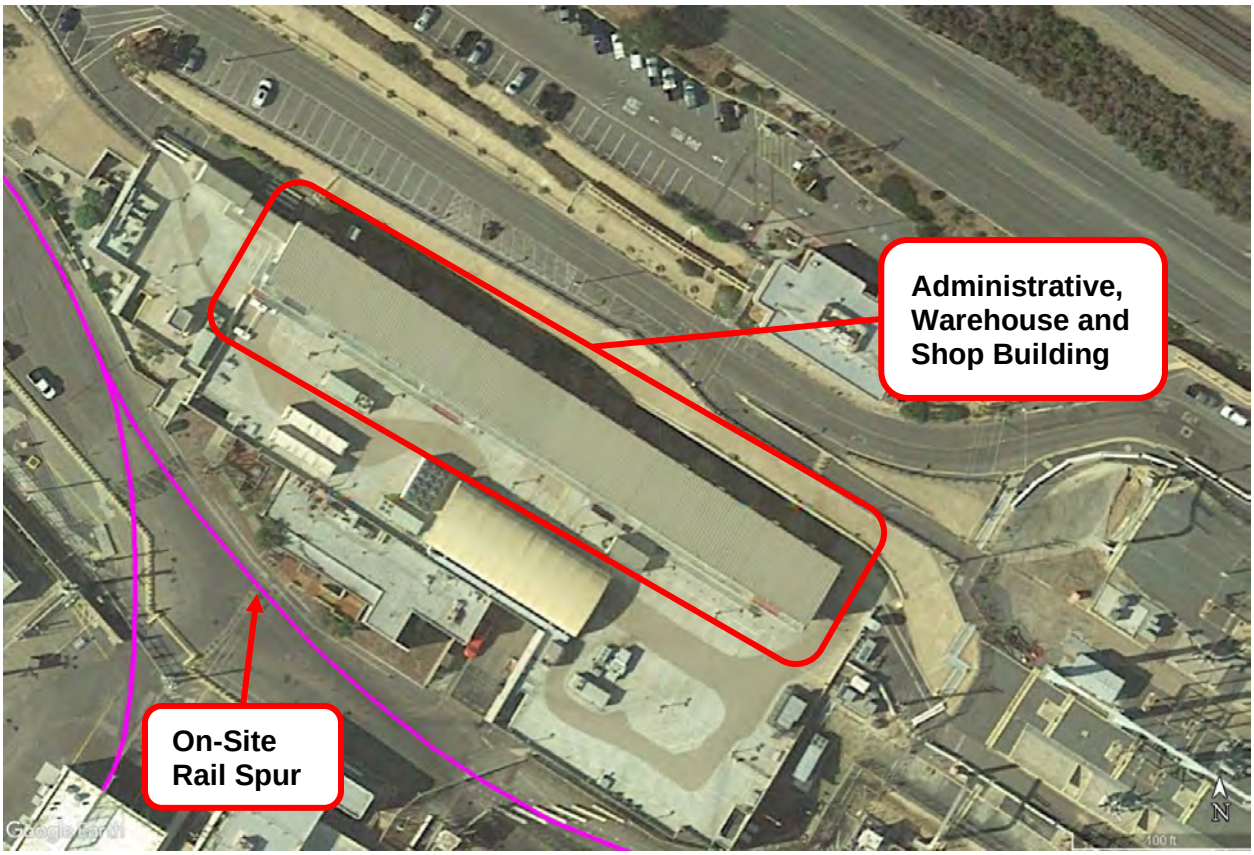


Figure 2-286. Aerial View of On-Site Rail Spur and the Administrative, Warehouse and Shop Building (Google 2019)

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 BNSF 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 2-287) and intermodal containers loaded onto rail cars (Figure 2-288) (EPRI 2008b).

In October 2015, a main generator rotor was shipped by rail from the San Onofre site to a location near Richmond, Virginia for refurbishment, after which it was shipped by rail to a storage location near the Fermi Nuclear Power Plant near Monroe, Michigan. The rotor weighed

slightly over 400,000 lb., was just over 50 ft. long, and was shipped on a 370-ton, 45-foot deck, 12-axle QTTX flat car (see Figure 2-289).

In 2020, the San Onofre-1 reactor pressure vessel was shipped by rail and heavy haul truck to the EnergySolutions low-level radioactive waste disposal facility in Clive, Utah. The reactor pressure vessel package weighed approximately 670 tons, was 15.5 ft. in diameter, and was 38.5 ft. long (Radwaste Solutions 2020). The reactor pressure vessel was moved by Goldhofer trailer (Figure 2-290) to the rail spur, transloaded onto a 36-axle Schnabel railcar (KRL 3600) (Figure 2-291) and moved by rail to Apex, Nevada where it was transloaded to a platform trailer (Figure 2-292), and moved by truck to Clive, Utah. The reactor pressure vessel departed San Onofre on May 25, 2020 and arrived in Clive, Utah July 14, 2020.

Truck shipments of 270 SNF 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 2-293 and Figure 2-294 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 North County Transit District also owns and maintains a maintenance and servicing facility at the Stuart Mesa rail yard, which is located about 13 miles south of the San Onofre site (see Figure 2-295 and Figure 2-296).



Photo courtesy of San Onofre

Figure 2-287. Gondola Railcar Used to Transport Large Non-Containerized Components



Photo courtesy of San Onofre

Figure 2-288. Articulating Intermodal Railcar Transporting Low-Level Radioactive Waste



Photo courtesy of San Onofre

Figure 2-289. Main Generator Rotor on QTTX Railcar (2015)



Photo courtesy of San Onofre

Figure 2-290. San Onofre-1 Reactor Pressure Vessel on Goldhofer Trailer



Photo courtesy of TheNavigator at Trainorders.com

Figure 2-291. San Onofre-1 Reactor Pressure Vessel on Schnabel Railcar



Photo courtesy of Nevada Department of Transportation

Figure 2-292. San Onofre-1 Reactor Pressure Vessel on Heavy Haul Truck Platform Trailer



Figure 2-293. Mainline at San Onofre Site (Looking North) (2015)



Figure 2-294. Mainline at San Onofre Site (Looking South) (2015)

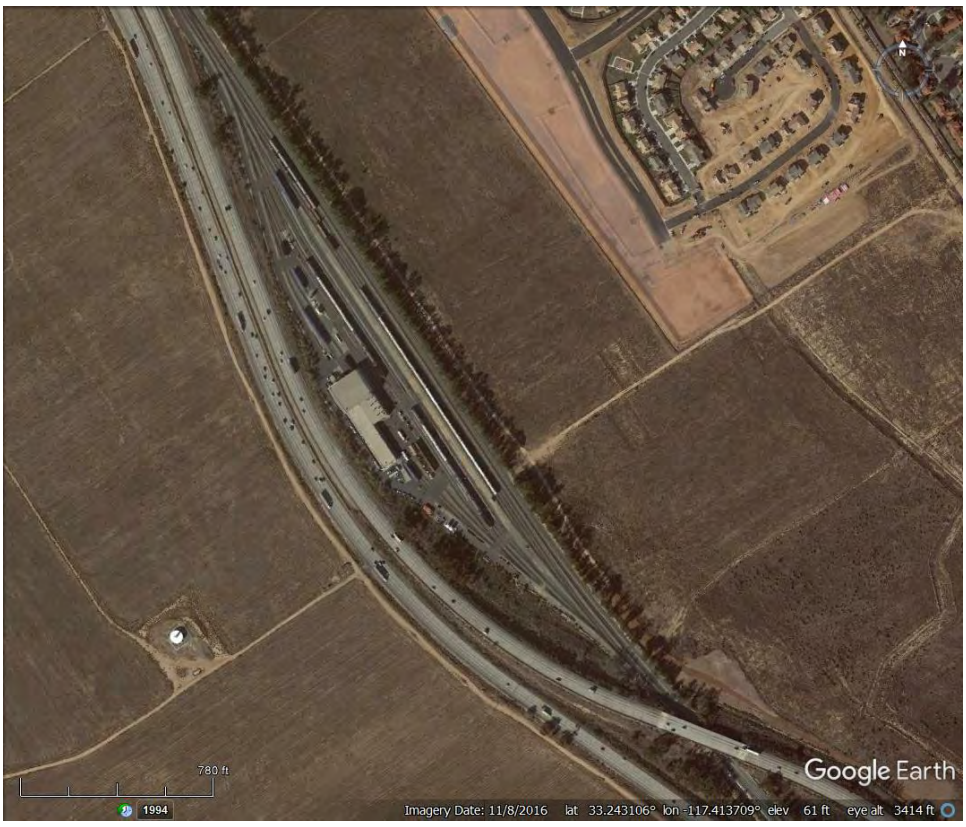


Figure 2-295. Aerial View of Stuart Mesa Rail Yard (Google 2019)



Figure 2-296. Stuart Mesa Rail Yard (Looking South) (2016)

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 2-297) and transported to the Del Mar Boat Basin (see Figure 2-298) 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 2-299). 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 2-300). 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 2-301). 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 2-302). Figure 2-303 shows the condition of the Del Mar Boat Basin bulkhead in 2016.

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 2-304 shows a steam generator (without its steam dome) on its heavy haul truck transporter.



Photo courtesy of California Public Utilities Commission

Figure 2-297. San Onofre Steam Generators on Barge Arriving at Del Mar Boat Basin (2009)



Figure 2-298. Del Mar Boat Basin (Google 2019)



Photo courtesy of California Public Utilities Commission

Figure 2-299. Offloading of Steam Generator on Goldhofer Trailer at Del Mar Boat Basin Bulkhead (2009)



Photo courtesy of California Public Utilities Commission

Figure 2-300. Steam Generator on Tracked Vehicle on Beach (2009)



Photo courtesy of San Diego Union-Tribune

Figure 2-301. Steam Generator on Goldhofer Trailer (2009)



Figure 2-302. Steam Generator Route from the Del Mar Boat Basin to the San Onofre Site (Google 2019)



Figure 2-303. Del Mar Boat Basin Bulkhead (2016)



Photo courtesy of San Diego Union-Tribune

Figure 2-304. Old Steam Generator on Heavy Haul Truck Transporter (2011)

2.12.4 Future Information Needs

At the San Onofre site, an on-site rail spur provides direct access to the BNSF Railroad and consequently, barge or heavy haul truck transport of SNF and GTCC waste would be unlikely from the San Onofre site.

There are 1123 SNF assemblies at San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. 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. The certificate of compliance for the HI-STAR 190 transportation cask authorizes the transport of high burnup fuel in the MPC-37 canister; therefore, the additional 1115 high burnup fuel assemblies would also be transportable.

2.13 Vermont Yankee

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs 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 SNF has been removed from the Vermont Yankee reactor vessel (Wamser 2015). Removal of SNF from the Vermont Yankee spent fuel pool was completed on August 1, 2018 (Chappell 2018). A total of 3879 SNF boiling water reactor assemblies and one fuel debris canister 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 3879 fuel assemblies are stored in 58 MPC-68 and MPC-68M multipurpose canisters. The MPC-68 and MPC-68M multipurpose canisters hold 68 boiling water reactor SNF assemblies and are 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. Two additional canisters containing GTCC waste could also be generated at the Vermont Yankee site (Wamser 2014).

The HI-STAR 100 transportation cask (Docket No. 71-9261) is certified to ship MPC-68 canisters. Transport of MPC-68M canisters, high burnup (> 45 GWd/MTHM) SNF, or GTCC waste is not authorized in the certificate of compliance for the HI-STAR 100. The certificate of compliance for either the HI-STAR 100MB (Docket No. 71-9378) or HI-STAR 100 could be revised to include these contents.

Figure 2-305 illustrates the number of SNF 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 SNF discharges and assembly burnups for the last Vermont Yankee core (368 assemblies), the U.S. Commercial Spent Fuel Projection Tool (Vinson 2015) was used.

Figure 2-306 illustrates the number of SNF assemblies at Vermont Yankee, based on their burnup. The lowest burnup is estimated to be 0.96 GWd/MTHM and the highest burnup is 52.9 GWd/MTHM. The median burnup is estimated to be 30.1 GWd/MTHM. There are 248 high burnup SNF (burnup greater than 45 GWd/MTHM) assemblies stored at Vermont Yankee. These 248 fuel assemblies are classified by the NRC as high burnup SNF.

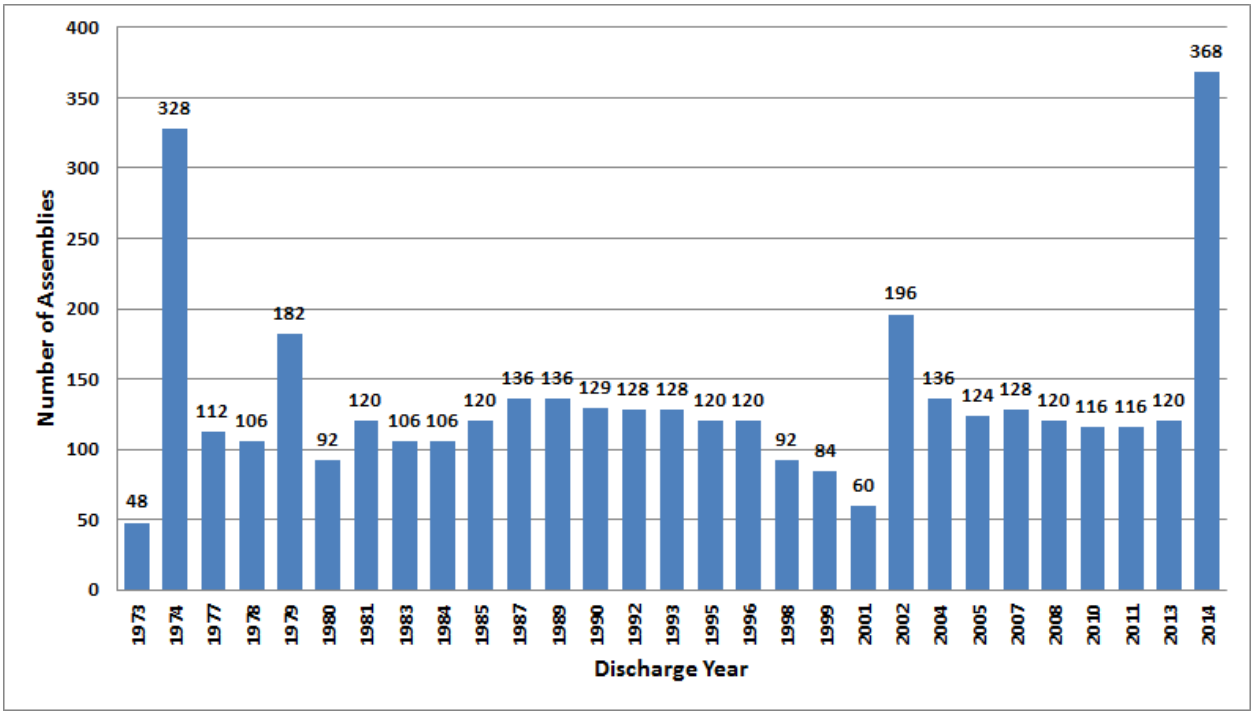


Figure 2-305. Vermont Yankee Number of Assemblies versus Discharge Year

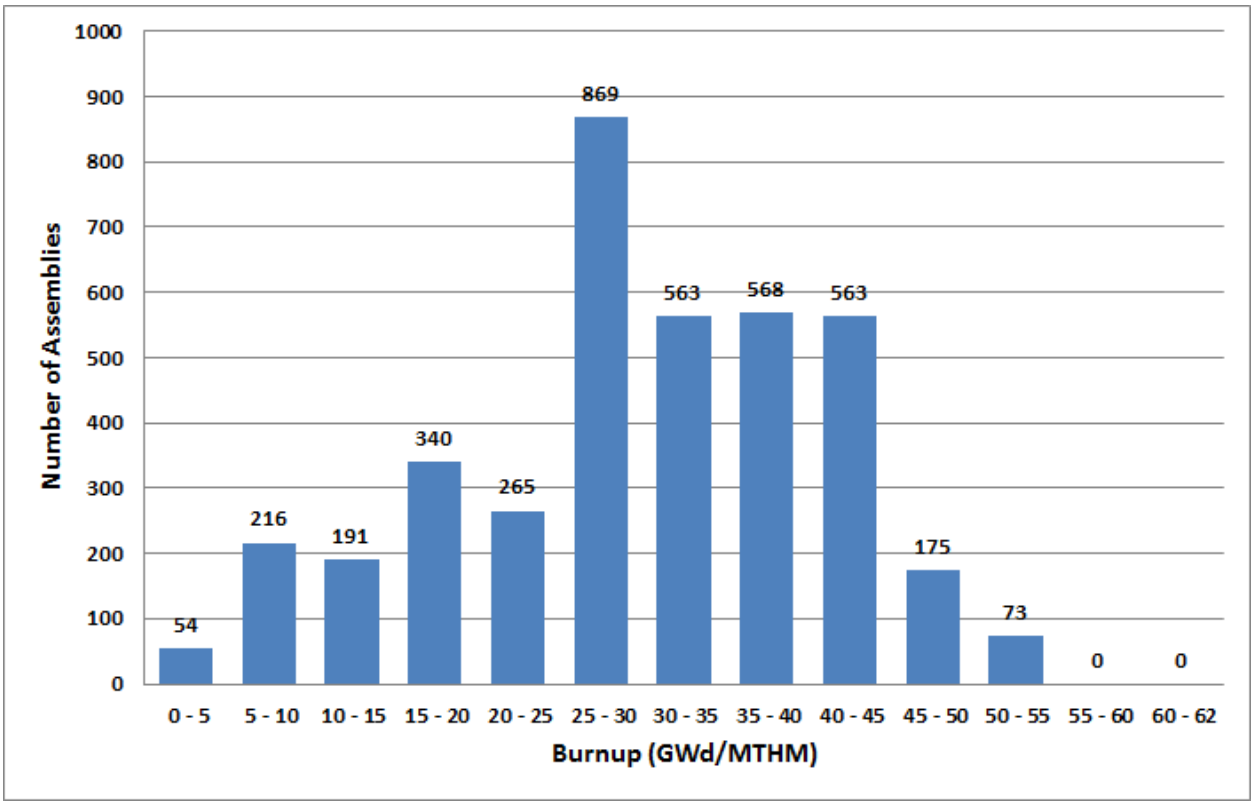


Figure 2-306. Vermont Yankee Number of Assemblies versus Burnup

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 2-307 provides an aerial view of the Vermont Yankee site. Figure 2-308 shows the Vernon Dam and Hydroelectric Station.

The Vermont Yankee ISFSI (see Figure 2-309) is located at the northern end of the Vermont Yankee site (see Figure 2-310). There are two ISFSI pads at the site, one with a capacity of 40 dry storage casks in an eight by five arrangement and a second pad with a capacity of 25 casks in a five by five arrangement. The second pad is approximately 30 feet immediately to the west of the existing ISFSI pad. A transfer cask, the platform used to move the vertical concrete casks from the reactor building to the containment access building, and the transporter used to move the vertical concrete storage casks from the containment access building to the ISFSI are available at the Vermont Yankee site.

Rail service to the Vermont Yankee site is provided by the New England Central Railroad. In the past, the Vermont Yankee on-site rail system had two branches, one spur that ran to the containment access building and a second spur that ran to the south end of the turbine building (TOPO 1994f). The spur that ran to the containment access building has largely been removed.

The spur that runs to the south end of turbine building has been refurbished and an additional spur has been added that runs to the southeast corner of the former protected area. The location of the second spur allows the concrete pad from the Construction Office Building (demolished in 2019) to be used for staging scrap material that will be shipped offsite via railcar. To facilitate railcar loading during poor weather conditions, a prefabricated metal-frame and plastic wall "big-top" structure has been erected over the southeastern end of the new rail spur. A short rail siding has also been added near the north end of the existing rail spur to facilitate on-site railcar storage (VTNDCAP 2020). The spur that runs to the turbine building is shown in Figure 2-311 through Figure 2-316. Figure 2-317 shows the locations of the on-site rail spurs.

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

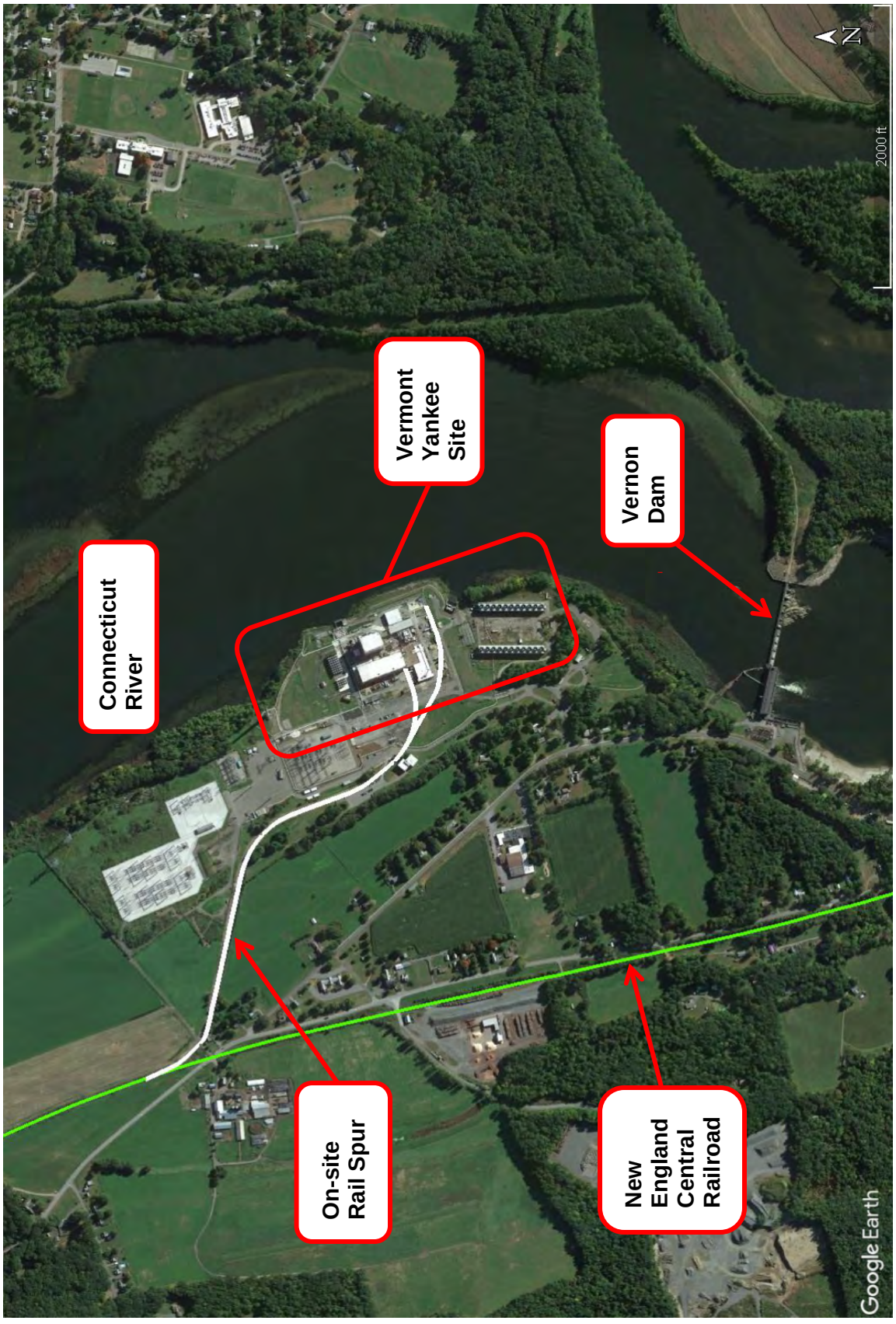


Figure 2-307. Aerial View of Vermont Yankee Site (Google 2019)



Figure 2-308. Vernon Dam and Hydroelectric Station (2016)



Photo courtesy of Vermont Yankee

Figure 2-309. Vermont Yankee Independent Spent Fuel Storage Installation (2016)

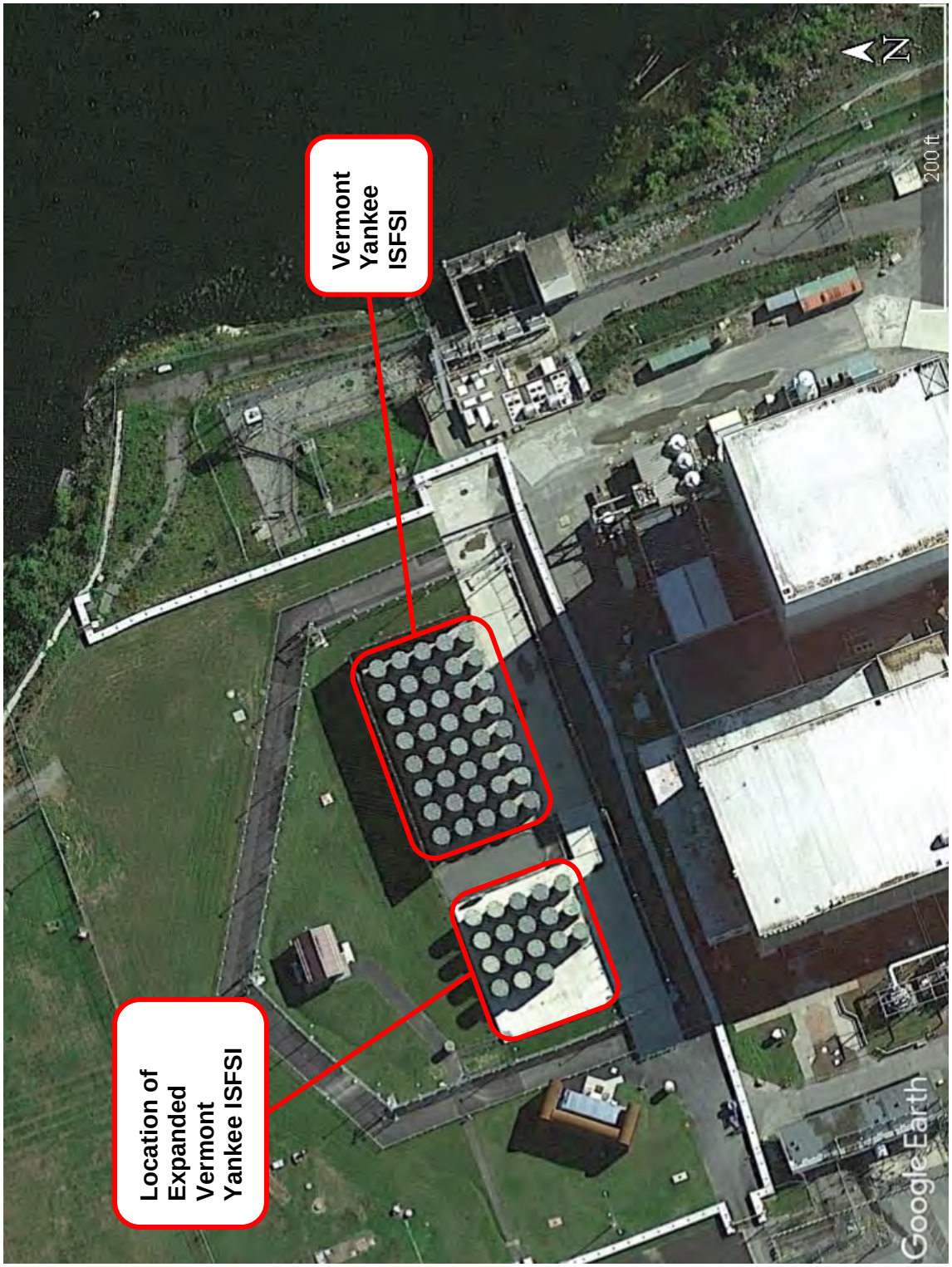


Figure 2-310. Aerial View of Vermont Yankee Independent Spent Fuel Storage Installation (Google 2019)



Photo courtesy of Vermont Yankee

Figure 2-311. Paved Over Portions on On-Site Rail Spur (2016)



Photo courtesy of Vermont Yankee

Figure 2-312. On-Site Rail Spur Approaching Turbine Building (2018)



Photo courtesy of Anthony Leshinskie

Figure 2-313. On-site Rail Spur Looking North (2017)



Photo courtesy of Anthony Leshinskie

Figure 2-314. On-site Rail Spur Looking South (2017)



Photo courtesy of Anthony Leshinskie

Figure 2-315. On-site Rail Spur Approaching Site Exit (2017)



Photo courtesy of Anthony Leshinskie

Figure 2-316. Rail Spur at Entrance to Vermont Yankee Site (2017)

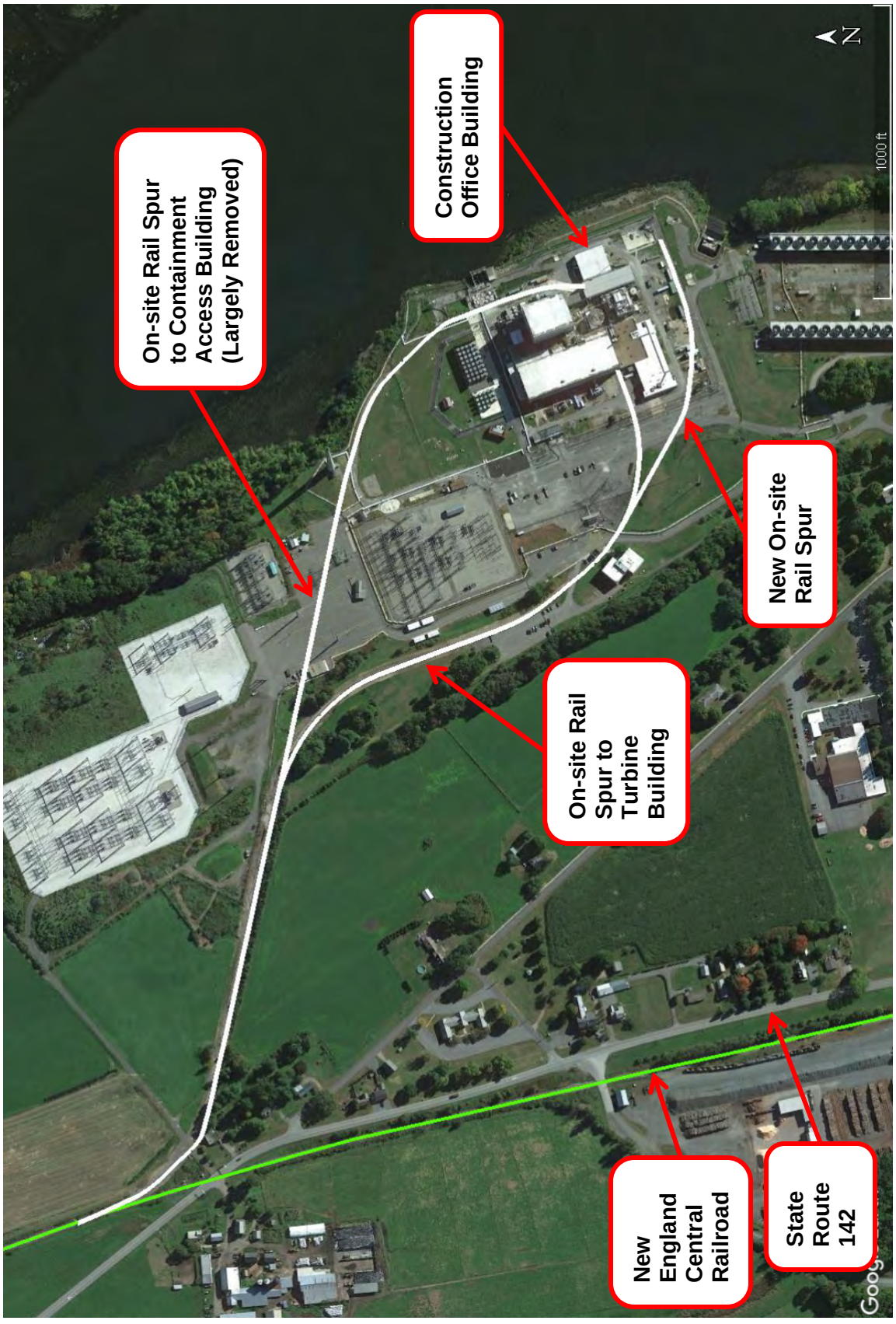


Figure 2-317. Aerial View of On-site Rail Spur (Google 2019)

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.

Figure 2-318 provides an aerial view of the Vermont Yankee rail spur, Figure 2-319 shows the rail spur at the Vermont Yankee site entrance, Figure 2-320 shows the junction of the Vermont Yankee rail spur and the New England Central Railroad (looking south), Figure 2-321 shows the junction of the Vermont Yankee rail spur and the New England Central Railroad (looking north), Figure 2-322 shows a derailer on the Vermont Yankee rail spur, and Figure 2-323 shows a dragging equipment detector and hot bearing detector located at the junction of the Vermont Yankee rail spur and the New England Central Railroad mainline.

The two major freight railroads that the New England Central Railroad interchanges with in the vicinity of the Vermont Yankee site are the Pan Am Southern and the CSX. The New England Central Railroad interchanges with the Pan Am Southern in Brattleboro, Vermont and with the CSXT in Palmer, Massachusetts. Figure 2-324 and Figure 2-325 show the railyards in these locations. Figure 2-326 shows the junction of New England Central Railroad and Pan Am Southern Railroad in East Northfield, Massachusetts.

In 2008, DOE, the 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. 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 2-327 from this assessment shows the State Route 142 railroad grade crossing at milepost 115.97, Figure 2-328 shows the grade crossing at milepost 112.68, Figure 2-329 shows the railroad bridge over the Connecticut River at milepost 109.15, and Figure 2-330 shows a smaller railroad bridge at milepost 103.33.

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 off-site barge terminal is located 60 miles from the Vermont Yankee site.



Figure 2-318. Aerial View of Vermont Yankee Rail Spur (Google 2019)



Photo courtesy of Anthony Leshinskie

Figure 2-319. Rail Spur at Vermont Yankee Site Entrance (2017)



Figure 2-320. Junction of Vermont Yankee Rail Spur (Left) and New England Central Railroad Mainline (Right) Looking South (2016)



Figure 2-321. Junction of Vermont Yankee Rail Spur and New England Central Railroad Mainline Looking North (2016)



Figure 2-322. Derailer on Vermont Yankee Rail Spur (2016)



Figure 2-323. Dragging Equipment Detector and Hot Bearing Detector on New England Central Railroad Mainline (2016)



Figure 2-324. Brattleboro Railyard (2016)



Figure 2-325. Palmer Railyard (2016)



Figure 2-326. Junction of New England Central Railroad (Left) and Pan Am Southern Railroad (Right) in East Northfield, Massachusetts (2016)



Photo courtesy of Federal Railroad Administration

Figure 2-327. State Route 142 Grade Crossing at Milepost 115.97 (2008)



Photo courtesy of Federal Railroad Administration

Figure 2-328. Grade Crossing at Milepost 112.68 (2008)



Photo courtesy of Federal Railroad Administration

Figure 2-329. Connecticut River Railroad Bridge at Milepost 109.15 (2008)



Photo courtesy of Federal Railroad Administration

Figure 2-330. Railroad Bridge at Milepost 103.33 (2008)

In 2020, Vermont Yankee began shipping segmented reactor internals by rail to the Waste Control Specialists low-level radioactive waste disposal facility located in Andrews, Texas. These segmented reactor internals are being shipped using the MP197HB transportation cask on the KRL 50002 railcar. The KRL 50002 railcar is an 8-axle, 55 ft. flat deck railcar with a load limit of 394,300 lb. Figure 2-331 shows the MP197HB transportation cask without impact limiters on the KRL 50002 railcar prior to shipping, Figure 2-332 shows the MP197HB transportation cask on the KRL 50002 with impact limiters, and Figure 2-333 shows the MP197HB transportation cask arriving at the Waste Control Specialists low-level radioactive waste disposal facility in Andrews, Texas.



Photo courtesy of NorthStar

Figure 2-331. MP197HB Transportation Cask Without Impact Limiters on Railcar (2019)



Photo courtesy of Orano

Figure 2-332. MP197HB Transportation Cask With Impact Limiters on Railcar (2020)



Photo courtesy of Orano

Figure 2-333. MP197HB Transportation Cask Carrying Segmented Reactor Internals from Vermont Yankee Arriving at the Waste Control Specialists Low-Level Radioactive Waste Disposal Facility in Andrews, Texas (2020)

2.13.4 Future Information Needs

The certificate of compliance for the HI-STAR 100 transportation cask does not allow the transport of MPC-68M canisters, high burnup (> 45 GWd/MTHM) SNF, or GTCC waste. Consequently, the certificate of compliance for either the HI-STAR 100MB (Docket No. 71-9378) or the HI-STAR 100 would have to be revised before the SNF stored in MPC-68M canisters, the 248 high burnup SNF assemblies, or the GTCC waste from decommissioning at the Vermont Yankee site could be transported.

2.14 Fort Calhoun

This section describes the inventory of SNF and GTCC waste, site conditions, near-site transportation infrastructure and experience, and future information needs for the Fort Calhoun site. The site is located on the western shore of the Missouri River in Washington County in eastern Nebraska (TOPO 1994g), about 19 miles north of Omaha, Nebraska.

2.14.1 Site Inventory

Fort Calhoun has been shut down since October 24, 2016 and final removal of SNF from the reactor vessel was completed on November 13, 2016 (Burke 2016a, 2016b). Removal of SNF from the Fort Calhoun spent fuel pool was completed on May 13, 2020 (Blome 2020). A total of 1264 SNF assemblies (463.6 MTHM) are stored at Fort Calhoun (Fisher 2017a). These pressurized water reactor SNF assemblies are in dry storage at the Fort Calhoun ISFSI (Docket No. 72-54). The fuel rods in the fuel assemblies are zirconium alloy-clad. The 1264 fuel assemblies are stored in 40 32PT dry shielded canisters. The 32PT dry shielded canister holds 32 pressurized water reactor SNF 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. Two transfer casks have been used at the Fort Calhoun site, the OS197 and the OS197L. The OS197L transfer cask is lighter and contains less shielding than the OS197 transfer cask. Two additional canisters containing GTCC waste could also be generated at the Fort Calhoun site. Fisher (2017b) states that GTCC waste would not be packaged until 2060-2065.

The MP197HB transportation cask (Docket No. 71-9302) is certified to transport the 32PT canister and also canisters containing GTCC waste. Transport of high burnup (> 45 GWd/MTHM) or damaged SNF in the 32PT canister is not authorized in the certificate of compliance for the MP197HB. An MP197HB transportation cask has been fabricated and is in use in the U.S.

Figure 2-334 illustrates the number of SNF assemblies at Fort Calhoun based on their discharge year. The oldest fuel was discharged in 1975 and the last fuel was discharged in 2016. The median discharge year of the fuel is 1998.

Figure 2-335 illustrates the number of SNF assemblies at Fort Calhoun based on their burnup. The burnup data for assemblies discharged from 2013 to 2016 are preliminary. The lowest burnup is 7.8 GWd/MTHM and the highest burnup is 58.2 GWd/MTHM. The median burnup is

38.8 GWd/MTHM. There are 186 SNF assemblies at Fort Calhoun that have burnups greater than 45 GWd/MTHM. These 186 fuel assemblies are classified by the NRC as high burnup SNF.

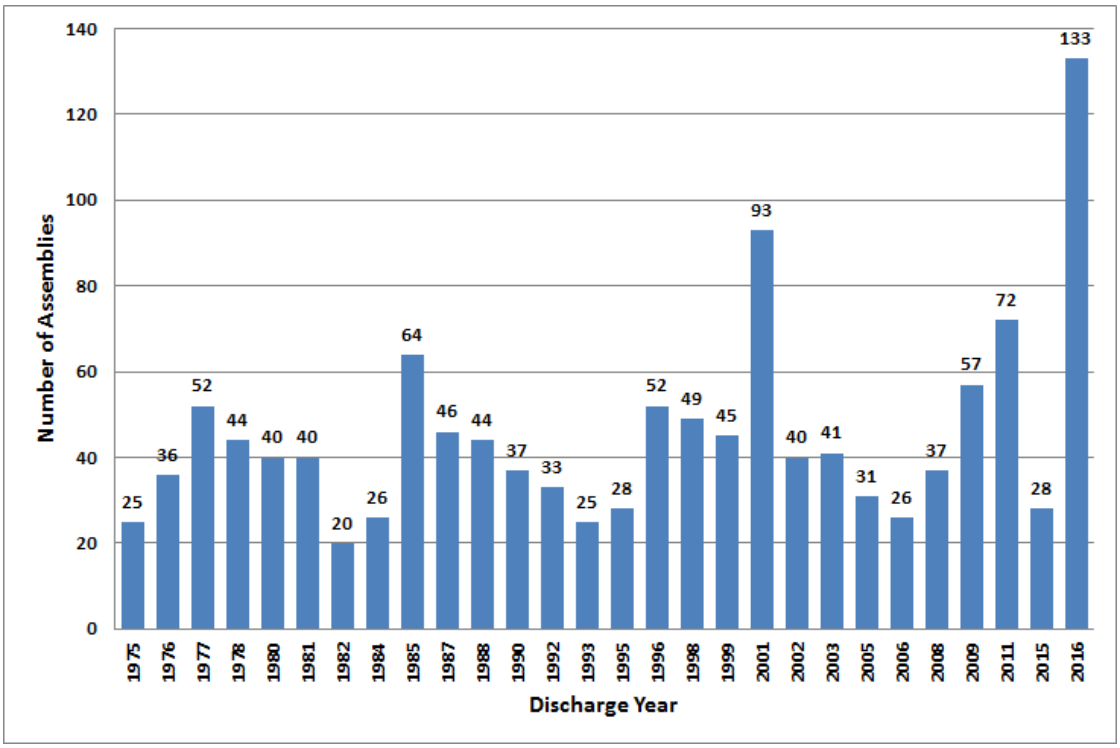


Figure 2-334. Fort Calhoun Number of Assemblies versus Discharge Year

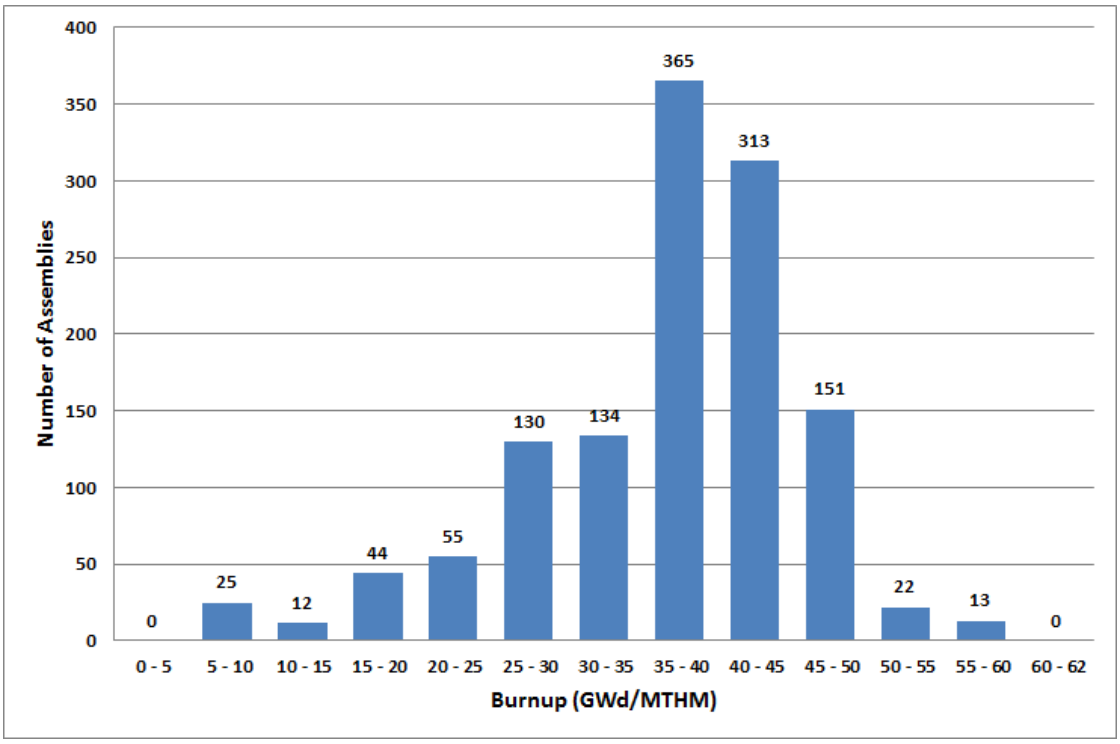


Figure 2-335. Fort Calhoun Number of Assemblies versus Burnup (Data for Assemblies Discharged from 2013 to 2016 Are Preliminary)

2.14.2 Site Conditions

The Fort Calhoun site is located on the western shore of the Missouri River in Washington County, Nebraska and consists of 660 acres of land. The nearest municipalities are Blair, Nebraska, approximately 6 miles to the northwest, and Fort Calhoun, Nebraska, approximately 5 miles to the south of the Fort Calhoun site (NRC 2003). Figure 2-336 provides an aerial view of the Fort Calhoun site.

The Fort Calhoun ISFSI (see Figure 2-337) is located at the northwestern end of the Fort Calhoun site (see Figure 2-338). The ISFSI pad has a capacity of 40 dry storage modules.

Rail service to the Fort Calhoun site is provided by the Union Pacific Railroad through the Cargill Industrial Spur (see Figure 2-339, Figure 2-340, and Figure 2-341). The Cargill Industrial Spur is on a right-of-way easement to the Union Pacific Railroad that follows the base of the bluff across the southern portion of the Fort Calhoun site and continues northwestward to Blair, where it joins the Union Pacific mainline (OPPD 2002). The spur was built in 1994 to serve the neighboring Cargill corn milling and processing facility and is coincident with the Chicago and Northwestern spur used for plant construction, which was subsequently abandoned and removed (OPPD 2002). It should be noted that the bridge over the Cargill Industrial Spur on the Fort Calhoun access road shown in Figure 2-341 has a weight limit of 30 tons (60,000 lb.) and would not support an MP197HB transportation cask, which weighs about 304,000 lb.

The rail spur is 4.33 mi. in length and is constructed from 136 lb. rail, concrete ties, and Pandrol clips (see Figure 2-342). The rail spur no longer extends into the site. In the past, the Fort Calhoun on-site rail system had two branches, one branch that ran between the reactor area and

the switchyard, and a second branch that ran to the Auxiliary Building (see Figure 2-343). It is possible that the on-site rail spur could be re-established to support decommissioning.

Recent barge access to the Fort Calhoun site has been provided at an area to the northeast of the Fort Calhoun ISFSI (see Figure 2-344).

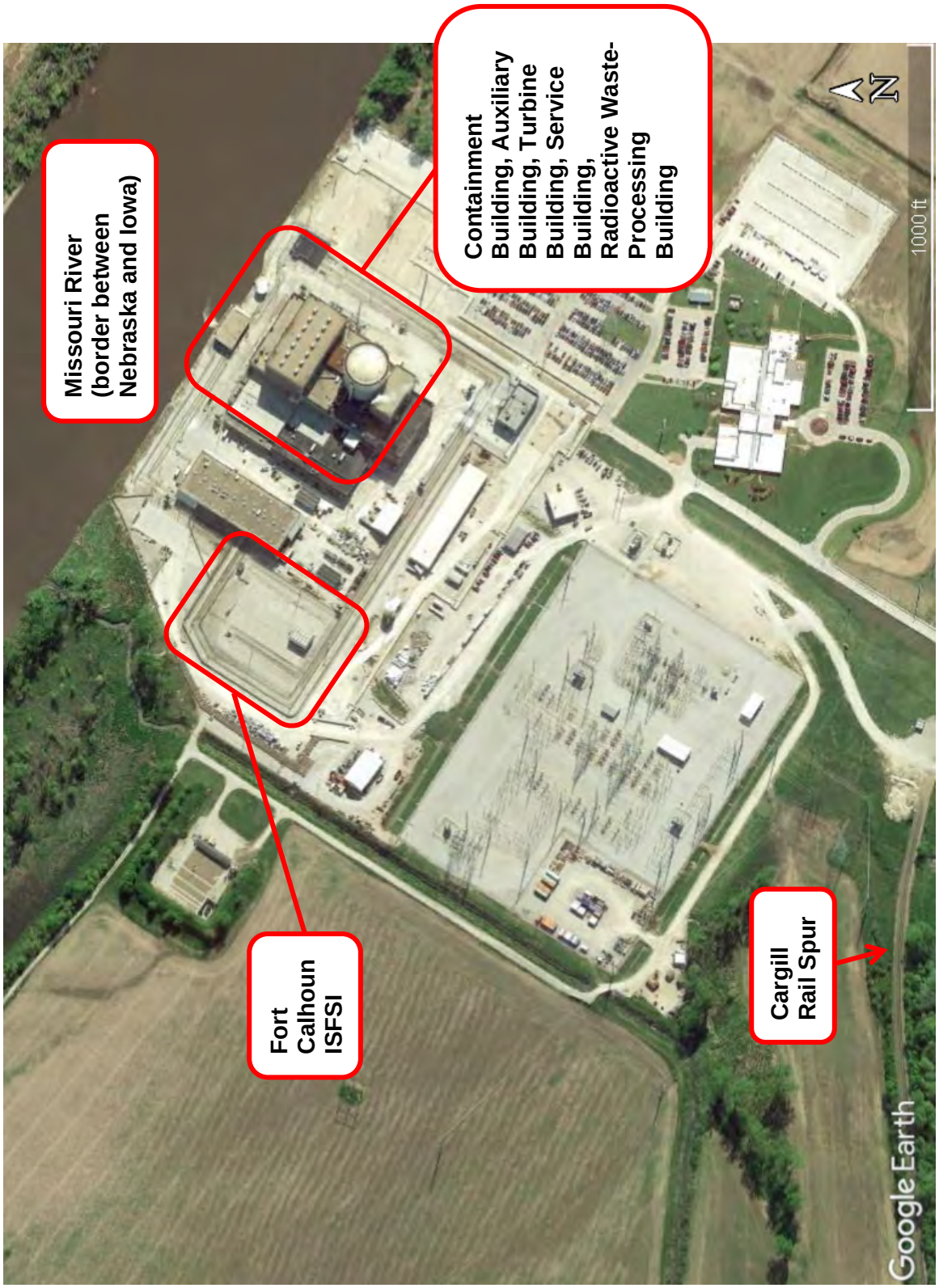


Figure 2-336. Aerial View of Fort Calhoun Site (Google 2019)



Figure 2-337. Fort Calhoun Independent Spent Fuel Storage Installation (2017)



Figure 2-338. Aerial View of Fort Calhoun Independent Spent Fuel Storage Installation (Google 2019)

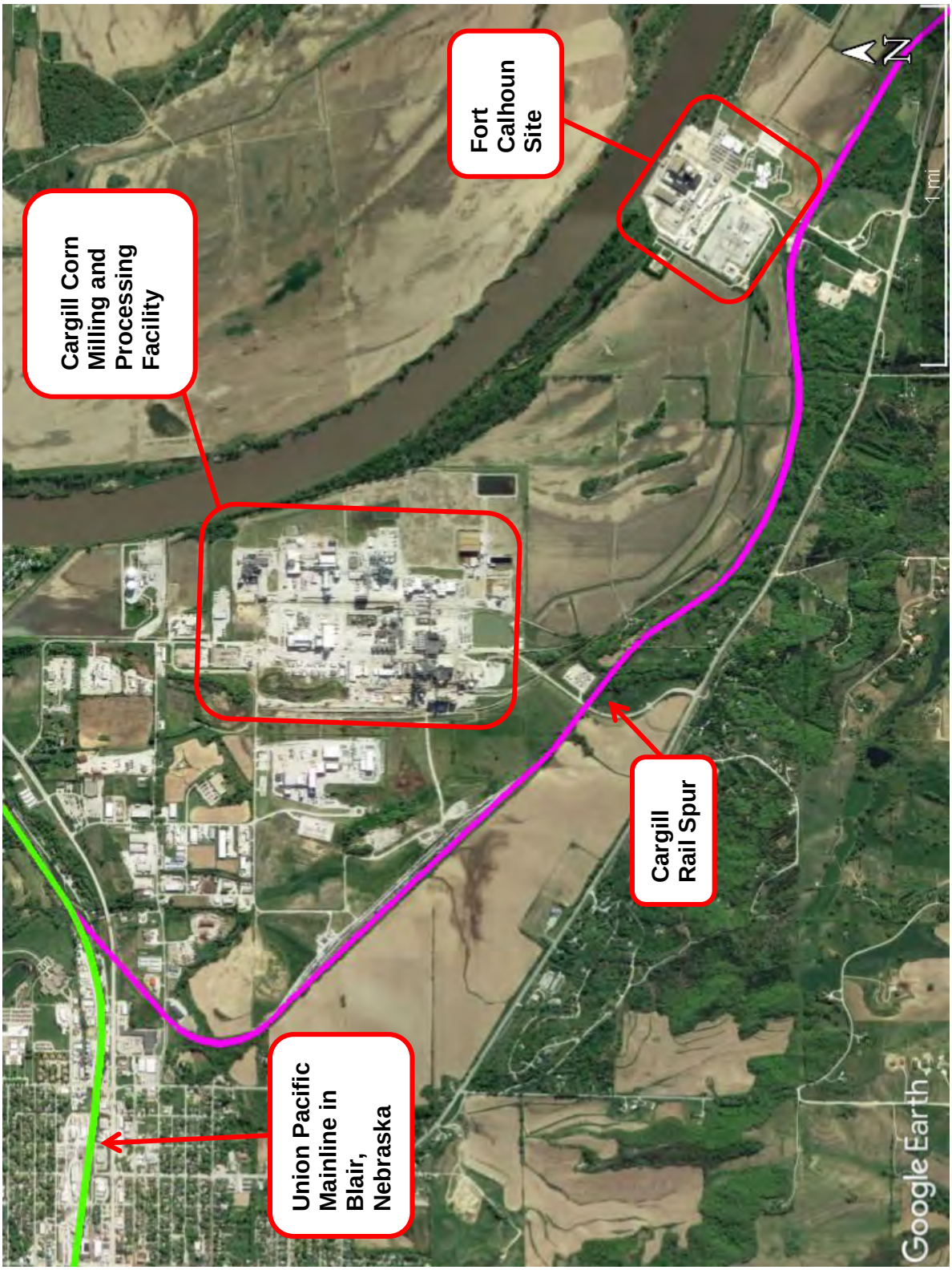


Figure 2-339. Cargill Industrial Spur (Google 2019)



Figure 2-340. Cargill Industrial Spur (Looking Northwest) (2017)



Figure 2-341. Cargill Industrial Spur (Looking Southeast) (2017)



Figure 2-342. Rail, Concrete Ties, and Pandrol Clips on Cargill Industrial Spur (2017)

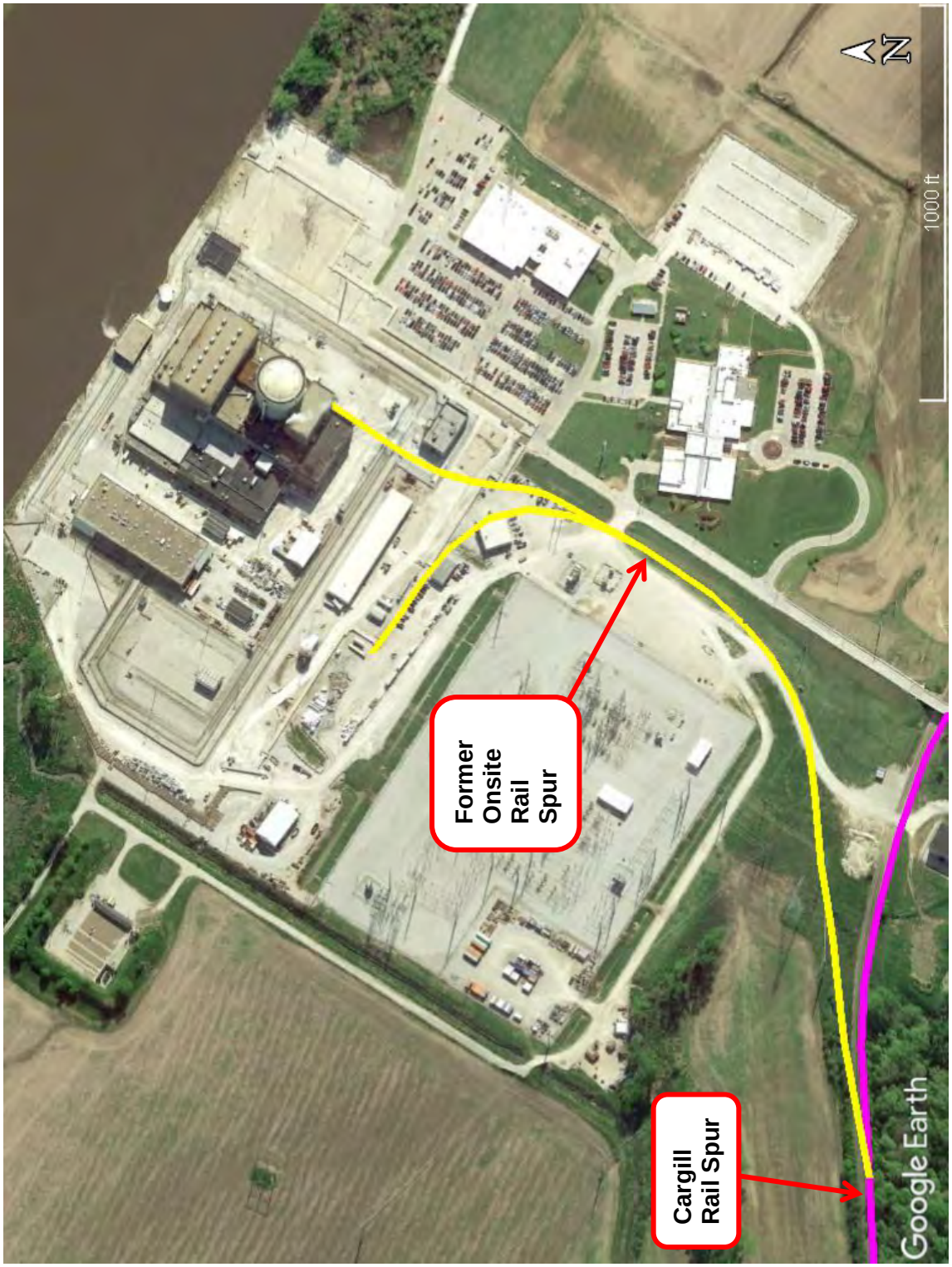


Figure 2-343. Former On-site Rail Spur at Fort Calhoun (Google 2019)

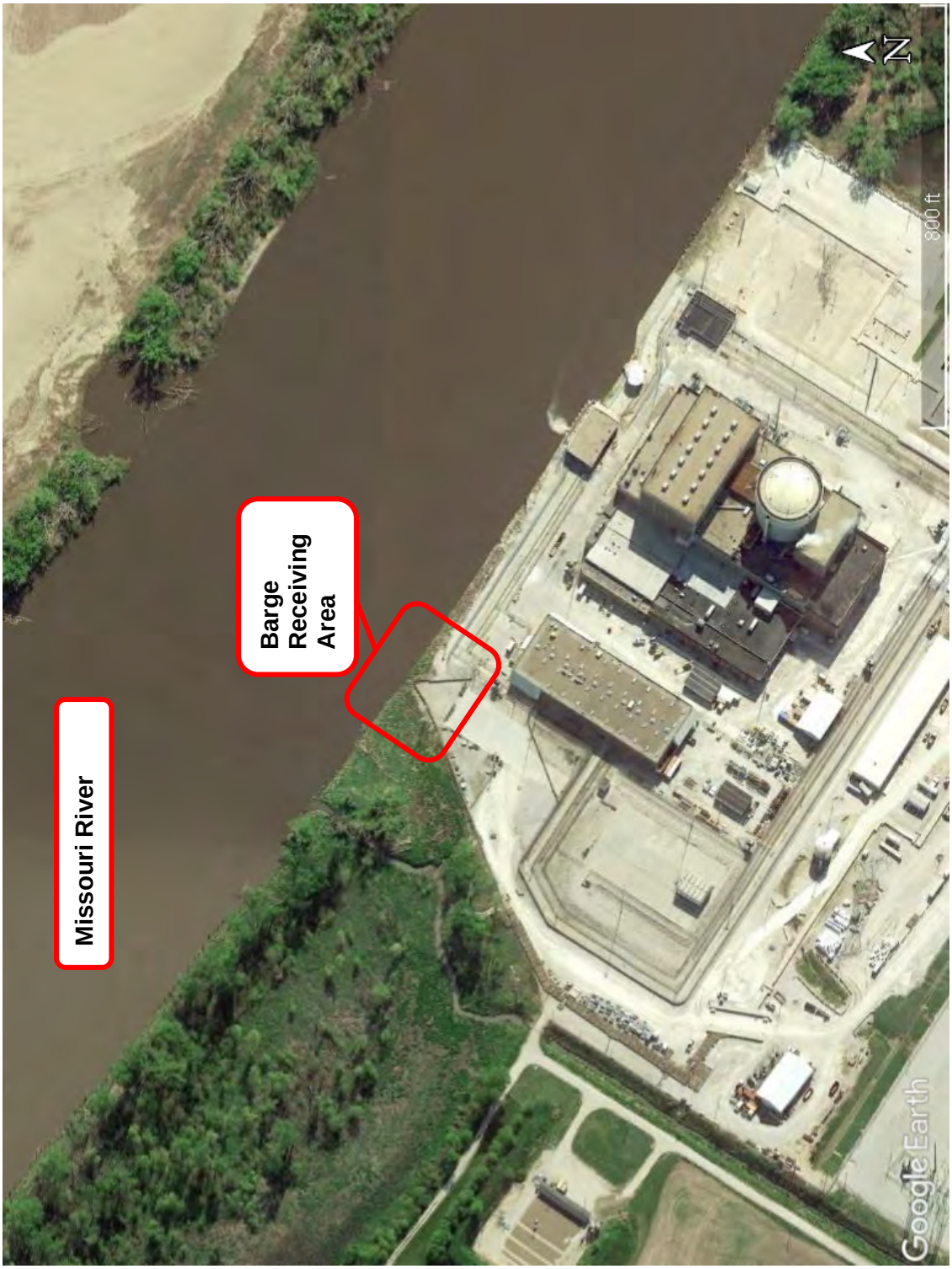


Figure 2-344. Aerial View of Barge Area at Fort Calhoun (Google 2019)

2.14.3 Near-site Transportation Infrastructure and Experience

As mentioned in Section 2.14.2, rail service to the Fort Calhoun site is provided by the Union Pacific Railroad through the Cargill Industrial Spur which connects to the mainline in Blair, Nebraska. In the vicinity of Blair, the Union Pacific Railroad mainline is track class 3. Figure 2-345 and Figure 2-346 show the track at the entrance to the Cargill Industrial Spur (looking south and north, respectively) and Figure 2-347 shows the derailer at the entrance to the spur. At the north end of the spur, Cargill maintains a railyard. North of the Cargill railyard, there is a 7.5-8 degree curve (716-764 ft. radius) (see Figure 2-348). At the entrance to the Cargill yard, there is a derailer and a greaser (see Figure 2-349). Greasers are installed before curves to lubricate the inside of a rail head to reduce wear on the rail and function by dispensing a small amount of grease as the flange of a wheel passes the activator. Figure 2-350 provides a close-up of the greaser and its activators. Figure 2-351 and Figure 2-352 shows the junction of the Cargill Industrial Spur and the Union Pacific Railroad at Blair, Nebraska, looking south and north, respectively.



Figure 2-345. Track at Entrance to Cargill Industrial Spur (Looking South) (2017)



Figure 2-346. Track at Entrance to Cargill Industrial Spur (Looking North) (2017)



Figure 2-347. Derailer at Entrance to Cargill Industrial Spur (2017)

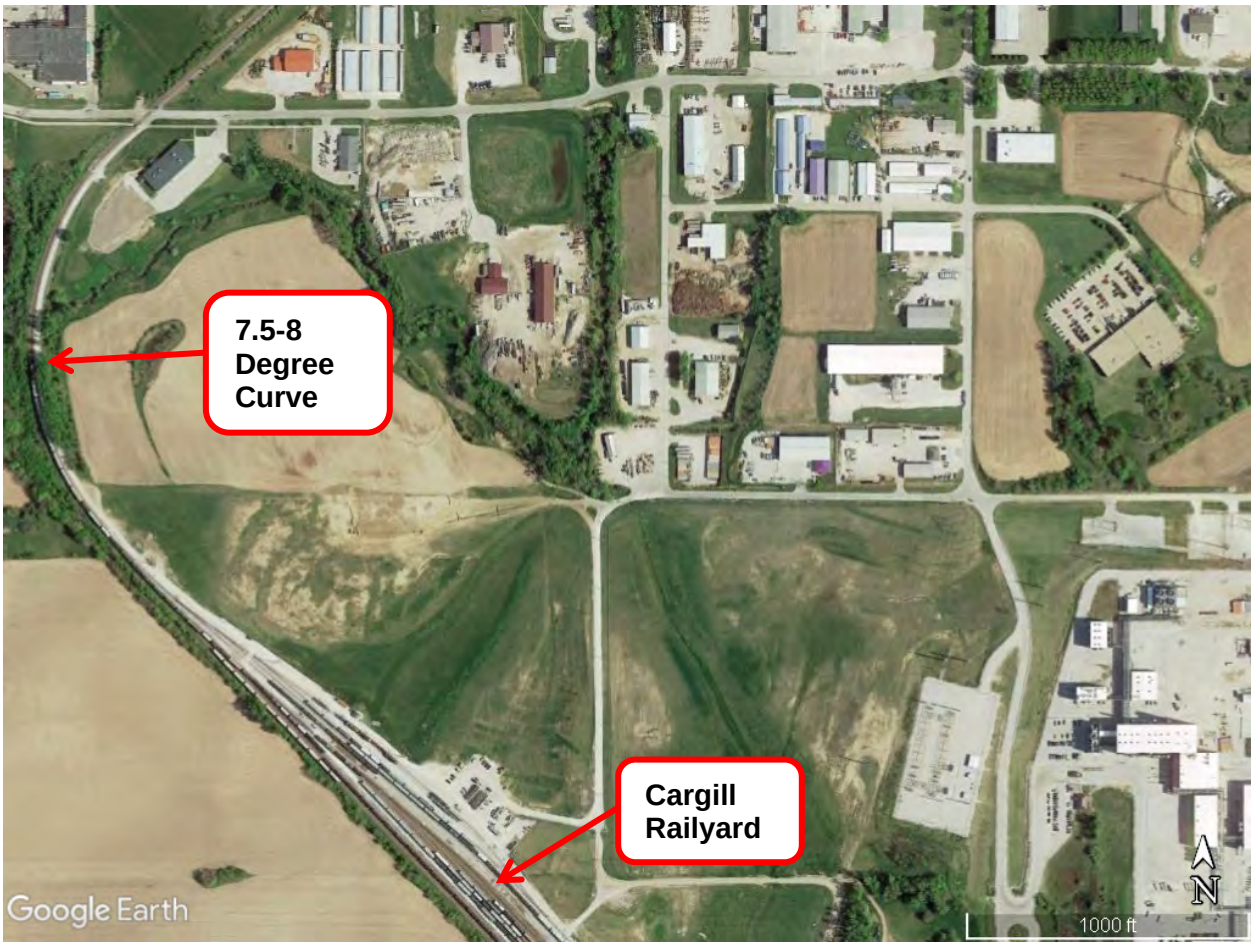


Figure 2-348. Cargill Railyard and 7.5-8 Degree Curve on the Cargill Industrial Spur (Google 2019)



Figure 2-349. Derailer and Greaser on Cargill Industrial Spur (2017)



Figure 2-350. Close-up of Greaser Activators on Cargill Industrial Spur (2017)



Photo courtesy of Federal Railroad Administration

Figure 2-351. Track at Junction of Cargill Industrial Spur and Union Pacific Railroad (Looking South) (2017)



Photo courtesy of Federal Railroad Administration

Figure 2-352. Track at Junction of Cargill Industrial Spur and Union Pacific Railroad (Looking North) (2017)

In 2006, ten horizontal storage modules were shipped to the Fort Calhoun site by rail. The horizontal storage modules were transported using 112-ton, 70-foot deck, 4-axle Kasgro flat cars. Each horizontal storage module weighed 178,000 lb., and had a length of 20.7 feet, a width of 9.7 feet, and a height of 14.8 feet. Figure 2-353 shows the horizontal storage modules being transported by rail; Figure 2-354 shows the horizontal storage modules being delivered; Figure 2-355 provides an aerial view of the transload location and haul road, which was located on the Fort Calhoun site; Figure 2-356 shows a horizontal storage module being transloaded onto a self-propelled modular transporter; Figure 2-357 shows two horizontal storage modules being moved on the haul road to the Fort Calhoun ISFSI; Figure 2-358 shows the horizontal storage modules being installed at the ISFSI; and Figure 2-359 shows the completed ISFSI. Figure 2-360 and Figure 2-361 show the current condition of the transload location and haul road, respectively.



Photo courtesy of Fort Calhoun

Figure 2-353. Horizontal Storage Modules Being Transported by Rail to Fort Calhoun



Photo courtesy of Fort Calhoun

Figure 2-354. Horizontal Storage Modules Being Delivered to Fort Calhoun

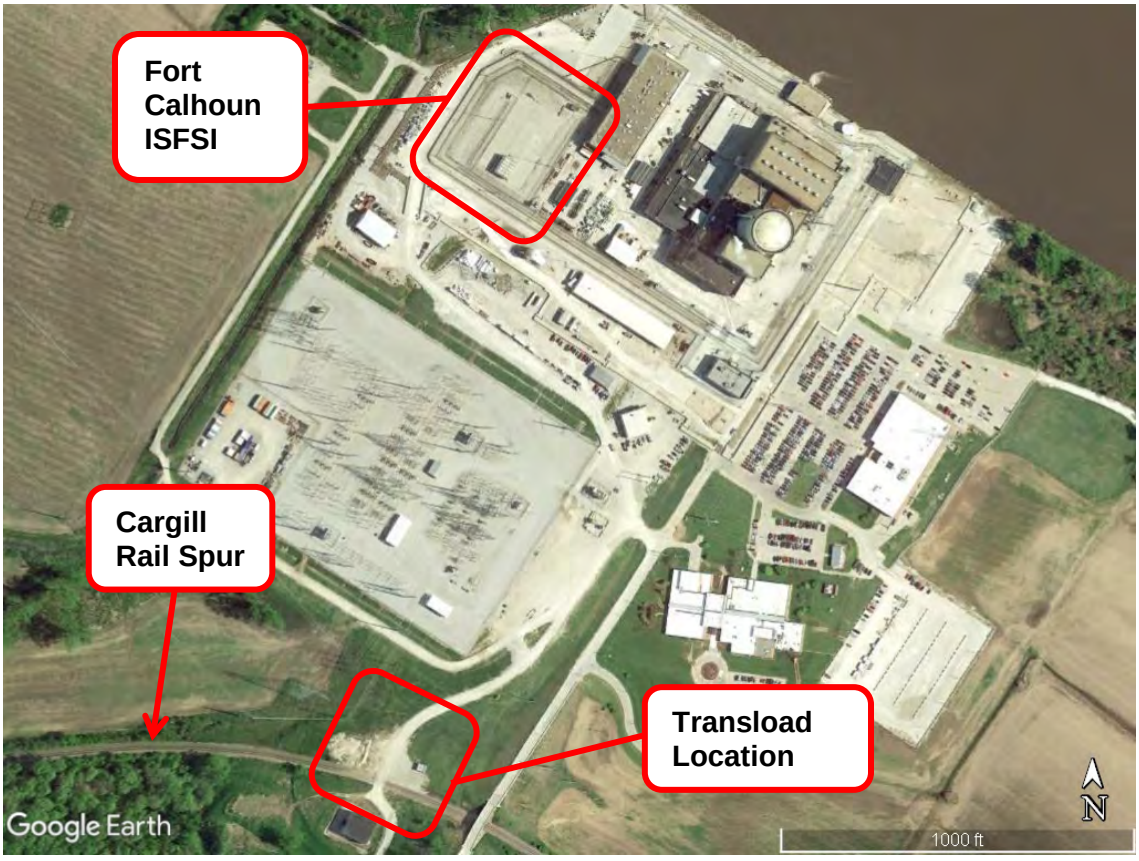


Figure 2-355. Aerial View of Transload Location (Google 2019)



Photo courtesy of Fort Calhoun

Figure 2-356. Horizontal Storage Module Being Transloaded from Railcar to Self-Propelled Modular Transporter



Photo courtesy of Fort Calhoun

Figure 2-357. Horizontal Storage Modules Being Moved on Haul Road to Independent Spent Fuel Storage Installation



Photo courtesy of Fort Calhoun

Figure 2-358. Installation of Horizontal Storage Modules at Independent Spent Fuel Storage Installation



Photo courtesy of Fort Calhoun

Figure 2-359. Completed Fort Calhoun Independent Spent Fuel Storage Installation



Figure 2-360. Current Condition of Transload Location (2017)



Figure 2-361. Current Condition of Haul Road (2017)

The Fort Calhoun site has also received large equipment by barge. On the Missouri River between Fort Calhoun (Missouri River Mile 646) and St. Louis (Missouri River Mile 0), there is a 9-foot-deep and 300-foot-wide navigation channel and no locks or dams. Harsh winter weather and low water levels on the Missouri River in the summer could limit the use of barge transport at the Fort Calhoun site.

During construction, the reactor vessel and steam generators were shipped by barge (see Figure 2-362 and Figure 2-363). In 2006, two steam generators, the pressurizer, and the reactor vessel head were shipped to the Fort Calhoun site by barge. Each steam generator weighed approximately 310 tons and measured approximately 55 ft. x 19.5 ft. x 17.5 ft. The pressurizer weighed approximately 67 tons, and measured approximately 28.5 ft. x 10 ft. x 10 ft. The reactor vessel head weighed approximately 65 tons, and measured approximately 14 ft. x 14 ft. x 12 ft.

The two steam generators, pressurizer, and reactor vessel head were shipped from Japan to New Orleans, loaded onto a barge, and towed from New Orleans to Fort Calhoun on the Mississippi and Missouri Rivers via Memphis, St. Louis, and Omaha.

At Fort Calhoun, two tugboats and two bulldozers stabilized the barge for unloading. Temporary ramps were used to unload the barge. Figure 2-364 shows the two steam generators, pressurizer, and reactor vessel head on the barge. Figure 2-365 and Figure 2-366 show the two tugboats and two bulldozers stabilizing the barge for unloading. Figure 2-367 shows the barge approaching the unloading area, Figure 2-368 shows the installation of the temporary ramps used for unloading, and Figure 2-369 shows a steam generator on a transporter after unloading from the barge.



Photo courtesy of Fort Calhoun

Figure 2-362. Reactor Vessel Being Shipped by Barge During Construction

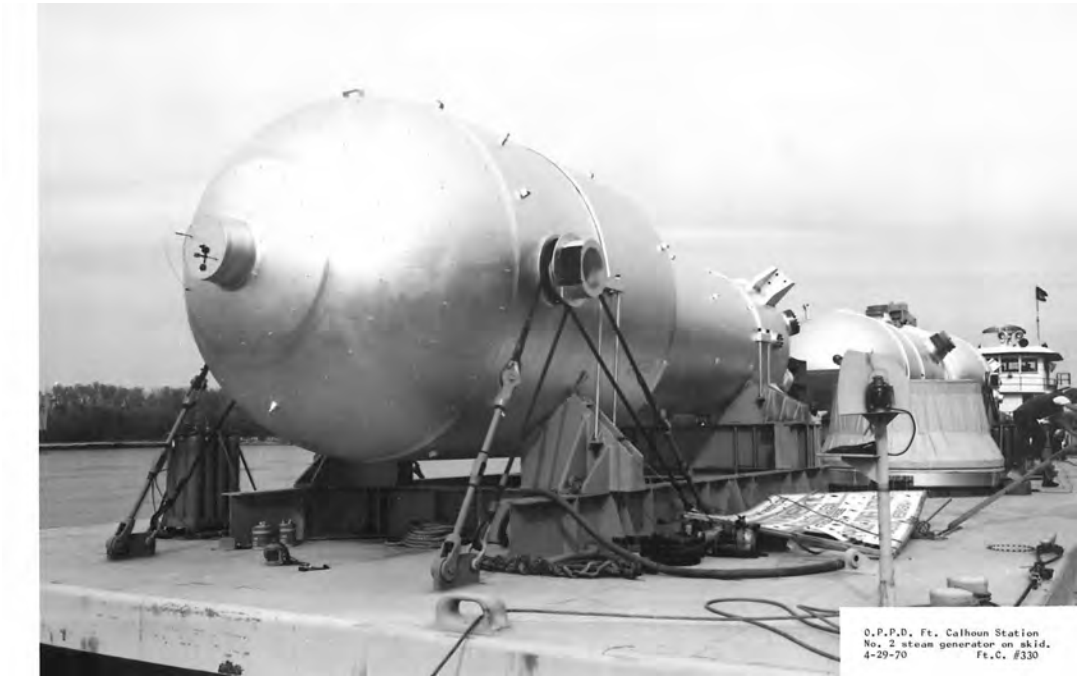


Photo courtesy of Fort Calhoun

Figure 2-363. Steam Generators Being Shipped by Barge During Construction



Photo courtesy of Fort Calhoun

Figure 2-364. Steam Generators, Pressurizer, and Reactor Vessel Head Being Shipped by Barge (2006)



Photo courtesy of Fort Calhoun

Figure 2-365. Tugboats Stabilizing Barge for Unloading (2006)



Photo courtesy of Fort Calhoun

Figure 2-366. Bulldozers Stabilizing Barge for Unloading (2006)



Photo courtesy of Fort Calhoun

Figure 2-367. Preparing to Unload Barge (2006)



Photo courtesy of Fort Calhoun

Figure 2-368. Installation of Temporary Ramps for Unloading (2006)



Photo courtesy of Fort Calhoun

Figure 2-369. Steam Generator on Transporter After Unloading (2006)

2.14.4 Future Information Needs

Direct rail access to the Fort Calhoun site is provided through the Union Pacific Railroad and the Cargill Industrial Spur, so heavy haul truck transport of SNF and GTCC waste to an off-site transload location is unlikely. However, an agreement with Cargill will be necessary to use the rail spur. It is also not known whether an on-site heavy haul and on-site transload would be performed, or if an on-site rail spur would be reinstalled from the Cargill Industrial Spur directly into the Fort Calhoun site. An on-site rail spur could also be used to support shipping of radioactive and nonradioactive waste from decommissioning.

The Fort Calhoun site has recent experience shipping large equipment by barge, and transport of SNF and GTCC waste by barge is also possible; however, the barge area at Fort Calhoun is unimproved.

2.15 Oyster Creek

This section describes the inventory of SNF, site conditions, near-site transportation infrastructure and experience, and future information needs for the Oyster Creek site. The site is located in Lacey Township in eastern New Jersey adjacent to Barnegat Bay, approximately 9 miles south of Toms River, New Jersey, 60 miles south of Newark, New Jersey, 35 miles north

of Atlantic City, New Jersey, and 50 miles east of Philadelphia, Pennsylvania (TOPO 1993g, NRC 2007c).

2.15.1 Site Inventory

Oyster Creek was a 1930 MW thermal/619 MW electric boiling water reactor (BWR) and was originally licensed in 1969. The Oyster Creek license was renewed in 2009 for 20 years. The Oyster Creek site permanently ceased power operations on September 17, 2018 and fuel was permanently removed from the Oyster Creek reactor vessel on September 25, 2018 (Gallagher 2018).

There are a total of 4504 BWR SNF assemblies (796.7 MTHM) stored at Oyster Creek, of which 2074 fuel assemblies are stored in 34 Standardized NUHOMS dry storage systems (Docket No. 72 1004) in 61BT and 61BTH dry storage canisters. These canisters can be shipped in the MP197HB transportation cask (Docket No. 71-9302). In addition to the SNF in dry storage, 2430 fuel assemblies and 17 individual fuel pins are stored in the spent fuel pool. The 2430 fuel assemblies and 17 fuel pins currently stored in the spent fuel pool will be stored in 33 HI-STORM FW dry storage systems (Docket No. 72-1032) in MPC-89 dry storage canisters. These canisters can be shipped in the HI-STAR 190 transportation cask (Docket No. 71-9373). Two to four additional canisters containing GTCC waste could also be generated.

Figure 2-370 illustrates the number of SNF assemblies at Oyster Creek based on their discharge year. The oldest fuel was discharged in 1971 and the last fuel was discharged in 2018. The median discharge year of the fuel is 1998.

Figure 2-371 illustrates the number of SNF assemblies at Oyster Creek based on their burnup. The lowest burnup is 4.5 GWd/MTHM and the highest burnup is 49.5 GWd/MTHM. The median burnup is 32.1 GWd/MTHM. There are 241 SNF assemblies at Oyster Creek that have burnups greater than 45 GWd/MTHM. These 241 fuel assemblies are classified by the U.S. Nuclear Regulatory Commission (NRC) as high burnup SNF.

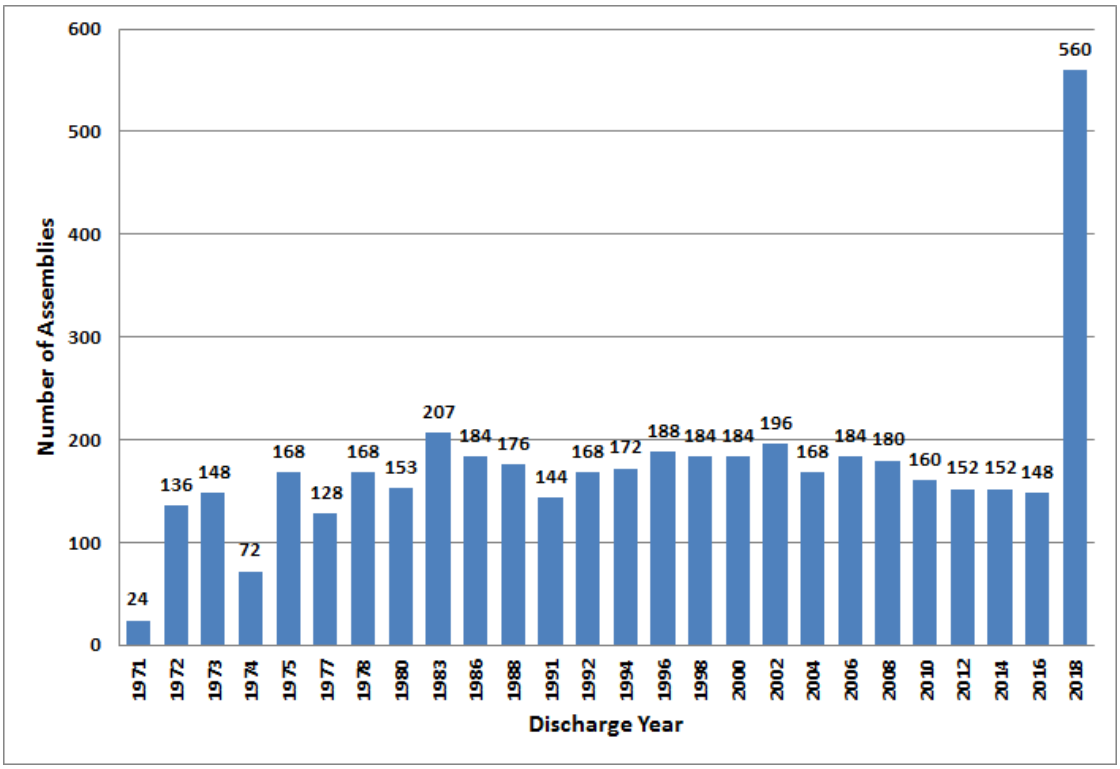


Figure 2-370. Oyster Creek Number of Assemblies versus Discharge Year

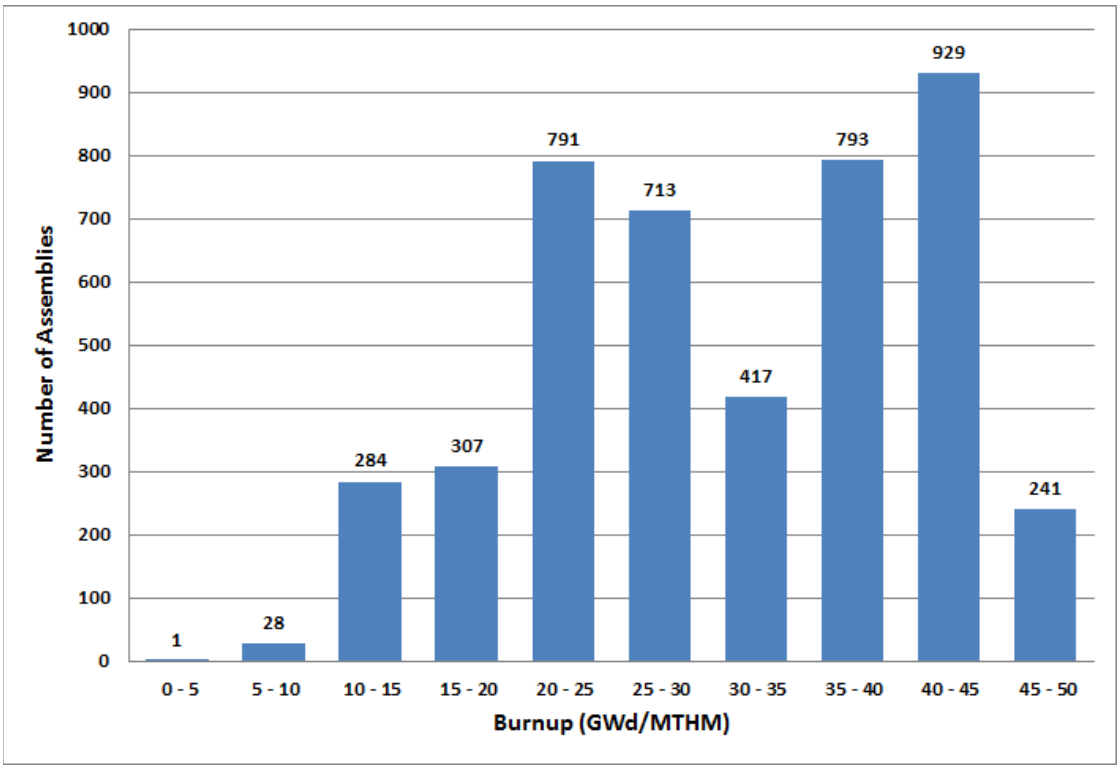


Figure 2-371. Oyster Creek Number of Assemblies versus Burnup

2.15.2 Site Conditions

Figure 2-372 provides an aerial view of the Oyster Creek site. The Oyster Creek Independent Spent Fuel Storage Installation (ISFSI) is located at the eastern edge of the Oyster Creek site. Figure 2-373 provides an aerial view of the Oyster Creek ISFSI and Figure 2-374 provides a ground-level view of the ISFSI.

Barge access to the Oyster Creek site is provided at two locations on the site, on the north and south banks of Oyster Creek at the US Route 9 bridge (see Figure 2-372 and Figure 2-375). Figure 2-376 shows the current conditions of the barge access location on the north bank of Oyster Creek, Figure 2-377 shows the barge access road, Figure 2-378 shows the barge access location on the south bank of Oyster Creek and Figure 2-379 shows Oyster Creek looking east from U.S. Route 9 bridge.

These locations were used to ship the 622-ton reactor vessel to Oyster Creek by barge in 1966, a 200-ton transformer to Oyster Creek in 1989, two 200-ton transformers to Oyster Creek in 2010, and one 200-ton transformer from Oyster Creek in 2011. In 1996, a barge carrying ten 100-ton horizontal storage modules to Oyster Creek ran aground in Barnegat Bay (Sheehan and Ortega 1996).

Oyster Creek is located between U.S. Route 9 and the Garden State Parkway. Figure 2-380 shows a potential heavy haul truck route from the Oyster Creek site to the Garden State Parkway. Figure 2-381 shows the potential heavy haul truck route to the Garden State Parkway looking east and Figure 2-382 shows the potential heavy haul truck route looking west at the Garden State Parkway. For this route to be used by heavy haul trucks, the route would require improvement and access to the Garden State Parkway would need to be established.

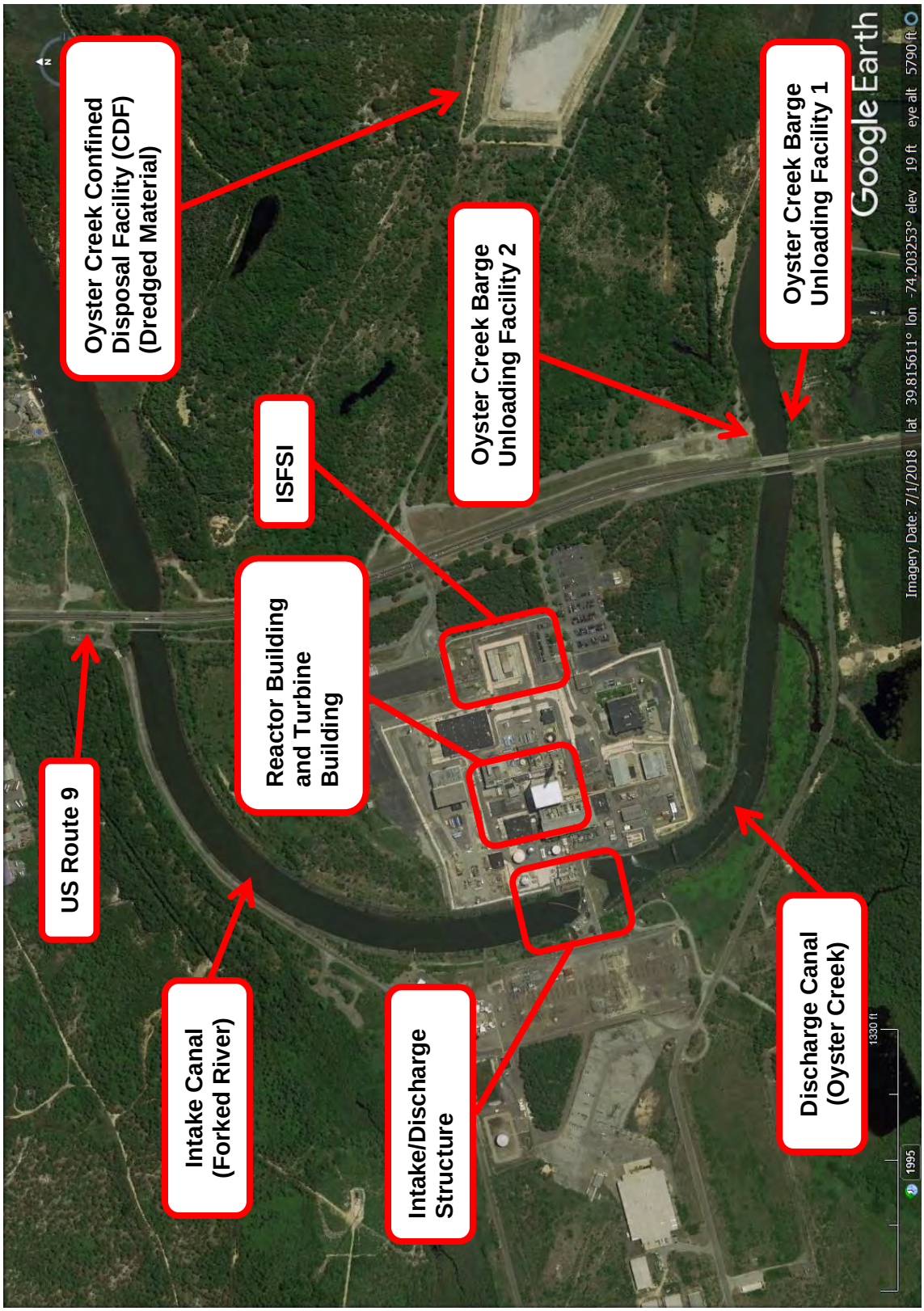


Figure 2-372. Aerial View of Oyster Creek Site (Google 2019)



Figure 2-373. Aerial View of Oyster Creek Independent Spent Fuel Storage Installation (Google 2019)



Figure 2-374. Ground-Level View of Oyster Creek Independent Spent Fuel Storage Installation (2019)

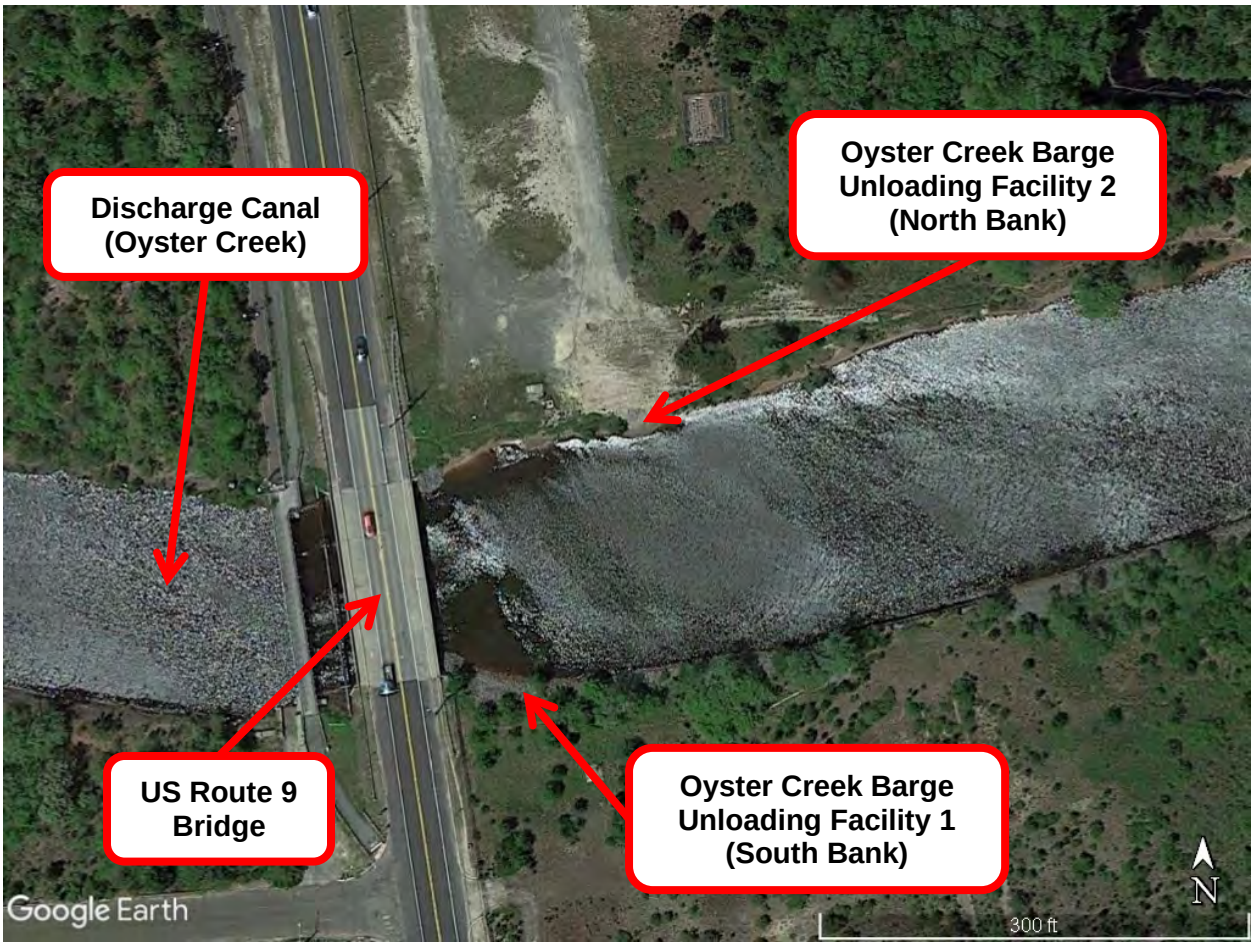


Figure 2-375. Aerial View of Oyster Creek Barge Locations (Google 2019)



Figure 2-376. Oyster Creek Barge Access (North Bank of Oyster Creek) (2019)



Figure 2-377. Oyster Creek Barge Access Road Looking North (2019)



Figure 2-378. Oyster Creek Barge Access Location on the South Bank of Oyster Creek (2019)



Figure 2-379. Oyster Creek Looking East from U.S. Route 9 Bridge (2019)

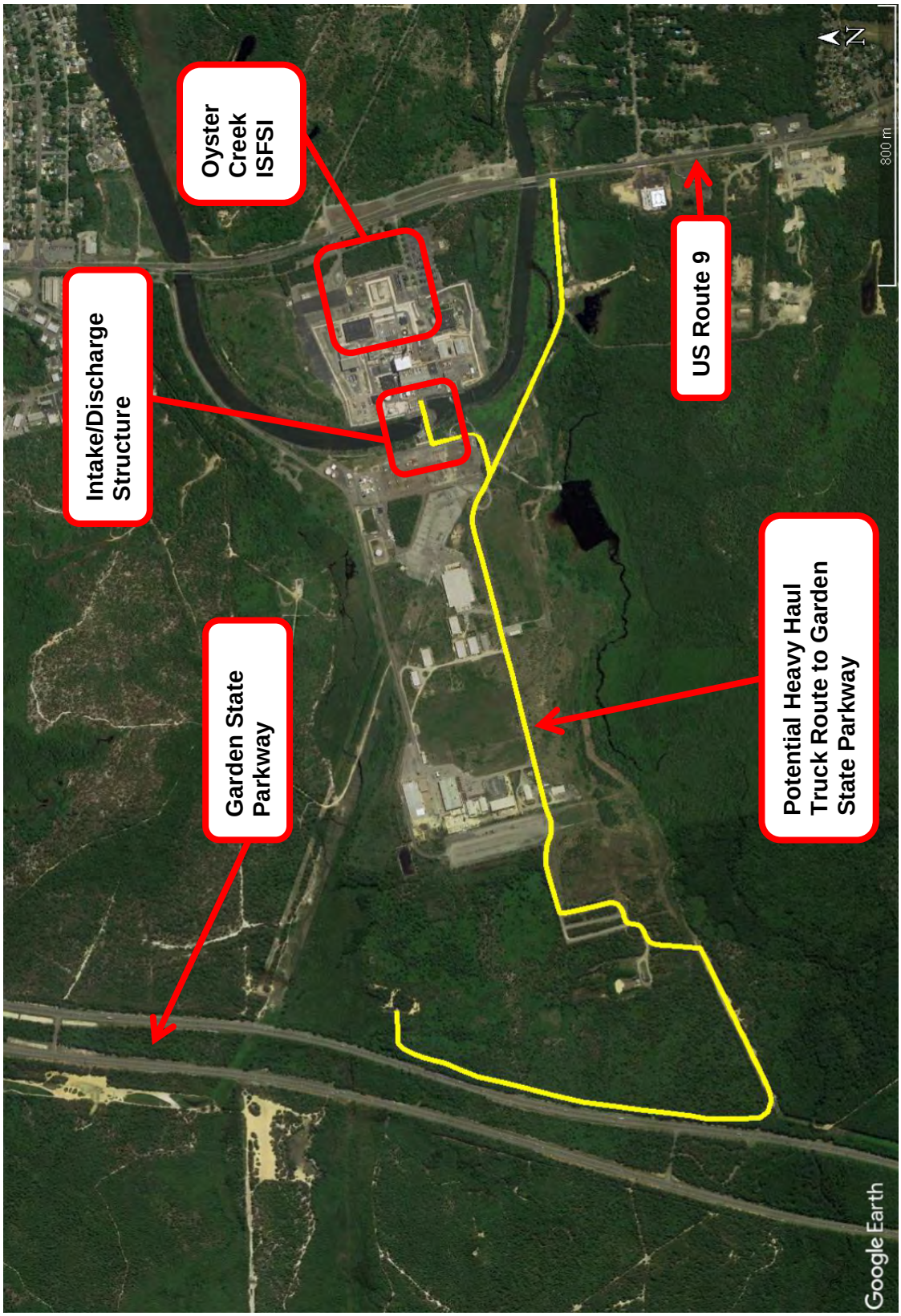


Figure 2-380. Aerial View of Potential Heavy Haul Truck Route to Garden State Parkway (Google 2019)



Figure 2-381. Potential Heavy Haul Truck Route to Garden State Parkway Looking East (2019)



Figure 2-382. Potential Heavy Haul Truck Route Looking West Towards Garden State Parkway (2019)

2.15.3 Near-site Transportation Infrastructure and Experience

Oyster Creek does not currently have rail service. During construction, rail service was provided from Toms River, New Jersey. This rail line is abandoned. The Oyster Creek site has used locations in Freehold and Lakehurst, New Jersey for truck-to-rail transloads (see Figure 2-383). These locations are served by the Conrail Railroad.

Freehold is about 70 miles from Oyster Creek and Lakehurst is about 30 miles from Oyster Creek. Access to these locations was provided via heavy haul truck transport. The Freehold transload location was used to ship two 150-ton transformers by rail to Philadelphia and Bradenton, Florida in 1989 for repair, and to ship one 150-ton transformer by rail from Bradenton, Florida in 1990. The Lakehurst transload location was used to ship a 235-ton transformer by rail in 1989.

Figure 2-384 and Figure 2-385 show the rail line in Lakehurst, New Jersey looking northeast and the end of the rail line in Lakehurst, respectively. Figure 2-386 and Figure 2-387 show the rail line in Freehold, New Jersey looking northwest and southeast, respectively. Figure 2-388 shows the end of the rail line in Freehold, New Jersey.

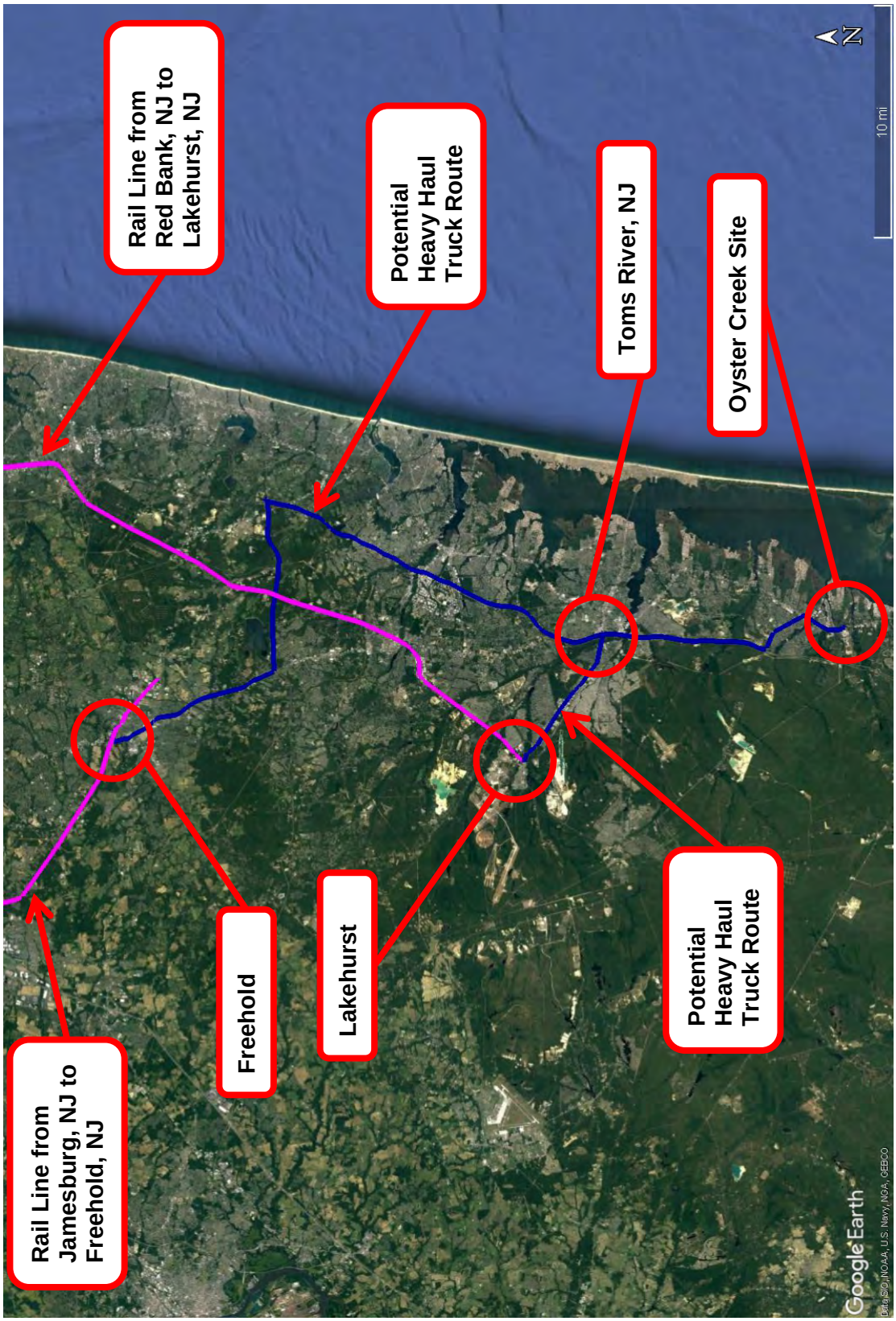


Figure 2-383. Potential Oyster Creek Rail Access Locations (Google 2019)



Figure 2-384. Rail Line in Lakehurst, New Jersey Looking Northeast (2019)



Figure 2-385. End of Rail Line in Lakehurst, New Jersey Looking Northeast (2019)



Figure 2-386. Rail Line in Freehold, New Jersey Looking Northwest (2019)



Figure 2-387. Rail Line in Freehold, New Jersey Looking Southeast (2019)



Figure 2-388. End of Rail Line in Freehold, New Jersey Looking Northwest (2019)

Conrail Railroad staff stated that the Freehold and Lakehurst locations were no longer viable transload locations and recommended evaluating the Conrail Railyard in Morrisville, Pennsylvania as an alternative transload location. This location is northwest of and approximately 57 to 69 miles from the Oyster Creek site (see Figure 2-389). A heavy haul truck route to this location would also require crossing the Delaware River, which is the border between New Jersey and Pennsylvania.

Figure 2-390 provides an aerial view of the Morrisville Railyard, Figure 2-391 shows the Morrisville Railyard looking east, Figure 2-392 shows a potential transload location on a rail spur at the Morrisville Railyard, Figure 2-393 shows the 131-lb. rail at the Morrisville Railyard, and Figure 2-394 shows the access road to the Morrisville Railyard.

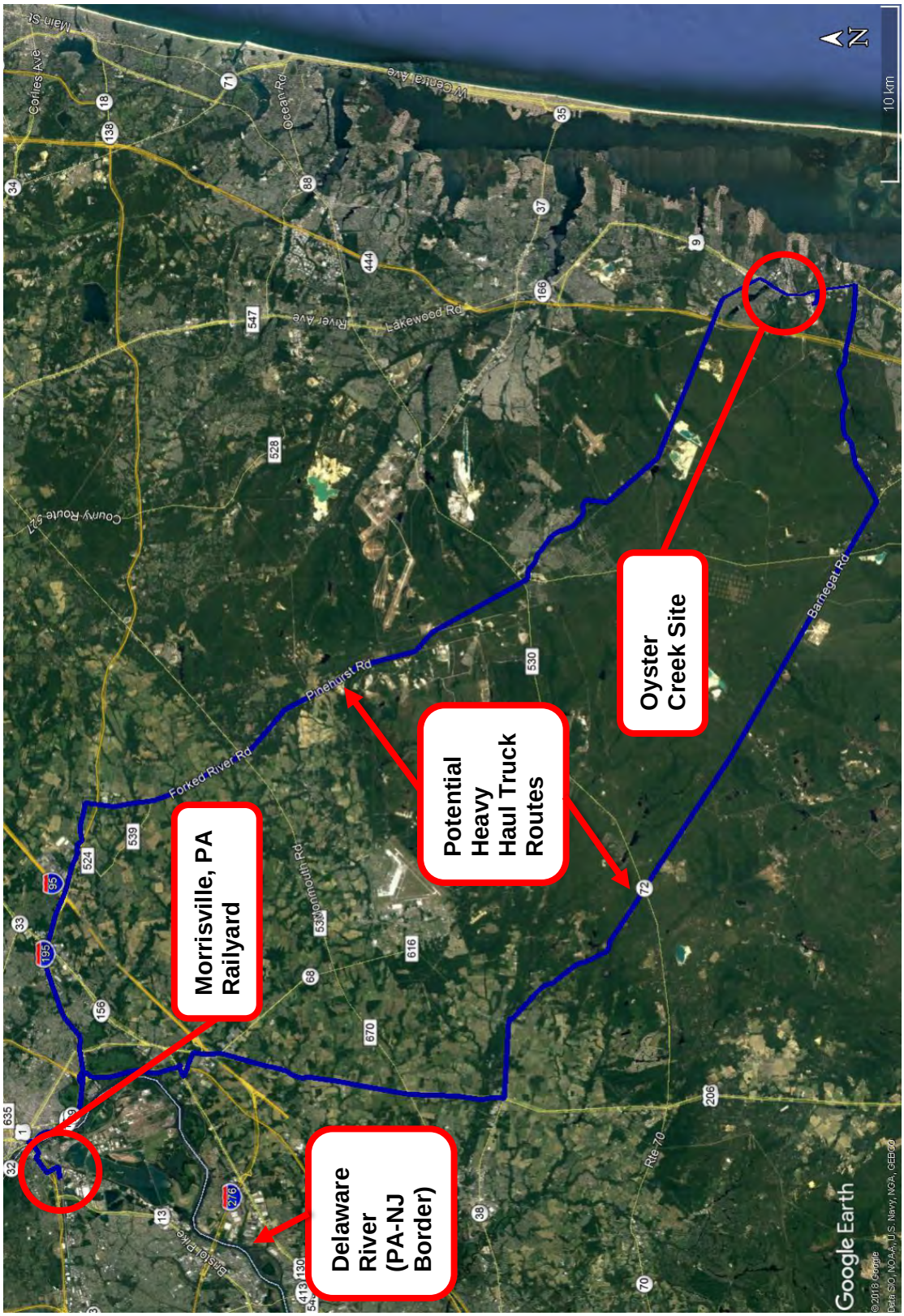


Figure 2-389. Location of Morrisville, Pennsylvania Railyard and Potential Heavy Haul Truck Routes from Oyster Creek (Google 2019)



Figure 2-390. Aerial View of the Morrisville, Pennsylvania Railyard (Google 2019)



Figure 2-391. Morrisville Railyard Looking East (2019)



Figure 2-392. Potential Transload Location at Morrisville Railyard (2019)



Figure 2-393. 131-lb. Rail at Morrisville Railyard (2019)



Figure 2-394. Morrisville Railyard Access Road (2019)

As mentioned previously, Oyster Creek has barge access to the Atlantic Ocean through the Barnegat Bay Inlet. Figure 2-395 provides an aerial view of the Oyster Creek State and federal channels, the Forked River State channel, the Intracoastal Waterway, and the Barnegat Bay inlet channel. Figure 2-396 shows the entrance to Barnegat Bay Inlet. The Oyster Creek channel is maintained at a depth of about 6 feet below mean low water (MLW) by the New Jersey Department of Transportation (NJDOT). Key waterways beyond the immediate boundary of the Oyster Creek site are located within Barnegat Bay and include the Intracoastal Waterway, the Oyster Creek channel, and Barnegat Bay Inlet, all of which are federal navigation channels maintained by the U.S. Army Corps of Engineers (USACE) at approximately 6 feet, 8 feet, and 8 feet, respectively, below MLW. The ocean bar beyond Barnegat Bay Inlet (not depicted in Figure 2-395) is also a federal navigation channel maintained at about 10 feet below MLW by USACE.

The Forked River State navigation channels were dredged in 2017 (Becker et al. 2019) and NJDOT typically conducts depth studies of Oyster Creek every 2 to 3 years. The Oyster Creek (federal) channel is typically dredged every 8 to 10 years, with the condition of the channel determining how often it is dredged. However, the existing depths (and widths) of these and the other State and federal navigation channels noted above are unknown and could be less than the maintained depths (and widths) due to frequent sediment deposition attributed to the geology of the Coastal Plain and to shoaling processes. For example, during severe winter weather, the width of the Oyster Creek channel (federal) may shrink from 75 feet to 30 feet, and depth may be reduced to 3 to 5 feet, with barge transport potentially requiring a 60-foot width and a greater depth (Becker et al. 2019).

In addition to depth and width of the waterways, a variety of conditions may impact potential dredging and barging activities. These include weather conditions, seasonal limitations, barge traffic, and potential restrictions due to seasonal fish spawning activities. Since the Oyster Creek site is no longer operating (resulting in an absence of heated cooling water discharge), Oyster Creek may freeze over for brief periods during winter. Barnegat Bay and the Forked River have frozen over periodically in winter regardless of the operational status of the Oyster Creek site. Such weather conditions may temporarily curtail dredging activities, restricting dredging to ice-free periods. The most suitable weather for dredging is generally June through August; however, this is also the period of greatest barge traffic in Barnegat Bay. Further, in-water work may need to be done outside time periods established by the National Marine Fisheries Service to protect essential fish habitat for winter flounder (*Pseudopleuronectes americanus*) (January 1–May 31), and summer flounder (*Paralichthys dentatus*) (April 15–October 15) in areas with submerged aquatic vegetation located adjacent to channels. Such restrictions have been applied previously to dredging projects in the vicinity of Barnegat Bay (Becker et al. 2019), and it is noteworthy that NJDOT's dredging of the Oyster Creek channel in 2017 was completed between early October and December 31 (outside the time periods for protecting winter flounder and summer flounder). Additionally, local tides may affect the ability to conduct dredging and barging because tides cause the water level to vary +/- 1 foot, with greater fluctuations occurring during storms.

Maintenance dredging of the Oyster Creek State channel occurred April–May 1970 when 63,467 yd^3 of sediment were removed (Becker et al. 2019). GPU Nuclear, Inc., the former owner and operator of Oyster Creek site until 1999, acquired a Waterfront Development Permit/Water Quality Certification in 1997 for maintenance and new dredging (Becker et al. 2019). The permit

was valid until 2002 and authorized the removal of 85,485 yd^3 of sediment from the Forked River. For this permit, dredging in the Forked River was limited to a depth of 5 feet below MLW. Dredged materials generated from dredging activities at the Oyster Creek site were deposited in the Confined Disposal Facility (CDF), located east of the Oyster Creek site (see Figure 2-372). The NJDOT currently owns and operates the CDF; however, dredged materials may be reused or deposited elsewhere, such as the Sedge Islands in Barnegat Bay.

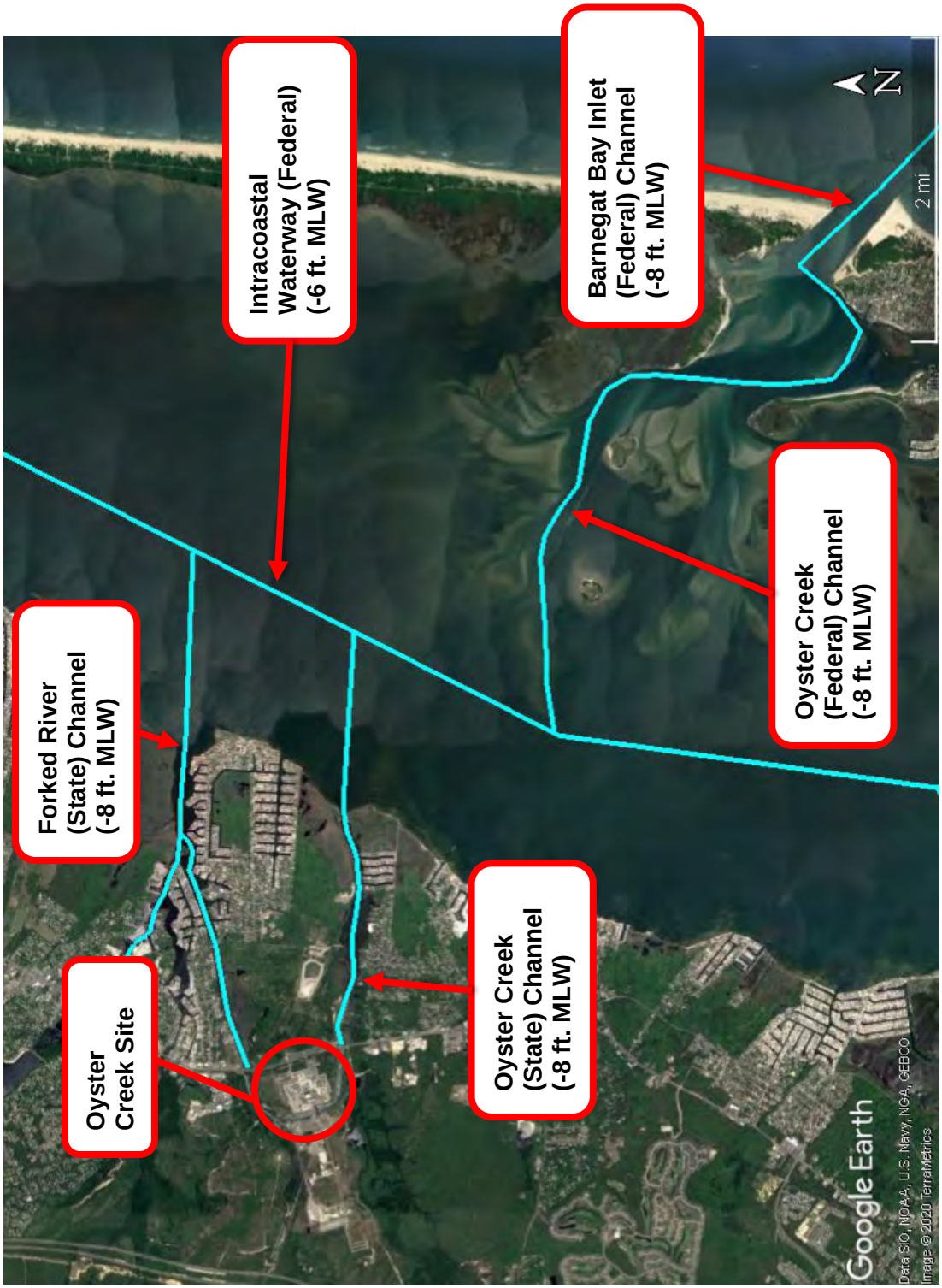


Figure 2-395. Aerial View of the Oyster Creek State and Federal Channels, the Intracoastal Waterway, and the Barnegat Bay Inlet Channel (Google 2019)



Figure 2-396. Entrance to Barnegat Bay Inlet (2019)

2.15.4 Future Information Needs

The Oyster Creek site does not have direct rail access. However, it does have two barge areas located on-site and has experience shipping large components by barge. Dredging of the Oyster Creek State and federal channels, the Intracoastal Waterway, and the Barnegat Bay Inlet federal channel could potentially be required to ship SNF from the Oyster Creek site by barge. Dredged materials generated from dredging activities at the Oyster Creek site could be deposited at the CDF located east of the Oyster Creek site; however, dredged materials may be reused or deposited elsewhere, such as the Sedge Islands in Barnegat Bay.

Three potential off-site heavy haul truck to rail transload locations were evaluated. Although two of the locations, Lakehurst and Freehold, New Jersey, have previously been used to move large equipment to and from the Oyster Creek site, Conrail Railroad staff, which operated freight services at these locations in the past, have stated that the Freehold and Lakehurst locations were no longer viable locations for transloading freight. This is due to factors such as the condition of the track at these locations, limited freight operational windows, and the presence of overhead electrified catenaries. The third transload location, the Conrail Railyard in Morrisville,

Pennsylvania, would require moving SNF transportation casks 57 to 69 miles by heavy haul truck to reach the transload location and would also require crossing the Delaware River, which is the border between New Jersey and Pennsylvania. In addition, a circuitious heavy haul route would likely be required to reach the Morrisville transload location because of overhead clearance obstacles (e.g., low bridges), road and bridge weight limits, and hazardous material restrictions.

2.16 Pilgrim

This section describes the inventory of SNF, site conditions, near-site transportation infrastructure and experience, and future information needs for the Pilgrim site. The Pilgrim site is located on the western shore of Cape Cod Bay in the Town of Plymouth, Massachusetts, about 38 miles southeast of Boston and 44 miles east of Providence, Rhode Island (TOPO 1994h, NRC 2007d).

2.16.1 Site Inventory

Pilgrim was a 2028 MW thermal/677 MW electric BWR originally licensed in 1972. The Pilgrim license was renewed in 2012 for 20 years. The Pilgrim site permanently ceased power operations on May 31, 2019, and fuel was permanently removed from the Pilgrim reactor vessel on June 9, 2019 (Sullivan 2019).

There are a total of 4114 BWR SNF assemblies (734.1 MTHM) stored at Pilgrim, of which 1156 fuel assemblies are stored in 17 HI-STORM dry storage systems (Docket No. 72-1014) in MPC-68 dry storage canisters and 748 fuel assemblies are stored in 11 HI-STORM dry storage systems in MPC-68M dry storage canisters. The remaining 2210 fuel assemblies will also be stored in HI-STORM dry storage systems. A total of 61 MPC-68 and MPC-68M canisters will eventually be stored at the Pilgrim site. Two additional canisters containing GTCC waste could also be generated.

The HI-STAR 100 transportation cask (Docket No. 71-9261) is certified to ship MPC-68 canisters. Transport of MPC-68M canisters, high burnup (> 45 GWd/MTHM) SNF, or GTCC waste is not authorized in the certificate of compliance for the HI-STAR 100. The certificate of compliance for either the HI-STAR 100MB (Docket No. 71-9378) or HI-STAR 100 could be revised to include these contents.

Figure 2-397 illustrates the number of SNF assemblies at Pilgrim based on their discharge year. The oldest fuel was discharged in 1973, and the last fuel was discharged in 2019. The median discharge year of the fuel is 1999.

Figure 2-398 illustrates the number of SNF assemblies at Pilgrim based on their burnup. The lowest burnup is 2.6 GWd/MTHM, and the highest burnup is 53.7 GWd/MTHM. The median burnup is 34.4 GWd/MTHM. There are 1443 SNF assemblies at Pilgrim that have burnups greater than 45 GWd/MTHM. These 1443 fuel assemblies are classified by the NRC as high burnup SNF.

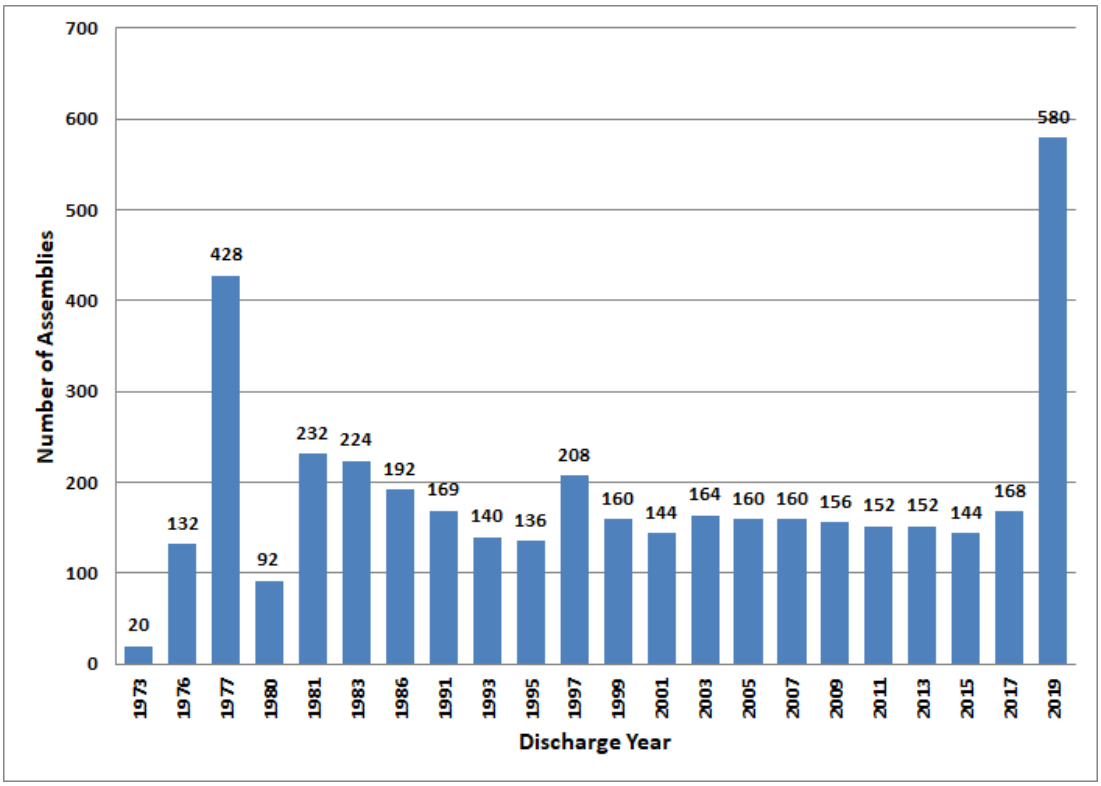


Figure 2-397. Pilgrim Number of Assemblies versus Discharge Year

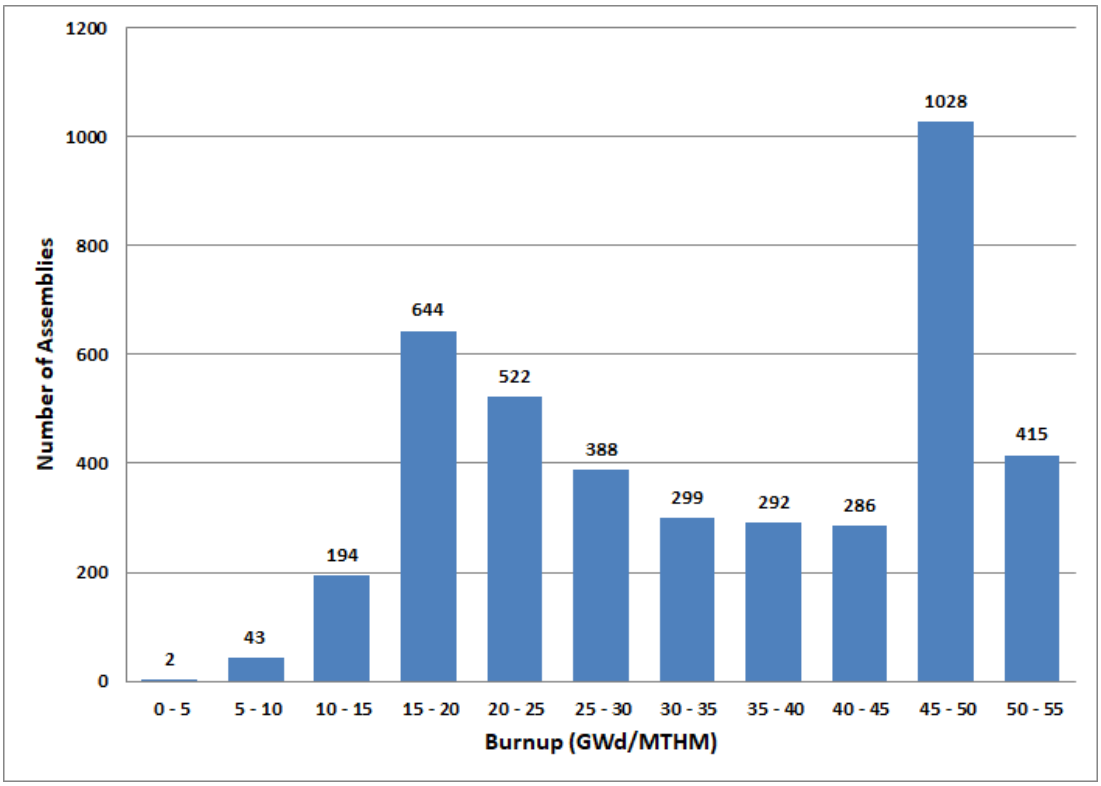


Figure 2-398. Pilgrim Number of Assemblies versus Burnup

2.16.2 Site Conditions

Figure 2-399 provides an aerial view of the Pilgrim site. The current Pilgrim ISFSI is located at the northwestern edge of the Pilgrim site (Figure 2-399, Figure 2-400 and Figure 2-401). A new ISFSI is currently being constructed at the Pilgrim site (see Figure 2-399, Figure 2-402, Figure 2-403, and Figure 2-404). The current ISFSI is located 25.5 feet above sea level; the new ISFSI will be located 75 feet above sea level. All dry storage canisters will be moved to this new ISFSI in 2021.

Barge access to the Pilgrim site is at the north end of the site on Cape Cod Bay (see Figure 2-405 and Figure 2-406). During construction, this location was used to receive the Pilgrim reactor pressure vessel. Although dredging of the Pilgrim intake channel was conducted during operations, the barge area was not regularly dredged. Refurbishment would be required to use this location for barge shipments of SNF and could involve dredging which would likely require multiple permits and may involve the Massachusetts Board of Underwater Archaeological Resources. Site-specific field surveys may be required to determine the extent of eelgrass (*Zostera marina*) beds, and the Massachusetts Division of Marine Fisheries recommends that all dredging activities should occur further than 25 feet from eelgrass beds (Ford et al. 2012). There could also be time of year restrictions on dredging due to potential impacts on species such as the winter flounder (*Pseudopleuronectes americanus*) and on shipping in Cape Cod Bay due to its use by North Atlantic right whales (*Eubalaena glacialis*). Disposal of dredged material would likely be at the Massachusetts Bay Disposal Site[24] or the Cape Cod Bay Disposal Site.[25]

[24] The Massachusetts Bay Disposal Site is located 12 nautical miles southeast of Gales Point, Massachusetts. Water depths at this location range from 269 to 302 feet.

[25] The Cape Cod Bay Disposal Site is located 8.0 nautical miles southwest of Long Point, Provincetown, Massachusetts. Water depths at this location average 102 feet.

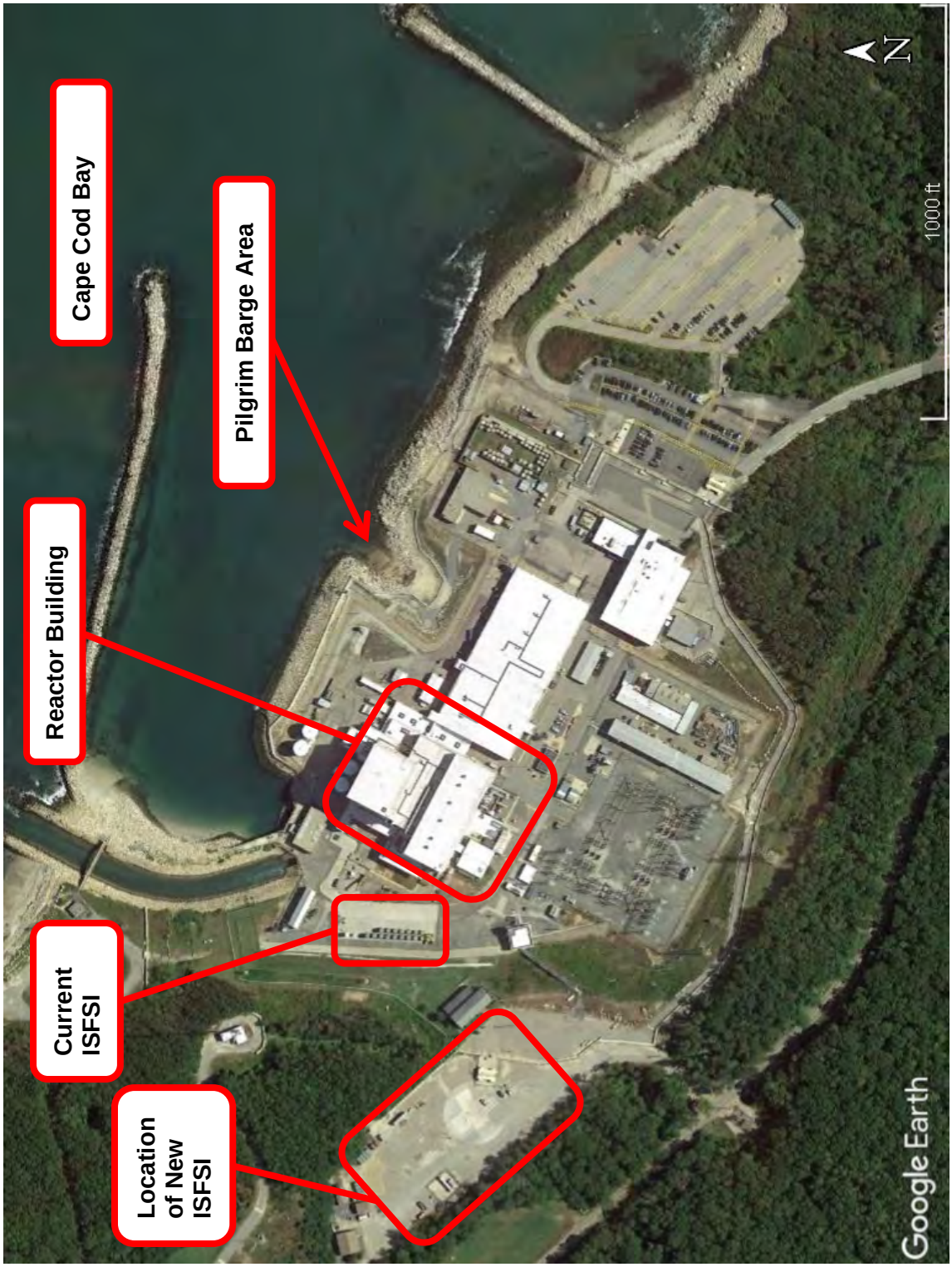


Figure 2-399. Aerial View of Pilgrim Site (Google 2019)



Figure 2-400. Current Pilgrim Independent Spent Fuel Storage Installation (2019)



Figure 2-401. Storage System Mover at Pilgrim Independent Spent Fuel Storage Installation (2019)



Figure 2-402. Location of New Pilgrim Independent Spent Fuel Storage Installation (Google 2019)



Figure 2-403. Construction of New Pilgrim Independent Spent Fuel Storage Installation (2019)



Figure 2-404. Construction of New Pilgrim Independent Spent Fuel Storage Installation (2019)



Figure 2-405. Aerial View of Pilgrim Barge Access Location (Google 2019)



Figure 2-406. Barge Access at Pilgrim Site (2019)

2.16.3 Near-site Transportation Infrastructure and Experience

Pilgrim does not currently have rail service. In the past, Pilgrim used a freight line that terminated in Plymouth, Massachusetts, about 7 miles from the site, for moving heavy equipment such as transformers to the site. This rail line is now a passenger line and is not suitable for shipping large SNF transportation casks because the large SNF transportation casks will not clear the station platforms.

Because Pilgrim does not have direct rail access, two off-site heavy haul truck to rail transload locations were evaluated, one in Middleborough, Massachusetts, about 23-30 miles from the Pilgrim site, and a second location also in Middleborough about 24-28 miles from the Pilgrim site (see Figure 2-407). Both locations are served by the Massachusetts Coastal Railroad. The rail line in this area is owned by by the Commonwealth of Massachusetts and leased to the Massachuetts Coastal Railroad.

Figure 2-408 shows an aerial view of the first potential transload location. Figure 2-409 and Figure 2-410 provide views of the transload location looking east and west, respectively. Figure 2-411 shows a derailer; Figure 2-412 shows positive train control sensors; and Figure 2-413 shows the 132-lb. rail at the first potential transload location. Access to the first location is provided by I-495; however, the closest exit contains a low overhead (13 feet 11 inches) bridge (see Figure 2-414).

Figure 2-415 shows an aerial view of the second potential transload location. Figure 2-416 and Figure 2-417 show the mainline at the second potential transload location looking southeast and northwest, respectively. Figure 2-418, Figure 2-419, Figure 2-420, and Figure 2-421 show the industrial spur at the second potential transload looking southeast, south, northwest, and east, respectively. Figure 2-422 shows the industrial spur covered with compost, and Figure 2-423 shows the end of the industrial spur. Figure 2-424 shows the 115-lb. rail at the second potential transload location.

Two sites south of the Cape Cod Canal were evaluated as potential barge to heavy haul truck to rail transload locations (see Figure 2-425 and Figure 2-426). These locations are served by Massachusetts Coastal Railroad. Use of these sites would require a short heavy haul and an additional transload from heavy truck to rail. Figure 2-427 shows the west transload location looking east, and Figure 2-428 shows the east transload location looking west. Figure 2-429 shows the rail line approaching the transload locations. The Cape Cod Canal Vertical Lift Railroad Bridge would be used to cross the Cape Cod Canal (see Figure 2-430).

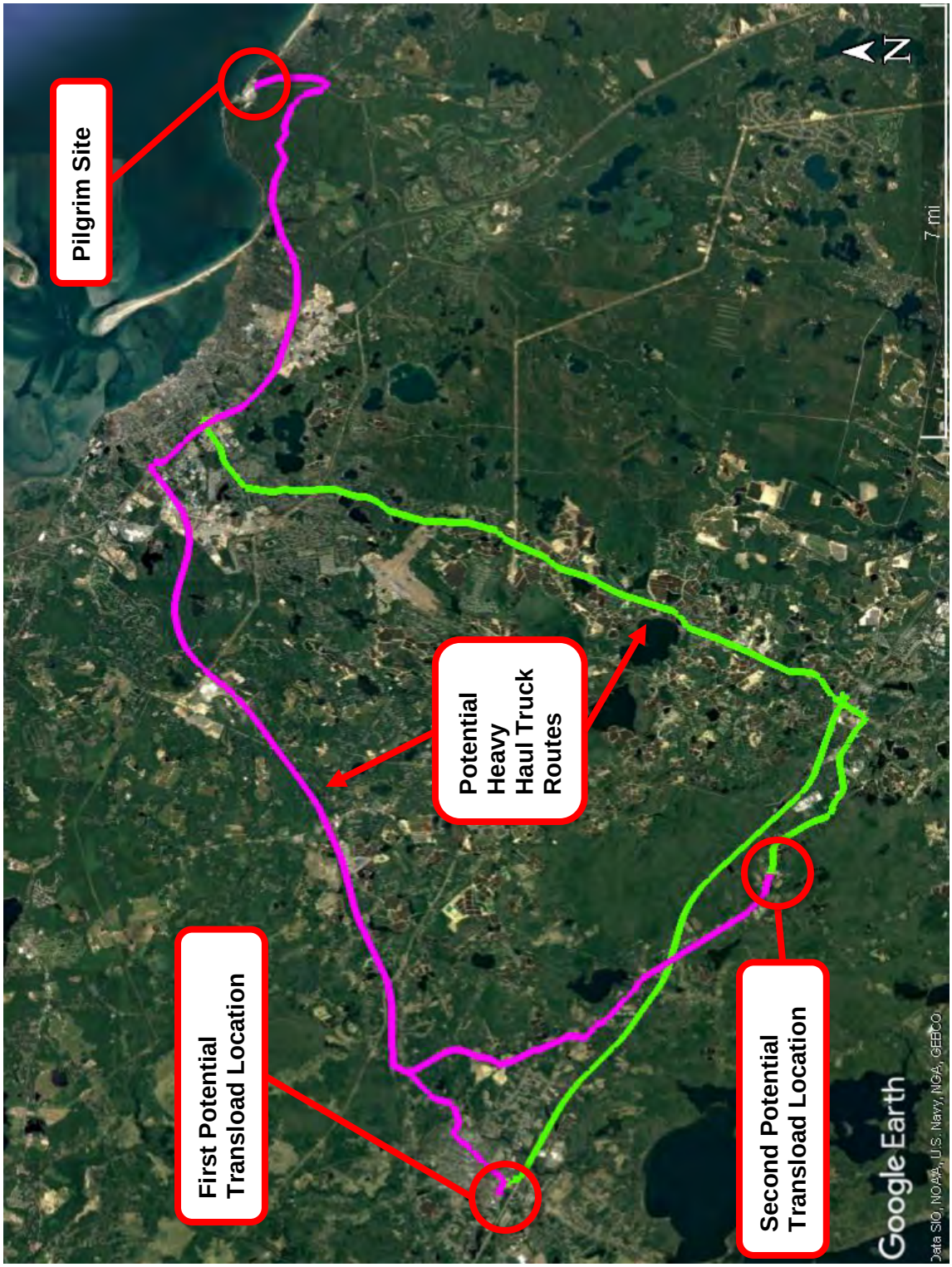


Figure 2-407. Potential Heavy Haul Truck Routes to Rail Transload Locations (Google 2019)



Figure 2-408. Aerial View of First Potential Rail Transload Location in Middleborough, Massachusetts (Google 2019)



Figure 2-409. First Potential Rail Transload Location Looking East (2019)



Figure 2-410. First Potential Rail Transload Location Looking West (2019)



Figure 2-411. Derailer at First Potential Rail Transload Location (2019)



Figure 2-412. Positive Train Control Sensors at First Potential Rail Transload Location (2019)



Figure 2-413. 132-lb. Rail at First Potential Rail Transload Location (2019)



Figure 2-414. Low Overhead Bridges (13’11”) Near First Potential Rail Transload Location (Google 2019)

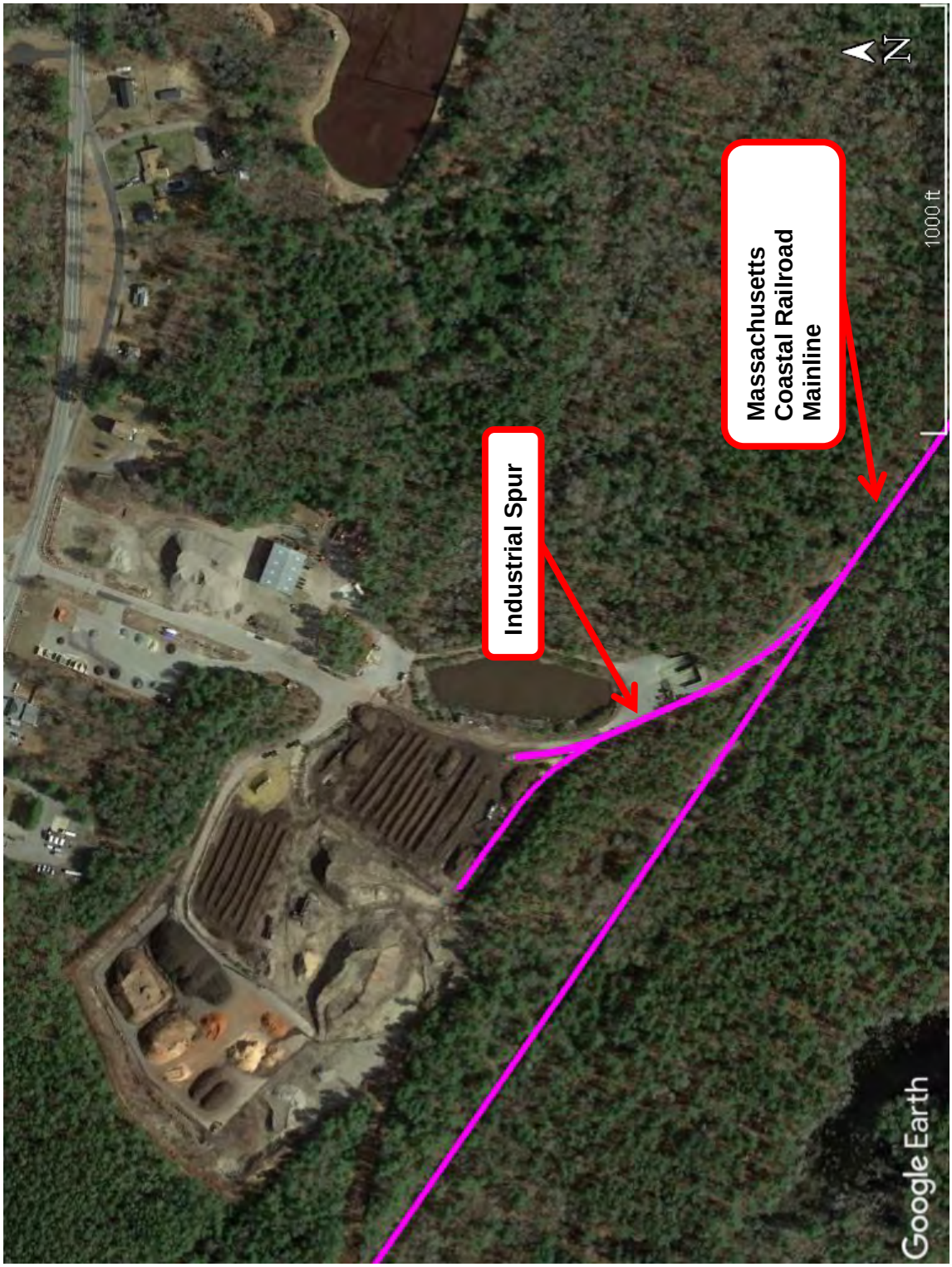


Figure 2-415. Aerial View of Second Potential Rail Transload Location (Google 2019)



Figure 2-416. Mainline at Second Potential Rail Transload Location Looking Southeast (2019)

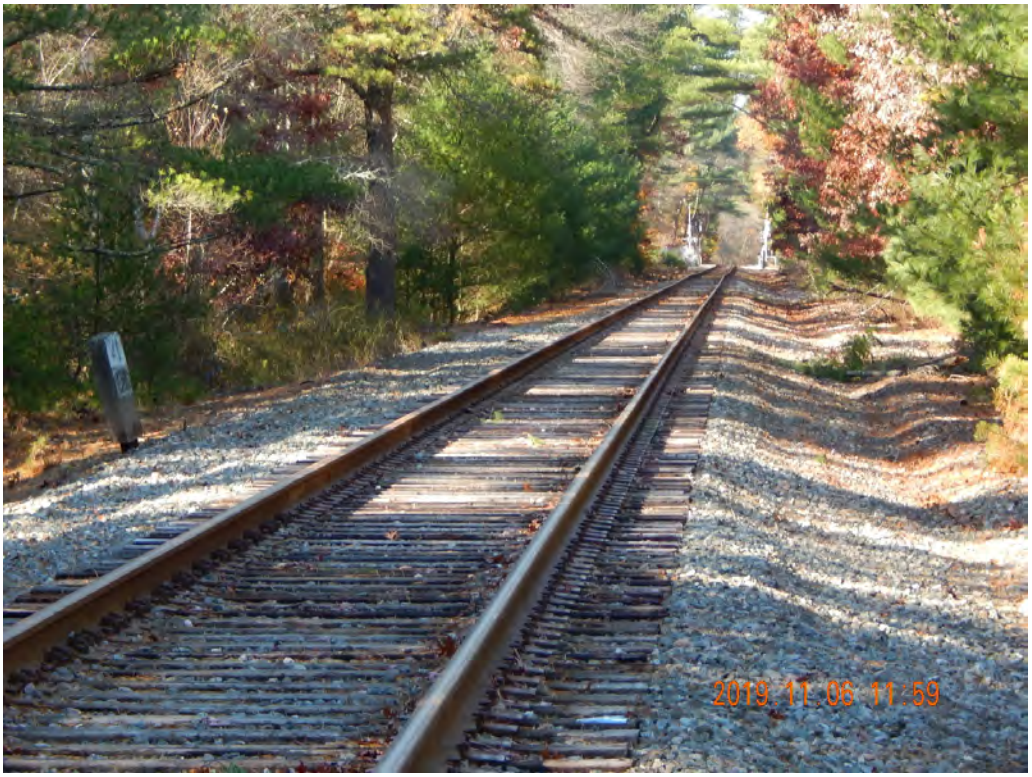


Figure 2-417. Mainline at Second Potential Rail Transload Location Looking Northwest (2019)



Figure 2-418. Industrial Spur at Second Potential Rail Transload Location Looking Southeast (2019)



Figure 2-419. Industrial Spur at Second Potential Rail Transload Location Looking South (2019)



Figure 2-420. Industrial Spur at Second Potential Rail Transload Location Looking Northwest (2019)



Figure 2-421. Industrial Spur at Second Potential Rail Transload Location Looking East (2019)



Figure 2-422. Industrial Spur at Second Potential Rail Transload Location Covered with Compost (2019)



Figure 2-423. End of Industrial Spur at Second Potential Rail Transload Location (2019)



Figure 2-424. 115-lb. Rail at Industrial Spur at Second Potential Rail Transload Location (2019)

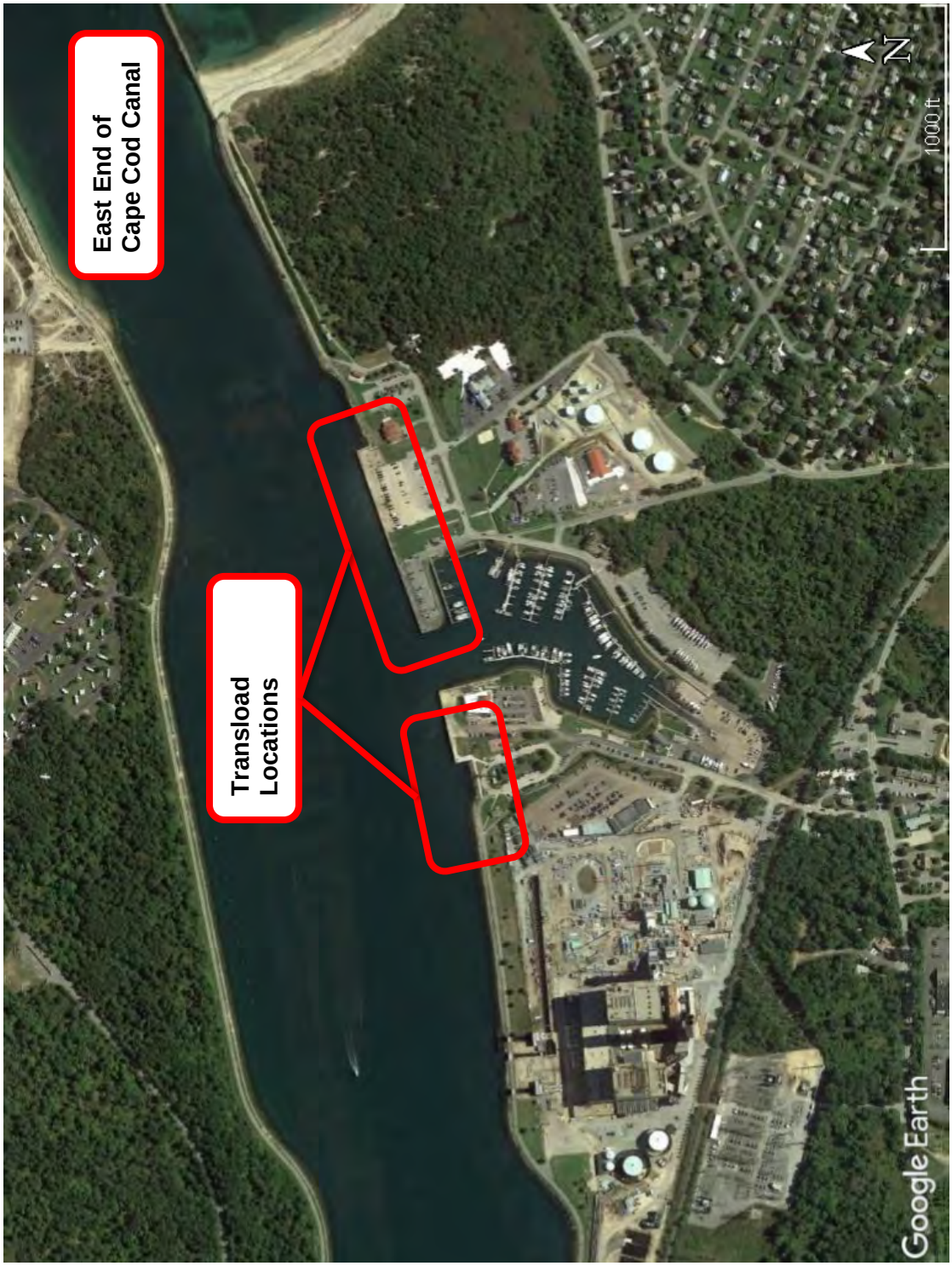


Figure 2-425. Aerial View of Potential Barge to Heavy Haul Truck to Rail Transload Locations on the South Bank of the Cape Cod Canal (Google 2019)



Figure 2-426. Closeup Aerial View of Potential Barge to Heavy Haul Truck to Rail Transload Locations (Google 2019)



Figure 2-427. West Barge Transload Location Looking East (2019)



Figure 2-428. East Barge Transload Location Looking West (2019)



Figure 2-429. Rail Line Approaching Barge Transload Locations (2019)



Figure 2-430. Cape Cod Canal Railroad Bridge (2019)

2.16.4 Future Information Needs

The Pilgrim site does not have direct rail access. However, it does have a barge area on-site, and during construction, this location was used to receive the Pilgrim reactor pressure vessel. Refurbishment would be required to use this location for barge shipments of SNF and could involve dredging which would likely require multiple permits and may involve the Massachusetts Board of Underwater Archaeological Resources. Site-specific field surveys may be required to determine the extent of eelgrass (*Zostera marina*) beds. Additional potential information needs include (Malkoski 2019):

- Size of barge and tug to be used – length, beam, draft, weight, functional minimum water depth
- Volume and dimensions of dredge footprint proposed to permit barge/tug use
- Size and extent of shore-side construction necessary to support this use
- Likely duration of barge grounding
- Proposed erosion protection measures
- Increased waterborne security considerations.

Two potential off-site heavy haul truck to rail transload locations were evaluated. Both locations are served by the Massachusetts Coastal Railroad. The use of these transload locations would require shipping SNF transportation casks by heavy haul truck a distance of 23-30 miles.

The certificate of compliance for the HI-STAR 100 transportation cask does not allow the transport of MPC-68M canisters, high burnup (> 45 GWd/MTHM) SNF, or GTCC waste. Consequently, the certificate of compliance for either the HI-STAR 100MB (Docket No. 71-9378) or the HI-STAR 100 would have to be revised before the SNF stored in MPC-68M canisters, the 248 high burnup SNF assemblies, or the GTCC waste from decommissioning at the Pilgrim site could be transported.

3. CONCLUSIONS AND RECOMMENDATIONS

This report provides evaluations of the NPP site infrastructure and near-site transportation infrastructure for removing SNF from 16 NPP sites. The evaluations were divided into four components:

- characterization of the SNF and GTCC 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 SNF and GTCC waste from the NPP sites
- identification of future information needs.

As part of conducting the evaluations of the NPP site infrastructure and near-site transportation infrastructure, 16 NPP sites have been visited since 2012: Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, Trojan, La Crosse, Zion, Crystal River, Kewaunee, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim. The 16 NPP sites use designs from 4 different suppliers, including 12 different (horizontal and vertical) storage systems that would require 9 different transportation cask designs. Transportation cask certificates of compliance are for 5-year periods, so these certificates will 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.

Several issues were identified with the SNF and GTCC waste inventory at these NPP sites that may affect future transportability. 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 (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.

The approved contents in the certificates of compliance for the TS125, HI-STAR 100, MP187, and HI-STAR 190 transportation casks do not include GTCC waste. For GTCC waste to be shipped from the Rancho Seco, San Onofre, Vermont Yankee, Oyster Creek, and Pilgrim sites in these transportation casks, changes to the transportation certificates of compliance would be required. Additionally, 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 or alternative transportation casks with -96 designations would have to be used.

Nine of the 16 sites, Maine Yankee, Zion, Crystal River, Kewaunee, San Onofre, Vermont Yankee, Fort Calhoun, Oyster Creek, and Pilgrim, have high burnup SNF in storage. The 90 high burnup SNF assemblies at Maine Yankee are packaged in Maine Yankee Fuel Cans (i.e., damaged fuel cans). This option for transporting high burnup SNF 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 SNF assemblies at Zion in the MAGNATRAN transportation cask. High burnup SNF stored in

32PTH1 canisters at Crystal River and 24PT4 canisters at San Onofre would be transportable in the MP197HB transportation cask. High burnup SNF that is stored in MPC-37 canisters at San Onofre and MPC-89 canisters at Oyster Creek would be transportable in the HI-STAR 190 transportation cask. High burnup SNF that is stored in MPC-68 and MPC-68M canisters at Vermont Yankee and Pilgrim would not be transportable without changes to the approved contents in the certificate of compliance for the HI-STAR 100MB or HI-STAR 100 transportation cask. The certificate of compliance for the MAGNATRAN transportation cask allows for transport of high burnup SNF in damaged fuel cans; however, the undamaged high burnup SNF stored in TSC-37 canisters at Kewaunee is not contained in damaged fuel cans, and a revision to the certificate of compliance would be required for this SNF to be transportable.

Table 3-1 summarizes the mode options for transporting SNF and GTCC waste from the 16 NPP sites. The modes listed in Table 3-1 were based on the evaluations of on-site transportation conditions, the near-site transportation infrastructure, and off-site transportation experience at the NPP sites, particularly during the shipping of large equipment and components to and from the NPP sites. An important observation regarding Table 3-1 is that all NPP sites have at least one off-site transportation mode option for removing their SNF and GTCC waste, and most NPP sites have multiple options.

DOE intends to continue conducting site evaluations of additional NPP sites and plans to eventually conduct evaluations for all NPP sites. For NPP sites previously evaluated, DOE plans to continue to update inventory and site condition information and imagery as it becomes available.

Table 3-1. Summary of Transportation Mode Options for Shipments from Nuclear Power Plant Sites

Site	Transportation Mode Options		Comments
Maine Yankee	Direct rail	Barge to rail	The on-site rail spur is not currently maintained. The condition of the Central Maine and Quebec Railway 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 distance would likely be about 52 miles to Gaylord, Michigan. A shorter heavy haul distance 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 currently 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 refurbished to support reactor decommissioning waste shipments.
Crystal River	Direct rail	Barge to rail	An extensive on-site rail system serves co-located fossil fuel plants.
Kewaunee	Heavy haul truck to rail	Heavy haul truck to barge to rail	The 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 refurbished to support reactor decommissioning shipments for San Onofre-1.
Vermont Yankee	Direct rail	–	The on-site rail spur was reactivated to support decommissioning.

Table 3-1. (contd)

Site	Transportation Mode Options		Comments
Fort Calhoun	Direct rail	Barge to rail	The on-site rail spur could be reinstalled or on-site transload performed. Barge was used to ship steam generators, pressurizer, and reactor vessel head.
Oyster Creek	Barge to rail	Heavy haul truck to rail	Two on-site barge access locations exist at the site. Heavy haul truck transport to rail transload locations could range from 30 to 70 miles.
Pilgrim	Barge to rail	Heavy haul truck to rail	One on-site barge access location exists at the site. Heavy haul truck transport to rail transload location could range from 23 to 30 miles.

4. REFERENCES

10 CFR Part 71. 2020. "Packaging and Transportation of Radioactive Material." *Code of Federal Regulations*, U.S. Nuclear Regulatory Commission. Available at https://www.govinfo.gov/app/collection/cfr/2020/.

10 CFR Part 72. 2020. "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 https://www.govinfo.gov/app/collection/cfr/2020/.

10 CFR Part 961. 2020. "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 https://www.govinfo.gov/app/collection/cfr/2020/.

49 CFR Part 213. 2020. "Track Safety Standards." *Code of Federal Regulations*, Federal Railroad Administration. Available at https://www.govinfo.gov/app/collection/cfr/2020/.

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.

42 U.S.C. 10101 et seq. Nuclear Waste Policy Act of 1982, as amended.

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

Bauder DR. 2020. Letter from Douglas R. Bauder (Vice President Decommissioning and Chief Nuclear Officer, San Onofre Nuclear Generating Station) to U.S. Nuclear Regulatory Commission. "Docket Nos. 50-206, 50-361, 50-362, 72-41, and 72-1040 Registration of Dry Fuel Storage Canister and Certification of Permanent Removal of All Spent Fuel Assemblies from the Spent Fuel Pools San Onofre Nuclear Generation Station Units 1, 2 and 3 and the Independent Spent Fuel Storage Facility (ISFSI)." August 7, 2020. ADAMS Accession Number ML20227A044.

Becker J, L Hibler, L Rodman, E Kennedy, and S Maheras. 2019. *Dredging Permit Requirements for the Oyster Creek Nuclear Power Plant Site*. Report No. PNNL-29037. Pacific Northwest National Laboratory, Richland, WA.

Blome BH. 2020. Letter from Bradley H. Blome (Director Licensing and Regulatory Assurance, Fort Calhoun Station) to U.S. Nuclear Regulatory Commission. "Fort Calhoun Station Unit No. 1, Independent Spent Fuel Storage Installation (ISFSI) Cask Registration and Certification of Permanent Removal of all Spent Fuel Assemblies from the Spent Fuel Pool." May 18, 2020. ADAMS Accession Number ML20139A138.

Burke TJ. 2016a. Letter from Timothy J. Burke (President and CEO, Omaha Public Power District) to U.S. Nuclear Regulatory Commission. "Certification of Permanent Cessation of Power Operations." August 25, 2016. ADAMS Accession Number ML16242A127.

Burke TJ. 2016b. Letter from Timothy J. Burke (President and CEO, Omaha Public Power District) to U.S. Nuclear Regulatory Commission. "Certification of Permanent Removal of Fuel from Reactor Vessel." November 13, 2016. ADAMS Accession Number ML16319A254.

Chappell CC. 2018. Letter from Coley C. Chappell (Manager, Design and Programs, Entergy Nuclear Vermont Yankee, LLC) to U.S. Nuclear Regulatory Commission. "Vermont Yankee Registration of Spent Fuel Cask Use and Notification of Permanent Removal of All Spent Fuel Assemblies from the Spent Fuel Pool Vermont Yankee Nuclear Power Station Docket Nos. 50-271, 72-59, and 72-1014 License No. DPR-28." August 16, 2018. ADAMS Accession Number ML18234A143.

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. "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. "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. "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.

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

EIA (Energy Information Agency). 2013. "Form GC-859, Nuclear Fuel Data Survey." Energy Information Agency, Washington, D.C.

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

EPRI (Electric Power Research Institute). 1996. *Evaluation of Expected Behavior of LWR Stainless Steel-Clad Fuel for Long-Term Dry Storage*. EPRI Report Number TR-106440, Electric Power Research Institute, Palo Alto, California.

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.

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.

Fisher MJ. 2017a. Letter from Mary J. Fisher (Senior Director-FCS Decommissioning) to U.S. Nuclear Regulatory Commission. "Fort Calhoun Irradiated Fuel Management Plan." March 31, 2017. ADAMS Accession Number ML17093A594.

Fisher MJ. 2017b. Letter from Mary J. Fisher (Senior Director-FCS Decommissioning) to U.S. Nuclear Regulatory Commission. "Fort Calhoun Station, Unit No. 1, Post-Shutdown Decommissioning Activities Report." March 30, 2017. ADAMS Accession Number ML17089A759.

Ford K, E Feeney, and NT Evans. 2012. *Summary of Marine Fisheries Resource Recommendations for Municipal Maintenance Hydraulic Dredging Activities on Cape Cod and the Islands*. Massachusetts Department of Fisheries and Game, Division of Marine Fisheries, New Bedford, MA.

Franke JA. 2013. Letter from Jon A. Franke (Vice President, Crystal River Nuclear Plant, Duke Energy) to U.S. Nuclear Regulatory Commission. "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.

Gallagher MP. 2018. Letter from Michael P. Gallagher (Vice President, License Renewal and Decommissioning, Exelon Generation Company) to U.S. Nuclear Regulatory Commission. "Certification of Permanent Removal of Fuel from the Reactor Vessel for Oyster Creek Nuclear Generating Station." September 25, 2018. ADAMS Accession Number ML18268A258.

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. 2019. Google Earth Pro (Version 7.3.2.5776). Available at https://www.google.com/earth/versions/.

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

HBHRCD (Humboldt Bay Harbor, Recreation & Conservation District). 2017. Humboldt Bay Shipping Terminals. Accessed August 2, 2017 at http://humboldtbay.org/shipping-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). 2020. Power Reactor Information System (PRIS). Available at https://pris.iaea.org/pris/. International Atomic Energy Agency, Vienna, Austria.

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.

Maheras SJ, RE Best, SB Ross, KA Buxton, JL England, PE McConnell, LM Massaro, and PJ Jensen. 2017. *Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites*. Report No. SFWD-IWM-2017-000024, U.S. Department of Energy, Washington, D.C.

Malkoski V. 2019. *Potential Impacts to Fisheries Habitat, Resources, and Harvest from Proposed Dredging and Use of the Barge Channel at Pilgrim Station*. Massachusetts Division of Marine Fisheries. November 5, 2019.

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 Report and Assessment, Rancho Seco Nuclear Generating Station*. NAC International, Norcross, Georgia. June.

NAC. 1991b. *Near-Site Transportation Infrastructure Project Report and Assessment, Trojan Nuclear Plant*. NAC International, Norcross, Georgia. June.

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). 2003. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 12, Regarding Fort Calhoun Station, Unit 1, Final Report*. NUREG-1437, Supplement 12. U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C.

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). 2007c. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 28, Regarding Oyster Creek Nuclear Generating Station, Final Report – Main Report*. NUREG-1437, Supplement 28. U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission). 2007d. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 29, Regarding Pilgrim Nuclear Power Station, Final Report – Main Report*. NUREG-1437, Supplement 29. 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). 2019. *2019-2020 Information Digest*. NUREG-1350, Volume 31. U.S. Nuclear Regulatory Commission, Office of Public Affairs, Washington, D.C.

OPPD (Omaha Public Power District). 2002. *Applicant's Environmental Report, Operating License Renewal Stage, Fort Calhoun Station Unit 1*. ADAMS Accession Number ML020180071.

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

Posivak E. 2016. *IP-2 Steam Generator Lower Assembly Packaging, Transport and Disposal*. WM2016 Conference, March 6-10, 2016, Phoenix, Arizona.

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.

Radwaste Solutions. 2020. "The Road to Utah." *Radwaste Solutions*, 27(2):32-39.

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). "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.

Ridder R. 2016. "Fuel Characterization Challenges for Pool Offload at Kewaunee." Presentation at the NEI Used Fuel Management Conference, May 3-5, 2016, Orlando, Florida.

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.), "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.), "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. "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. "Dominion Energy Kewaunee, Inc., Kewaunee Power Station, Revision to Post-Shutdown Decommissioning Activities Report." April 25, 2014. ADAMS Accession Number ML14118A382.

Sheehan NA and R Ortega. 1996. "Tug Sinks; Barge Runs Aground." *Asbury Park Press*. January 23, 1996.

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. "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. "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.

Sullivan BR. 2019. Letter from Brian R. Sullivan (Site Vice President, Entergy Nuclear Operations, Pilgrim Nuclear Power Station) to U.S. Nuclear Regulatory Commission. "Certifications of Permanent Cessation of Power Operations and Permanent Removal of Fuel from the Reactor Vessel." June 10, 2019. ADAMS Accession Number ML19161A033.

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). 1993g. *Oyster Creek Nuclear Generating Station, GPU-Nuclear Corporation, Jersey Central Power and Light Company, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19931215.0010. 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.

TOPO (Transportation Operations Project Office). 1994g. *Fort Calhoun Nuclear Station, Omaha Public Power District, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19940510.0029. Oak Ridge, Tennessee.

TOPO (Transportation Operations Project Office). 1994h. *Pilgrim Nuclear Station, Boston Edison Company, Site and Facility Waste Transportation Services Planning Document*. DOE Records Information System Accession Number HQV.19940510.0031. 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. 2017. Table 14. Dry Cask Storage in the US by Vendor (as of June 6, 2017). *StoreFUEL and Decommissioning Report.* 19(226):114-115. June 6.

Vinson D. 2015. *Description and Validation of a Revised Tool for Projecting of U.S. Commercial Spent Nuclear Fuel Inventory*. Report No. FCRD-NFST-2015-000534. U.S. Department of Energy, Washington, D.C.

VTNDCAP (Vermont Nuclear Decommissioning Citizens Advisory Panel). 2020. Nuclear Decommissioning Citizens Advisory Panel 2019 Annual Report to the Governor and the Vermont Legislature.

Wamser, CJ. 2014. Letter from Christopher J. Wamser (Site Vice President, Entergy Nuclear Operations, Inc., Vermont Yankee) to U.S. Nuclear Regulatory Commission. “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. “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), “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.

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 SNF from the NPPs. 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 NPPs. 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 Spent Nuclear Fuel from the Nuclear Power Plant 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	23	05/31/2024	ML19318G674
MP187	71-9255	USA/9255/B(U)F-85	14	11/30/2023	ML18330A247
HI-STAR 100, HI-STAR HB, and HI-STAR HB GTCC	71-9261	USA/9261/B(U)F-96	12	04/30/2024	ML19239A189
NAC-UMS UTC	71-9270	USA/9270/B(U)F-96	5	10/31/2022	ML17297B417
TS125	71-9276	USA/9276/B(U)F-85	6	10/31/2022	ML19317E422
MP197 and MP197HB	71-9302	USA/9302/B(U)F-96	10	08/31/2022	ML19352D465
MAGNATRAN	71-9356	USA/9356/B(U)F-96	2	04/30/2024	ML20139A101
HI-STAR 190	71-9373	USA/9373/B(U)F-96	1	08/31/2022	ML18332A026

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 Nuclear Power Plant 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 12/11/2017	01/23/2015 01/23/2055	16	09/14/2020	ML20226A014
HI-STORM 100	72-1014	05/31/2000	05/31/2020	14	12/17/2019	ML19343B287
NAC-UMS	72-1015	11/20/2000	11/20/2020	7	01/07/2019	ML18333A232
NAC-MPC	72-1025	04/10/2000	04/10/2020	8	03/04/2019	ML19039A088
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	4	03/12/2019	ML19036A557
MAGNASTOR	72-1031	02/04/2009	02/04/2029	8	03/24/2020	ML20036E079
HI-STORM UMAX	72-1040	04/06/2015	04/06/2035	2	01/09/2017	ML16341B061

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 Nuclear Power Plant Sites

Site	License	Docket	License Issue Date	License Expiration Date	Amendment	Amendment Date	ADAMS Accession Number
Trojan	SNM-2509	72-17	03/31/1999	03/31/2059	6	08/09/2019	ML19221B647 ML19221B648 ML19221B649 ML19221B650 ML19221B651 ML19221B652
Rancho Seco	SNM-2510	72-11	03/09/2020	06/30/2060	4	03/09/2020	ML20065N276
Humboldt Bay	SNM-2514	72-27	11/17/2005	11/17/2065	4	06/10/2020	ML20161A025 ML20161A027 ML20161A029

ADAMS= U.S. Nuclear Regulatory Commission Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams.html)

Appendix B:

Summary of Permitting Requirements for Oversize and Overweight Trucks

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Appendix B
Summary of Permitting Requirements for Oversize and Overweight Trucks

This appendix summarizes the permitting requirements for oversize and overweight trucks for states with NPP sites (California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Nebraska, New Jersey, Oregon, Pennsylvania, Vermont, and Wisconsin). In addition, state super load dimension and weight requirements are also summarized. A vehicle and load are considered oversized when the vehicle and the cargo that it carries exceed the legal dimensions of length or width, as defined by federal requirements or the 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 are considered overweight when the vehicle and the cargo that it carries exceed the legal weight limit as defined by federal and state requirements (GAO 2015). A vehicle and load are considered a super load when the 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.

B.1 California

Table B-1 summarizes the oversize vehicle permitting practices in California.

Table B-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[a]	15 ft. 0 in.
Super Load Height Requirement[a]	17 ft. 0 in.
Super Load Length Requirement[a]	135 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.2 Connecticut

Table B-2 summarizes the oversize vehicle permitting practices in Connecticut.

Table B-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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	15 ft. 4 in.
Super Load Length Requirement[a]	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.3 Florida

Table B-3 summarizes the oversize vehicle permitting practices in Florida.

Table B-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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	16 ft. 0 in.
Super Load Length Requirement[a]	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.4 Illinois

Table B-4 summarizes the oversize vehicle permitting practices in Illinois.

Table B-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[a]	14 ft. 6 in.
Super Load Height Requirement[a]	14 ft. 6 in.
Super Load Length Requirement[a]	145 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.5 Maine

Table B-5 summarizes the oversize vehicle permitting practices in Maine.

Table B-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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	16 ft. 0 in.
Super Load Length Requirement[a]	125 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.6 Massachusetts

Table B-6 summarizes the oversize vehicle permitting practices in Massachusetts.

Table B-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[a]	14 ft. 0 in.
Super Load Height Requirement[a]	Varies
Super Load Length Requirement[a]	120 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.7 Michigan

Table B-7 summarizes the oversize vehicle permitting practices in Michigan.

Table B-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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	15 ft. 0 in.
Super Load Length Requirement[a]	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.8 Nebraska

Table B-8 summarizes the oversize vehicle permitting practices in Nebraska.

Table B-8. Nebraska Oversize Vehicle Permitting Practices

Permit Issuing Agency	Nebraska Department of Roads
Permit Enforcement Agency	Nebraska State Patrol – Carrier Enforcement Division
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	15
Regional Permit Agreement Membership	None
Maximum Legal Width	102 in.
Maximum Legal Height	14 ft. 6 in.
Maximum Legal Length for a Semitrailer	53 ft. 0 in.
Maximum Legal Gross Vehicle Weight	80,000 lb. (Interstate and Defense Highways) 95,000 lb. (secondary highways)
Super Load Width Requirement[a]	16 ft. 0 in.
Super Load Height Requirement[a]	16 ft. 0 in.
Super Load Length Requirement[a]	100 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	160,000 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 (vehicle width ≥ 20 ft.)
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)
a. Minimum width, height, length, or gross vehicle weight.

B.9 New Jersey

Table B-9 summarizes the oversize vehicle permitting practices in New Jersey.

Table B-9. New Jersey Oversize Vehicle Permitting Practices

Permit Issuing Agency	New Jersey Department of Transportation – Bureau of Freight Planning and Services
Permit Enforcement Agency	New Jersey Department of Law and Public Safety – Division of State Police
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	4
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[a]	None specified
Super Load Height Requirement[a]	None specified
Super Load Length Requirement[a]	None specified
Super Load Gross Vehicle Weight Requirement[a]	None specified
Escort Vehicle Requirement for Overheight Permitted Vehicle	No
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	No
Certification Requirement for Escort Vehicle Driver	No

Source: GAO (2015)
a. Minimum width, height, length, or gross vehicle weight.

B.10 Oregon

Table B-10 summarizes the oversize vehicle permitting practices in Oregon.

Table B-10. 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[a]	> 16 ft. (interstates and other multilane highways) > 14 ft. (state two-lane highways)
Super Load Height Requirement[a]	17 ft. 0 in.
Super Load Length Requirement[a]	150 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.11 Pennsylvania

Table B-11 summarizes the oversize vehicle permitting practices in Pennsylvania.

Table B-11. Pennsylvania Oversize Vehicle Permitting Practices

Permit Issuing Agency	Pennsylvania Department of Transportation – Central Permit Office
Permit Enforcement Agency	Pennsylvania State Police – Bureau of Patrol
Online Oversize and Overweight Permit System	Yes
Automated Truck Routing Software	Yes
Number of Different Oversize and Overweight Permit Types Available	96
Regional Permit Agreement Membership	None
Maximum Legal Width	102 inches
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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	None specified
Super Load Length Requirement[a]	160 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	201,000 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	No
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)
a. Minimum width, height, length, or gross vehicle weight.

B.12 Vermont

Table B-12 summarizes the oversize vehicle permitting practices in Vermont.

Table B-12. 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[a]	15 ft. 0 in.
Super Load Height Requirement[a]	14 ft. 0 in.
Super Load Length Requirement[a]	100 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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)
a. Minimum width, height, length, or gross vehicle weight.

B.13 Wisconsin

Table B-13 summarizes the oversize vehicle permitting practices in Wisconsin.

Table B-13. 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[a]	16 ft. 0 in.
Super Load Height Requirement[a]	None specified
Super Load Length Requirement[a]	160 ft. 0 in.
Super Load Gross Vehicle Weight Requirement[a]	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) a. Minimum width, height, length, or gross vehicle weight.	

B.14 Summary of State Super Load Dimension and Weight Requirements

Table B-14 summarizes the super load width, height, length, and gross vehicle weight requirements for California, Connecticut, Florida, Illinois, Maine, Massachusetts, Michigan, Nebraska, New Jersey, Oregon, Pennsylvania, Vermont, and Wisconsin.

Table B-14. Summary of State Super Load Dimension and Weight Requirements

State	Minimum Super Load Width Requirement	Minimum Super Load Height Requirement	Minimum Super Load Length Requirement	Minimum 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
Nebraska	16 ft. 0 in.	16 ft. 0 in.	100 ft. 0 in.	160,000 lb.
New Jersey	None specified	None specified	None specified	None specified
Oregon	16 ft. 0 in.[a] 14 ft. 0 in.[b]	17 ft. 0 in.	150 ft. 0 in.	None specified
Pennsylvania	16 ft. 0 in.	None specified	160 ft. 0 in.	201,000 lb.
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.

B.15 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.

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