INITIAL SITE-SPECIFIC DE-INVENTORY REPORT FOR VERMONT YANKEE

DECEMBER 2024

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY | SPENT FUEL & HIGH-LEVEL WASTE DISPOSITION

PNNL-37130

Cover photo courtesy of the Vermont Yankee Site.

Initial Site-Specific De-Inventory Report for Vermont Yankee

RPT-3026151-000

Prepared by: Orano Federal Services LLC

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
000	11/22/24	N/A	Initial Issue

DISCLAIMER

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAR	Association of American Railroads
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
AWS	Automated Welding System
B&E	Berkshire & Eastern Railroad
BOL	Bill of Lading
BWR	Boiling Water Reactor
CAD	Computer Aided Drawing
CBR	Cask Bottom Region
CFR	Code of Federal Regulations
CLS	Closure Lid System
CN	Canadian National
CO	Crane Operator
CoC	Certificate of Compliance
COSS	Cask Operations Shift Supervisor
COTP	Captain of the Port
CPKC	Canadian Pacific Kansas City
CRCPD	Conference of Radiation Control Program Directors, Inc.
CSXT	Chessie-Seaboard (Merger)
CT	Connecticut
CTR	Cask Top Region
DC	District of Columbia
DFC	Damaged Fuel Container
DFI	Damaged Fuel Isolator
DHS	Department of Homeland Security
DOE	Department of Energy
DOT	Department of Transportation
EO	Tractor/JCB Driver and Equipment Operator
ERP	Emergency Response Plan
EV	Enclosure Vessel
FA	Fuel Assembly
FRA	Federal Railroad Administration
FSAR	Final Safety Analysis Report
FSO	Facility Security Officer
FSP	Facility Security Plan
ft	feet
GCS	Gamma Capture Space
GCUS	Geographical Center of the 48 Contiguous United States
GE	General Electric
GMRC	Green Mountain Railroad
GNF	Global Nuclear Fuels
GPS	Global Positioning System
GTCC	Greater Than Class C
GWd	GigaWatt-day
GWRR	Genesee & Wyoming Inc.

HAZMAT	Hazardous Material
HBU	High Burnup Fuel
HHT	Heavy Haul Truck/Trailer
HI-STAR	Holtec International Storage, Transport, And Repository
HLW	High-Level Radioactive Waste
HRCQ	Highway Route Controlled Quantity
HTUA	High Threat Urban Areas
IL	Illinois
in	inch
IN	Indiana
ISFSI	Independent Spent Fuel Storage Installation
ISR	Independent Safety Review
kW	Kilowatt
lbs	Pounds
LLC	Limited Liability Corporation
LLEA	Local Law Enforcement Agency
LLW	Low-Level Radioactive Waste
LUA	Lead Use Assembly
MA	Massachusetts
MCC	Movement Control Center
MCER	Massachusetts Central Railroad
MPC	Multi-Purpose Canister
mph	miles per hour
MTHM	Metric Tons Heavy Metal
MTSA	Maritime Transportation Security Act
MUA	Multi-Attribute Utility Analysis
MWe	MegaWatt electric
NCVS	Neutron Capture Space
NDCAP	Nuclear Decommissioning Citizens Advisory Panel
NECR	New England Central Railroad
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NRHM	Non-Radioactive Hazardous Materials
NS	Norfolk Southern
NWPA	Nuclear Waste Policy Act
NY	New York
OH	Ohio
OJT	On the Job Training
OM	Operations Manager
OSHA	Occupational Safety and Health Administration
PA	Pennsylvania
PAR	Pan Am Railways
PAS	Pan Am Southern
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIH	Poisonous Inhalation Hazard
PPE	Personal Protective Equipment
PW	Procedure Writer

PW	Providence and Worcester Railroad
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
QS	QA/QC Specialist
RAM	Radioactive Material
RCA	Radiation Control Area
RCT	Radiation Control Technician
REV	Rail Escort Vehicle
RM	Rigger/Cask Operations Technician/Mechanic
RP	Radiation Protection
RSAT	Risk and Security Assessment Team
RSSM	Rail Security Sensitive Materials
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SL	Standard Length
SME	Subject Matter Expert
SNF	Spent Nuclear Fuel
SP	Security Personnel
START	Stakeholder Tool for Assessing Radioactive Transportation
TC	Transport and Waste Management Coordinator
TIH	Toxic Inhalation Hazards
TPE	Training Program Evaluation
TS	Training Specialist
TSA	U.S. Transportation Security Administration
TWIC	Transportation Worker Identification Credential
TX	Texas
U.S.	United States
USACE	U.S. Army Core of Engineers
USCG	U.S. Coast Guard
VDS	Vacuum Drying System
VRS	Vermont Rail System
VSP	Vessel Security Plan
VT	Vermont
VTR	Vermont Railway
VY	Vermont Yankee
VYNPS	Vermont Yankee Nuclear Power Station
WCS	Waste Control Specialists
XL	Extended Length

EXECUTIVE SUMMARY

The purpose of this report is to assist the United States (U.S.) Department of Energy's (DOE) preparations for transporting spent nuclear fuel (SNF) and applicable Greater Than Class C (GTCC) low-level radioactive waste (LLW) to a future federal consolidated interim storage facility. This report addresses the tasks, equipment, and interfaces necessary for the complete de-inventory of the Vermont Yankee Nuclear Power Station (VYNPS) independent spent fuel storage installation (ISFSI) site. It is located in the town of Vernon, VT, approximately 80 miles northwest of Boston, MA and 100 miles south of Montpelier, VT. As such, this report is intended to provide information useful for planning options within an integrated nuclear waste management system.

Multiple modes of transport for the SNF and GTCC LLW were considered as part of this report (i.e., heavy haul truck [HHT], rail, and barge). Barge-to-rail, HHT-to-rail, and direct rail access were evaluated as viable modes of transport by this assessment. To further rank the identified routes and modes, a Multi-Attribute Utility Analysis (MUA) was performed. In addition to subject matter expert (SME) input, data from DOE's Stakeholder Tool for Assessing Radioactive Transportation (START) program was utilized to support the evaluation of the routes in the MUA. The MUA identified a favored route and mode(s) of transport for shipping the SNF and GTCC LLW from VYNPS to a Class I railroad and then to the hypothetical destination near the geographical center of the 48 contiguous United States (GCUS).

The MUA results identified a ranking of five possible routes from the VY site, listed here in order of decreasing favorability as analyzed by the MUA:

1) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel to Palmer, MA and then to GCUS on two rail carriers;
2) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel along multiple railroads/rail carriers on a minimum distance path to GCUS as established by START;
3) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel along multiple railroads/rail carriers on a minimum travel time path to GCUS as established by START;
4) A HHT route of about 34 miles north to Bellows Falls, VT to the Riverside Transload Center where a transload occurs from the HHT to railcars and then travels by rail using three rail carriers to GCUS; and
5) A HHT route of about 31 miles north to Bellows Falls, VT to the Green Mountain Rail Yard where a transload occurs from the HHT to railcars and then travels by rail using two rail carriers to GCUS.

Sensitivity analyses were performed on the MUA results to examine the impact on the rankings of the routes created by changes in the weighting of metrics used to evaluate those routes (e.g., cost of rental equipment, ease of permitting, etc.) and by suppressing the evaluation range of some specific metrics (e.g., cumulative worker exposure). The sensitivity analyses showed fairly consistent rankings: the highest ranked route (Rail via Palmer) always remained the same and changes occurred between the ranking of the second and third ranked routes (rail-only routes) and the fourth and fifth ranked routes (HHT-to-rail routes) depending on the sensitivity analyzed (e.g., when the safety and public acceptability metrics were removed from consideration).

Using the primary MUA result, a concept of operations and a recommended budget and spending plan are detailed for the removal of SNF and GTCC LLW from the VY site using the most attractive shipment route: by rail on the NECR and CSXT through Palmer, MA to the GCUS. The total estimated budget for the entire VY campaign organized over 81 weeks is $18.5M (2024). Also documented in this assessment are aspects of a Security Plan and associated procedures and an Emergency Response Plan and associated preparedness for the prospective shipments. Finally, a set of actions to be taken before initiating the removal of the SNF and GTCC LLW from the VY site are proposed.

1.0 INTRODUCTION

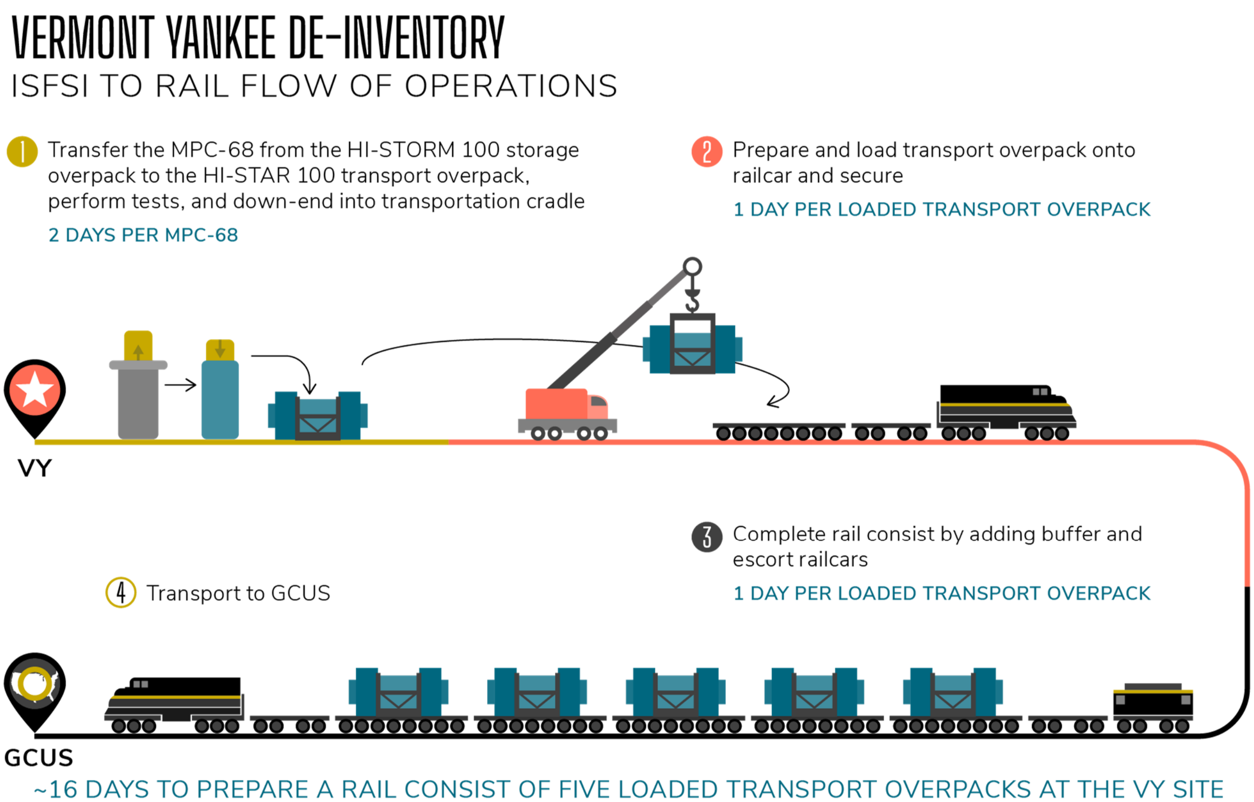
This report provides an assessment of the tasks, equipment, and interfaces that would be necessary to remove the spent nuclear fuel (SNF) and Greater Than Class C (GTCC) low-level waste (LLW) from the Vermont Yankee (VY) Independent Spent Fuel Storage Installation (ISFSI) located in the town of Vernon, VT, approximately 80 miles northwest of Boston, MA and 100 miles south of Montpelier, VT. The objective of this removal activity would be to transport the SNF and GTCC LLW to a Class I railroad, where it could then be transported to a future federal consolidated interim storage facility or geological repository. A railroad hub in the central U.S. with connections to all other major rail carriers was used as the route endpoint for the purposes of this study, because it could serve as a connection point to storage or disposal facilities located in any region of the U.S. The use of the geographical center of the 48 contiguous United States (GCUS) as a hypothetical destination does not imply that this location is being considered for a future federal consolidated interim storage facility, geological repository, or a transportation hub but was used, for purposes of this report, as a basis for scheduling and costing estimates assessed in this report.

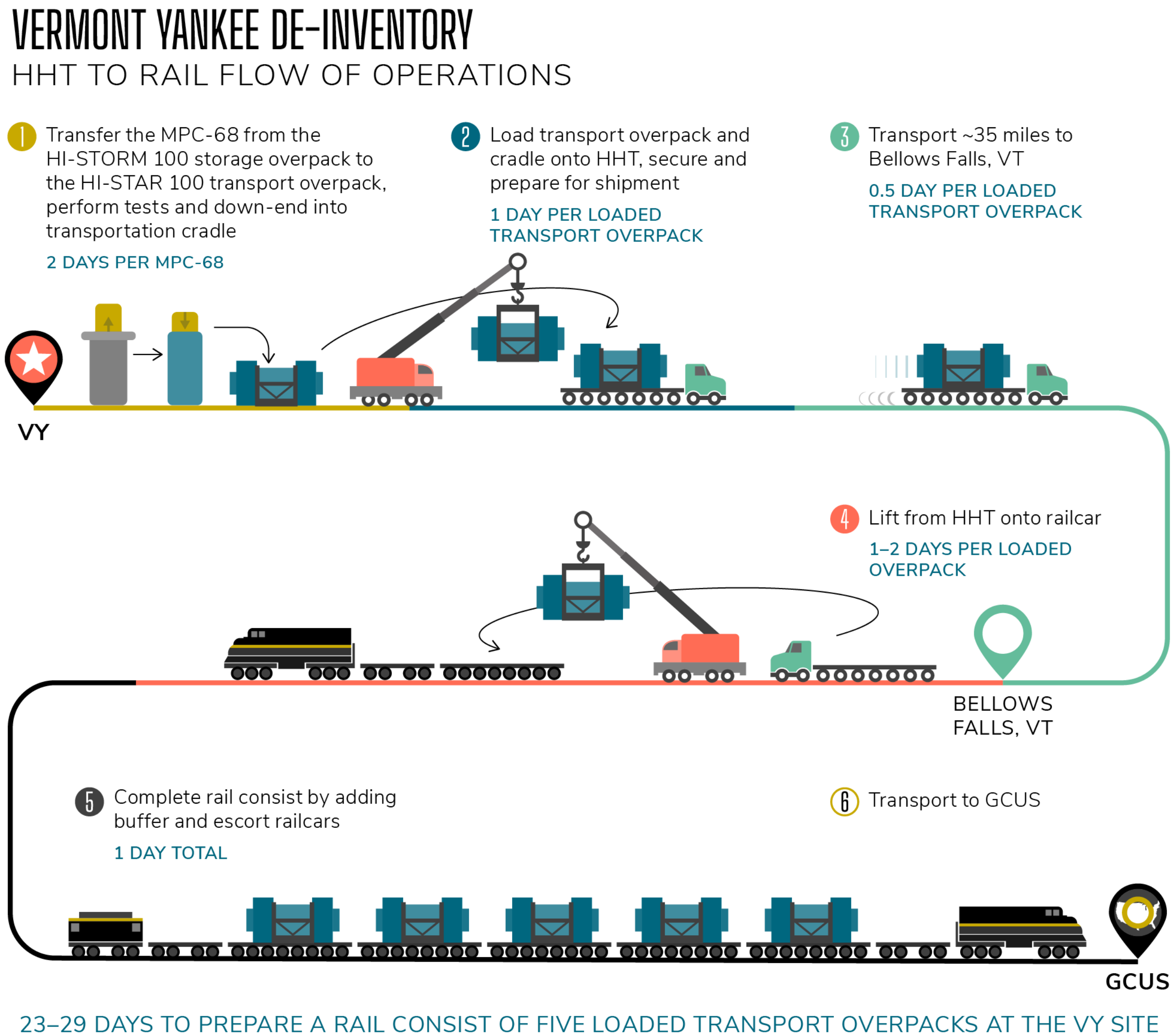
In performing this assessment, the results are expected to support preparations for transporting SNF and applicable GTCC low-level radioactive waste to a future federal consolidated interim storage facility for the U.S. Department of Energy (DOE). This assessment specifically examines the removal of the SNF and GTCC LLW contained within the VY ISFSI using the Orano team's experiences in the shipping of like and similar materials. For the purposes of this assessment, it is assumed that DOE would be responsible for a federal consolidated interim storage facility or geological repository to which the material would be shipped and would be the shipper of record; it is also assumed that the shipments would be regulated by the Department of Transportation (DOT) using U.S. Nuclear Regulatory Commission (NRC) certified packages and approved routes like comparable commercial shipments.

To lay the foundation of the assessment, the report begins by examining the pertinent site information in Section 2.0, including a description of the site and its characteristics; the characteristics of the SNF and the GTCC LLW to be shipped from the site; and a description of the Holtec HI-STORM 100 system used to store this material on-site and the associated transportation packaging system, the Holtec HI-STAR 100 cask. The site information is vital to establishing if sufficient space exists to perform transfer activities and assessing and identifying the potential need for site infrastructure modifications (e.g., fence line modifications to optimize/streamline transfer operations and/or loading activities) and/or hardware requirements (e.g., need for a transfer cask) to facilitate the shipment of these HI-STAR 100 casks from the VY ISFSI. Although accessing the site was not within the scope of this activity, sufficient sources of information existed for an informed assessment of the site to be performed. Ultimately a formal inspection would be necessary to verify assumed site criteria. The characteristics of the SNF and GTCC LLW at the VY ISFSI were reviewed against the requirements found in the NRC Certificate of Compliance (CoC) for the transportation packaging system. Similarly, the information for the Holtec dry storage canisters (MPC-68) to be shipped was also reviewed against the associated requirements in the CoCs. Finally, the information about the storage system in use was reviewed along with the characteristics of the transportation packaging system to identify any challenges to the ability to transfer the canisters into the transportation packaging system. If any potential issues were identified during these three reviews, the problems were documented along with any needed or recommended corrective actions, including the possible need to revise the CoC or request an exemption from the NRC.

After the pertinent site information was assessed and a transportation route analysis was performed, as described in **Section 3.0**, transportation routes from the VY ISFSI to a Class I railroad were identified, which could be used for subsequent shipment to a federal repository or interim storage facility. Multiple modes of transport of the SNF and GTCC LLW were considered (i.e., heavy haul truck [HHT], rail, and barge). From the VY ISFSI site itself, all three modes were evaluated to be viable options for shipment of the SNF and GTCC LLW, however no direct barge routes from the site were viable and all the viable barge routes first required HHT transport a significant distance before reaching a transload site to a barge and hence were screened from further consideration. **Figure 1-1** depicts the major steps of the potential transfer scenarios considered for the HHT and rail routes. As shown in this figure, the direct to rail scenario appears to be the least complicated approach, with the minimum number of times a Holtec HI-STAR 100 cask is handled, whereas the HHT scenario appears to be more complicated, with additional handling activities. The assessment of the transportation routes resulted in a listing of multiple viable routes with both positive and negative attributes that require evaluation to identify the optimal and/or favored route to transport the SNF and GTCC LLW from the VY site.

Figure 1-1: Potential Flow of Operations per Mode of Transport from the VY ISFSI





A Multi-Attribute Utility Analysis (MUA) was selected as the means to assess and rank the various routes and modes. Due to the large number of routes and associated modes initially identified, performing the MUA for all possible routes would be burdensome, so initial screening criteria were established to allow for less attractive routes to be screened from further consideration based on attributes associated with a particular mode of transport (i.e., screening is performed only between routes associated with a particular mode of transport). These screening criteria were applied in **Section 3.0** to reduce the number of identified routes from greater than 20 to a more manageable five. After the participating entities were identified in **Section 4.0**, these five routes (using two common modes from the site: HHT and direct loading on to rail) were evaluated using the MUA to rank the routes for shipping the SNF and GTCC LLW from VY to the hypothetical destination of GCUS by Class I rail in **Section 5.0**. **Figure 1-2** identifies the routes evaluated in the MUA.

Based on the results from the MUA, a concept of operations and recommended budget and spending plan are detailed for the highest ranked shipment route in **Sections 6.0** and **7.0**, respectively. This assessment also includes information on a Security Plan and associated procedures in **Section 8.0** and an Emergency Response Plan and associated preparedness for the prospective shipments in **Section 9.0**. Finally, **Section 10.0** identifies the recommended next steps to initiate removal of SNF and GTCC LLW from VY.

The routes are described in further detail in **Section 3.0**. These figures were produced using results from DOE's Stakeholder Tool for Assessing Radioactive Transportation (START) software [1]. The colored lines indicate the routes analyzed by the MUA as explained in **Section 5.0**.

Figure 1-2: Possible Routes Evaluated by the MUA for Shipment of SNF and GTCC LLW from VY ISFSI

2.0 PERTINENT SITE INFORMATION

2.1 Description of Site/Characteristics

2.1.1 Overview

The Vermont Yankee Nuclear Power Station (VYNPS) site, owned by NorthStar Nuclear Decommissioning Co. LLC, is located in the southeast corner of Vermont in the town of Vernon in Windham County, approximately three miles north of the Vermont-Massachusetts border and on the west shore of the Connecticut River which establishes the Vermont-New Hampshire border [2]. **Figure 2-1** shows the location of the VYNPS relative to the Vermont-Massachusetts state border.

The site is bordered on the east by the Connecticut River; to the south and sporadically in between the VYNPS parcel and the Connecticut River is land owned and operated by Great River Hydro, LLC; to the west is residential which includes Vernon Elementary School under one mile away; and to the north of the site is agricultural land [3].

The site, shown in **Figure 2-4**, consists of approximately 145 acres [3] owned by NorthStar Vermont Yankee, LLC, within this there is 125 acres of controlled area surrounded by a 6 ft foot fence topped with 1 ft of barbed wire [4]. The majority of the ground is a mixture of sand and loam with less than eight percent slopes. Along the riverbank the ground is up to 60% grade.

The topography of the site and its immediate surroundings is relatively flat with grades less than 3% and an elevation around 250 ft above sea level, the elevation of the river near the site is approximately 210 ft above sea level. The area to the west of the site has a gradual slope, the elevation of Interstate 91, approximately 2.5 miles west of the site, is around 660 ft above sea level, this yields a grade of just over 3%. The slopes of all grades along the routes to Interstate 91 are less than 3%.

The full VYNPS parcel is shown in **Figure 2-2**, the secure controlled area was updated from its final operating boundaries to an ISFSI-only configuration in 2018, both boundaries are shown in **Figure 2-3**. The center of the community of Vernon is less than 1 mile from the plant location on the site. There is little commercial development and a small amount of residential development in the nearby area, which is mostly dominated by agricultural use. The majority of the area within a five-mile radius is undeveloped woods [2].

VYNPS was licensed and began operation in 1972 under ownership of a collection of regional utility companies. In 2002, VYNPS was sold to a subsidiary of Entergy Corporation. In 2011, the operating license was renewed for an additional 20 years. The VYNPS permanently ceased operations at the end of 2014 and placed all SNF into the spent fuel pool, the NRC certified these actions in 2015. By August of 2018, all SNF had been moved into dry storage within the ISFSI. The two ISFSI pads can be seen in **Figure 2-4**. In 2019, Entergy Nuclear Vermont Yankee transferred the license to subsidiaries of NorthStar Group Services, Inc. to continue decommissioning actions.

The VYNPS consisted of a single General Electric Boiling Water Reactor 4 (BWR-4) in a Mark 1 containment [5], henceforth referred to as the reactor. The reactor began operation in 1972 and was originally designed for 540 megawatts electric (MWe) but was upgraded in 2006 to 620 MWe, the reactor was officially shut down in 2014 with no incident. The reactor core held up to 368 fuel assemblies and 89 control rods.

The nearest railroad line runs north-south and is approximately 0.5 miles west of the plant at its closest approach. The VYNPS is directly rail served by the New England Central Railroad (NECR) with a single refurbished rail spur connecting the NECR mainline to the south end of the VYNPS turbine building. The plant also has direct truck access to interstate route VT-142 via Fort Bridgman Rd. The VYNPS does not have on-site barge access and the closest potential barge site is Port of Boston which is at minimum 102 miles by heavy haul truck HHT.

Figure 2-1: Vermont Yankee Nuclear Power Station (VYNPS) Geographical Context [2]

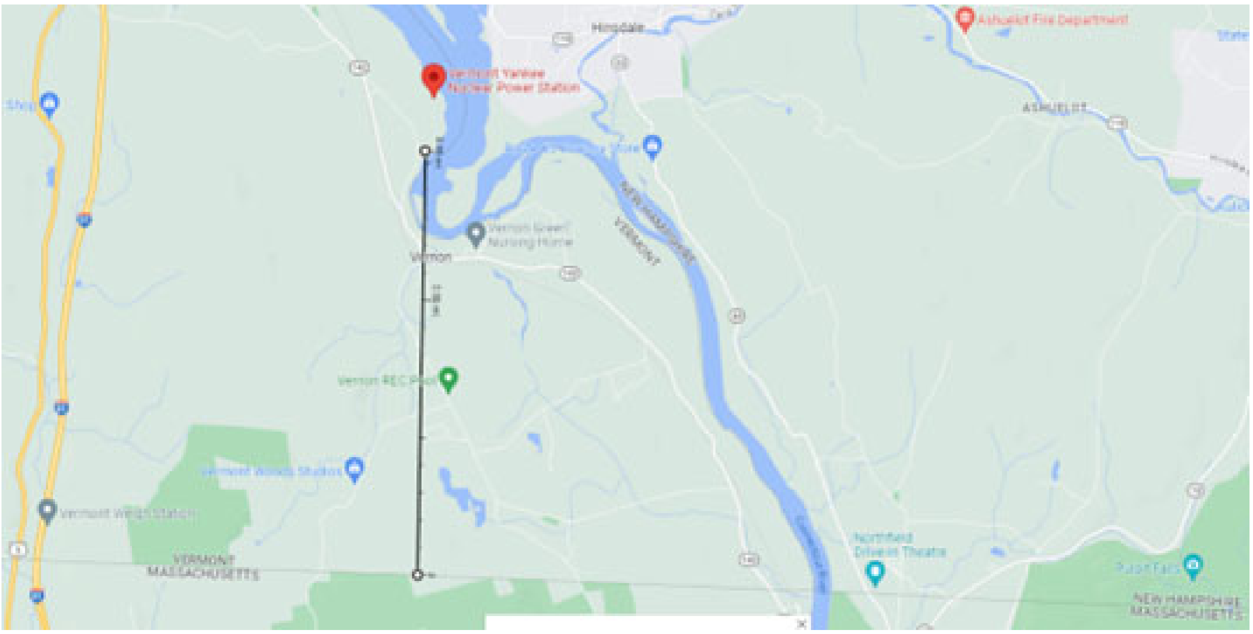


Figure 2-2: VYNPS Parcel/Site Boundary [2]

Figure 2-3: VYNPS Controlled Area Before (Green) and After (Red) 2018 ISFSI Only Security Amendment to Physical Security Plan

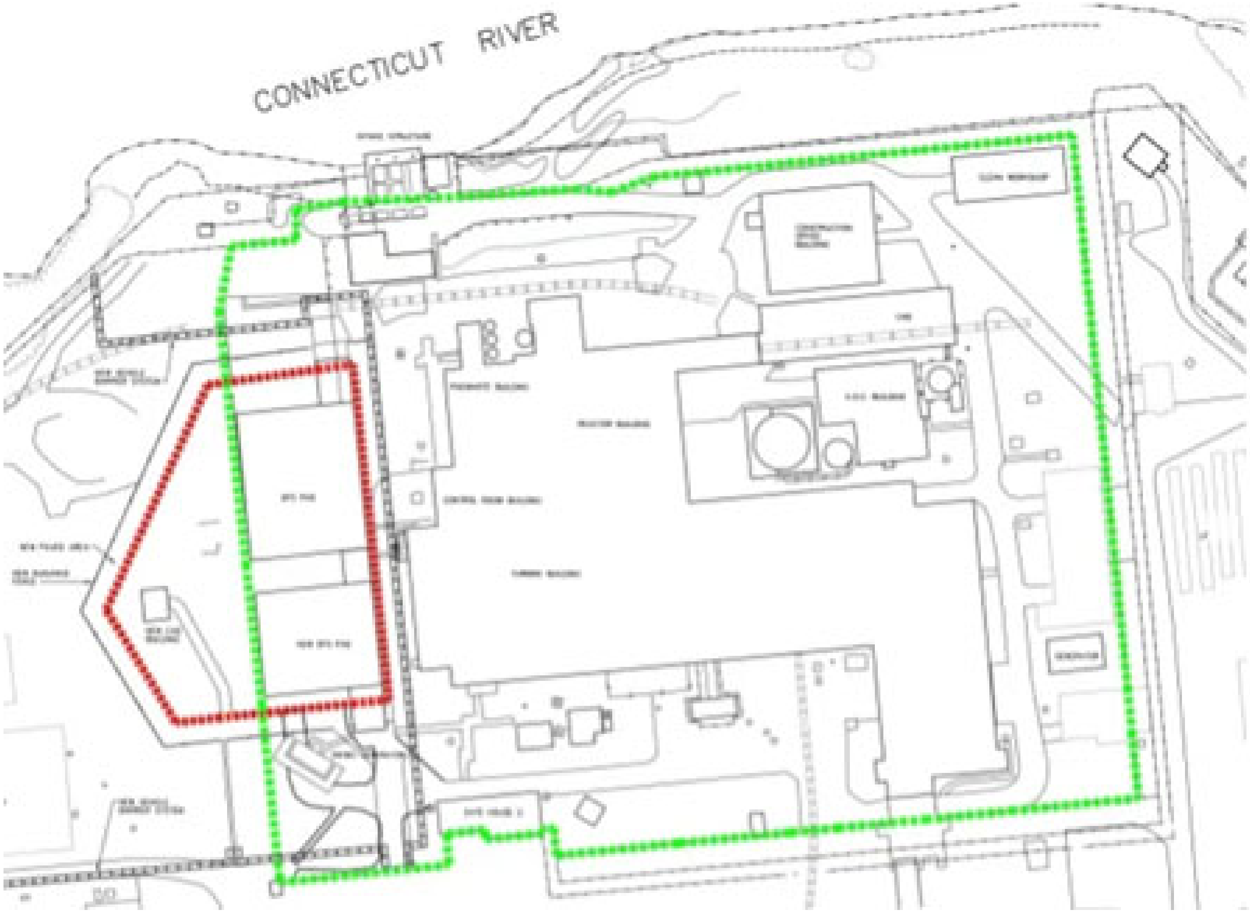


Figure 2-4: VYNPS Elevated Photo Facing South

2.1.2 Site Infrastructure

Rail service to the Vermont Yankee site is provided by the New England Central Railroad (NECR). 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, these paths are depicted in **Figure 2-5** through **Figure 2-9** [6].

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 secure controlled area. 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. **Figure 2-6** provides an aerial view of the Vermont Yankee rail spur and **Figure 2-7** shows the rail spur at the Vermont Yankee site entrance. There is a derailer and a dragging equipment detector as well as a hot bearing detector located at the junction of the Vermont Yankee rail spur and the NECR mainline.

The Connecticut River is dammed both upstream and downstream from the Vermont Yankee site. The Vernon Dam is located 0.75 mile downstream of the Vermont Yankee site at river mile 142, shown in **Figure 2-10**, and the Bellows Falls Dam is located upstream of the Vermont Yankee site at river mile 174 [6]. These dams on the Connecticut River to the north and south of the Vermont Yankee site preclude barge shipments from this site and, consequently, there is no on-site barge facility at Vermont Yankee.

Figure 2-5: VYNPS Aerial View of Site Infrastructure [6]

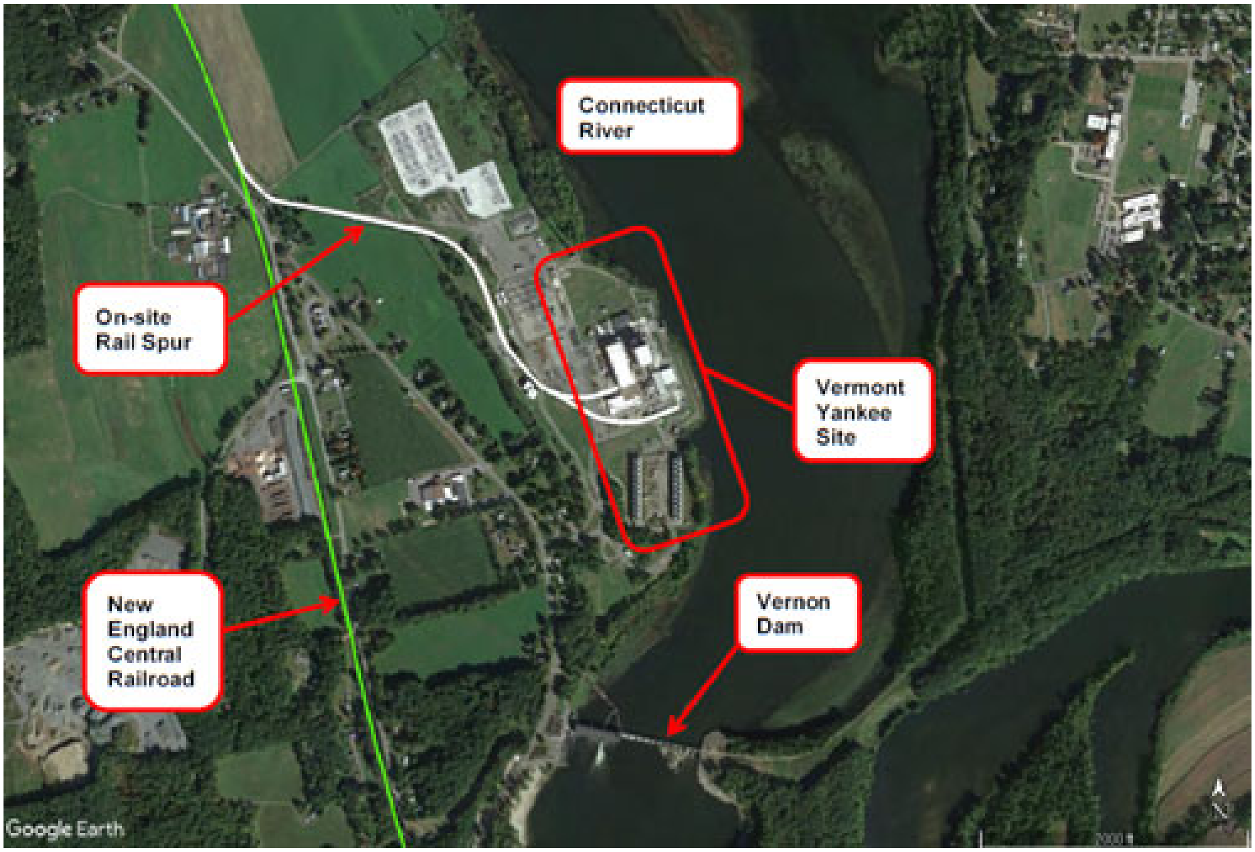


Figure 2-6: VYNPS Aerial View of Onsite Rail Spur [6]

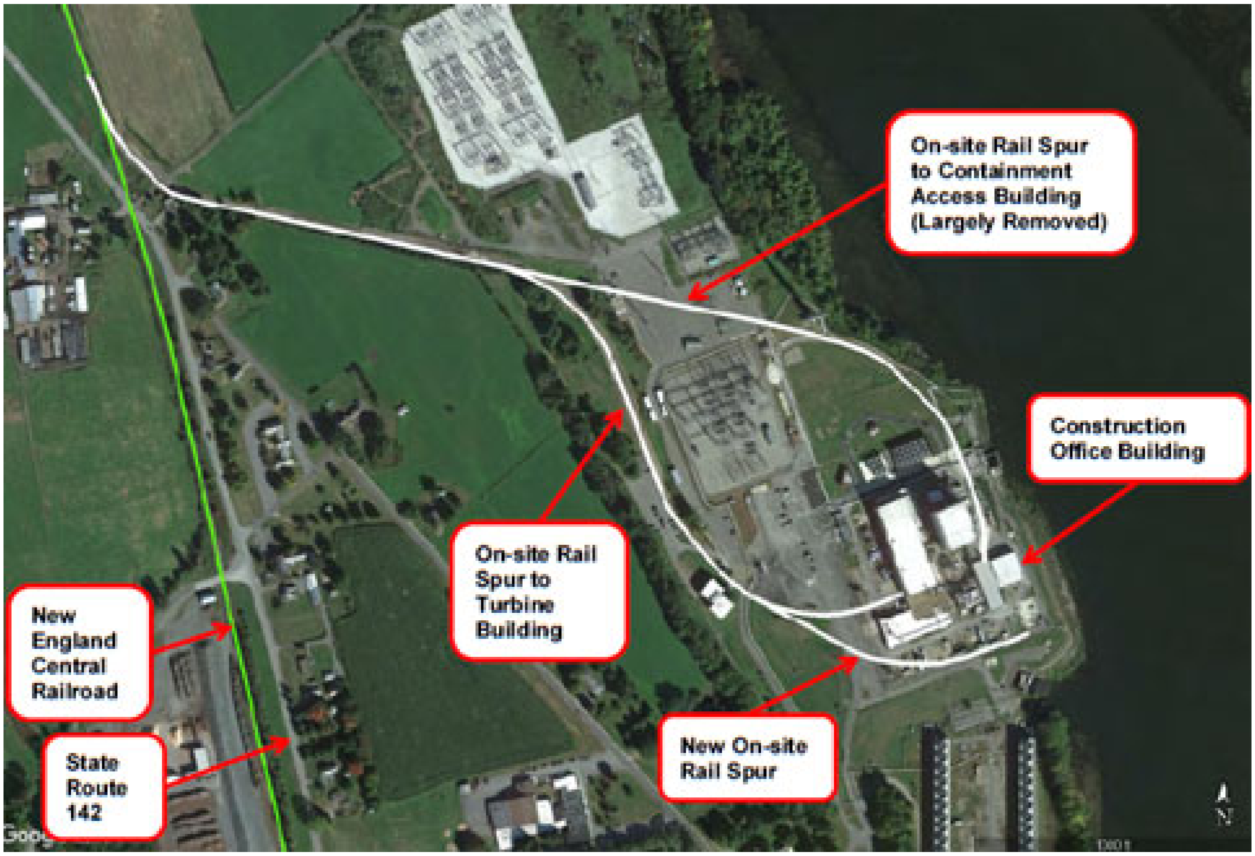


Figure 2-7: Rail Spur Entrance to VYNPS, Right Side Spur goes to Containment Building, Left Side Spur goes to Turbine Building [6]

Figure 2-8: Paved Over Rail Spur Originally Connecting the VYNPS Rail Spur Entrance to the Containment Building [6]

Figure 2-9: VYNPS Onsite Rail Spur to Turbine Building [6]

Figure 2-10: Vernon Dam Downstream of VYNPS

2.1.3 Near-Site Transportation Infrastructure

2.1.3.1 Rail

The NECR is a Class III railroad and operates 384 miles of track in Massachusetts, Connecticut, New Hampshire, and Vermont, from the Canadian border at East Alburgh, Vermont to New London, Connecticut. The NECR interchanges traffic with the Canadian National (CN), the Canadian Pacific Kansas City (CPKC), the CSXT, the Massachusetts Central Railroad (MCER), the Norfolk Southern (NS), the Pan Am Southern (PAS), the Providence and Worcester Railroad (PW), and the Vermont Railway (VTR). PAS also operates trains via trackage rights on the NECR between East Northfield, Massachusetts and White River Junction, Vermont. The NECR hosts the Amtrak Vermonter passenger service from East Northfield, Massachusetts to St. Albans, Vermont, including passing by the Vermont Yankee site. PAS and CSXT, which pass by VYNPS, interchange with NECR in Battleboro, VT and Palmer, MA, respectively. See report PNNL-30429 [6] for additional details and photos of the rail system.

The NECR was acquired by Genesee & Wyoming Inc. in 2012. In 2022, CSXT purchased the operations branch of PAS, the Pan Am Railways (PAR). The PAR was fully integrated into the CSXT in January 2023 with all routing now reflecting CSXT. CSXT intends to invest $100 million in upgrading the PAR infrastructure in New England, including the mainline and rail yards. PAS is jointly owned by the NS and CSXT and is operated by an independent company, Berkshire & Eastern Railroad (B&E). B&E is the neutral operator of the jointly owned railroad.

In 2008 and in 2016, DOE, the Federal Railroad Administration, and the Council of State Governments – Eastern Regional Conference assessed the rail infrastructure at and near the Vermont Yankee site. The assessment was focused on the NECR from the Vermont Yankee site to Palmer, Massachusetts, where the NECR interchanges with the CSXT, a distance of about 51 rail miles from the VY site. The assessment identified one major bridge over the Connecticut River, 13 other bridges, and 17 grade crossings.

Figure 2-11 shows the State Route 142 railroad grade crossing at milepost 115.97, **Figure 2-12** shows the grade crossing at milepost 112.68, **Figure 2-13** shows the railroad bridge over the Connecticut River at milepost 109.15, and **Figure 2-14** shows a smaller railroad bridge at milepost 103.33.

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 were shipped in the MP197HB transportation cask (docket 71-9302) 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 2-15** shows the MP197HB transportation cask without impact limiters on the KRL 50002 railcar prior to shipping and **Figure 2-16** shows the MP197HB transportation cask arriving at the Waste Control Specialists (WCS) low-level radioactive waste disposal facility in Andrews, Texas.

Figure 2-11: State Route 142 Grade Crossing at Milepost 115.97, 2008 [6]

Figure 2-12: Grade Crossing at Milepost 112.68, 2008 [6]

Figure 2-13: Connecticut River Railroad Bridge at Milepost 109.15, 2008 [6]

Figure 2-14: Railroad Bridge at Milepost 103.33, 2008 [6]

Figure 2-15: MP197HB Transportation Cask without Impact Limiters on Rail Prior to Shipping at VYNPS (Photo Courtesy of Orano)

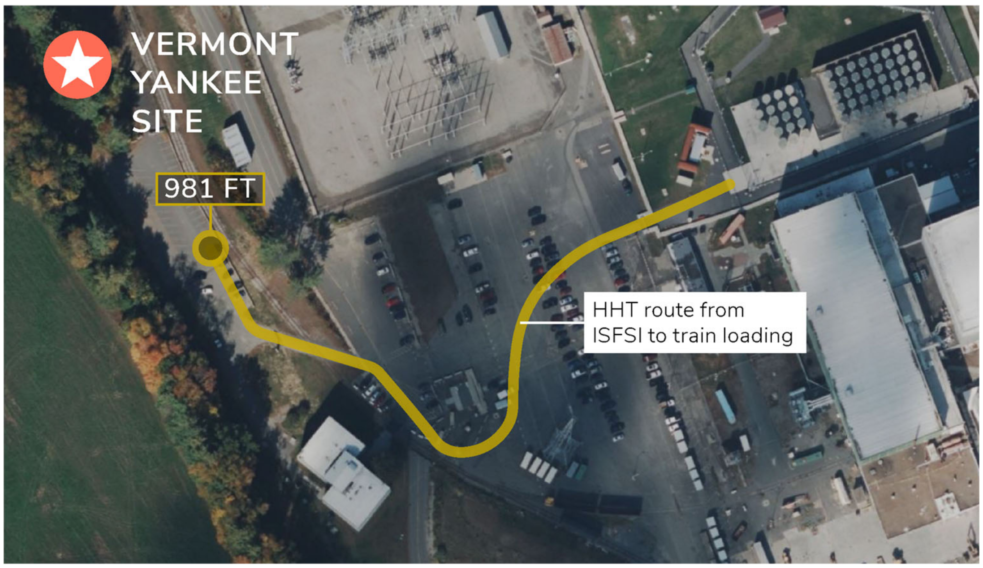
Figure 2-16: MP197HB Transportation Cask on Rail at WCS Low Level Radioactive Waste Disposal Facility (Photo Courtesy of Orano)

2.1.3.2 Heavy Haul Truck

The Vermont Yankee site is located off of highway VT-142, Fort Bridgman Road, which is a two-lane road leading to Brattleboro to the north and the Vermont/Massachusetts state border to the south (as seen in **Figure 2-6**). There are two options for moving the MPC-68's off of the site and they include either by train or by HHT.

If the off-site shipment is planned to be by loading a train on the VY site using existing track, the HHT will move one cask at a time from the ISFSI to the on-site transload track which is located approximately 981' from the ISFSI gate (see **Figure 2-17**). A new gate will need to be installed in the fence to allow for the egress of the HHTs to reach the road leading to the current parking lot, which will be the location of the transload operation. The yellow line depicts the on-site haul path from the ISFSI gate to the transload point.

Figure 2-17: On-Site HHT Infrastructure to Support Direct-Rail Loading or HHT Off-Site Shipment



A new fence will be erected to enclose the transload operation and staging of the loaded train, effectively extending the protected area to enclose the loading operations. The HHT will pass through the new gate and cross the road leading to the entrance to the parking lot and will pull up next to the white "X" shown in **Figure 3-4,** which denotes the placement of the crane for the transload operation where the cask and skid will be lifted from the HHT and placed on the deck of the railcar and appropriately secured.

The choice to use this location for the on-site transload/train loading operation allows for some flexibility to use as much or as little of the track as required to build various sizes of trains if necessary. The transload location is on existing track which is located very close to the ISFSI. Further description of the loading operation is provided in **Section 6.0**.

The HHT routes leading to off-site transload facilities will follow the on-site road to where it intersects with Governor Hunt Road and then turn right (negotiating the tight right-hand turn to get off of the site) to the potential off-site transload facility to transfer the transport overpack from the HHT to a railcar. **Section 3.1** provides an overview of the potential off-site transload locations.

2.1.3.3 Barge

The closest water served locations for barge loading would involve a HHT or rail movement to reach the barge sites. The shortest option is using HHT to Port of Boston (102-139 miles) and loading at a commercial pier with the space to conduct the transload and barge loading operation, such as the Conley Container Terminal. However, it is unknown whether Port of Boston accepts radioactive waste. This HHT would involve passing multiple rail sidings to reach the port. Another option would be to use HHT to The Port of New London, CT, based on the facilities there (131-150 miles). This is operated by the CT Port Authority. The last option introduced for barge transport is to use HHT to the Port of New Haven, CT (119-129 truck miles), where there are four potential established private piers: LaFarge North America slip, Gateway Terminals, American Green Fuels, and All-American Waste. These barge locations are the closest to the site, however, they may not be ideal for conducting a loading campaign as they are operating facilities, which may introduce significant additional complications around interrupting normal operations.

Because the VY site is directly rail served, there appears to be no need to further investigate barge options, especially since they do not exist on the VY site.

2.1.4 Holtec HI-STORM 100 Storage System Details

The 3,880 fuel assemblies at VY are stored in 58 HI-STORM 100 storage systems which are loaded with Multipurpose Canisters (MPCs). The utilized MPCs at VY include 23 MPC-68 and 35 MPC-68M as part of the HI-STORM 100 System. The total of 58 MPCs are stored in 13 HI-STORM 100S depicted in **Figure 2-18**, 45 HI-STORM 100S Version B. See **Table 2-1** for a summary of storage date, overpack and MPC details for stored fuel assemblies. The GTCC is stored in a single HI-SAFE overpack which has been placed in the VY ISFSI.

HI-STORM 100 System is a spent nuclear fuel storage system designed to be in full compliance with NRC requirements codified in 10 CFR 72. The HI-STORM 100S and HI-STORM 100S Version B overpack designs depicted in **Figure 2-18** and **Figure 2-19**, respectively, are enhanced variants of the HI-STORM 100 overpack design. The HI-STORM 100S and 100S Version B accept the same MPCs and fuel types as the HI-STORM 100 overpack and the basic structural, shielding, and thermal-hydraulic characteristics remain unchanged. The HI-STORM overpack is constructed from a combination of steel and concrete and weighs over 100 tons empty, as indicated by the 100 signifier in its label.

The HI-STORM 100 System is comprised of three discrete components, an interchangeable MPC, the HI-STORM overpack for long-term storage of the MPC placed inside it, and the HI-TRAC, shown in **Figure 2-20** for transfer of a loaded MPC from a storage overpack to a transport overpack. In addition, the HI-STAR 100 and HI-STAR 100MB transport overpacks (see **Figure 2-21**) have been identified as possible transport casks due to the expectation for transport certification of MPC-68M, HBU SNF, and GTCC, as well as their compatibility with the HI-STORM 100 System. The external diameters of all MPCs are identical to allow the use of a single overpack. The HI-STORM storage overpack provides physical protection, cooling, and radiological shielding for the contained MPC.

CoC No. 9261 [49] for the HI-STAR 100 transportation cask does not allow for the transport of the MPC-68M canisters, high burnup (> 45 GWd/MTHM) SNF, or GTCC waste. CoC No. 9378 [50] for the HI-STAR 100MB transportation cask does not allow for the transport of any of the VY SNF or GTCC waste. Consequently, the CoC for either the HI-STAR 100 or the HI-STAR 100MB would have to be revised before the SNF stored in MPC-68M canisters, the 248 HBU SNF assemblies, or the GTCC waste from decommissioning at the Vermont Yankee site could be transported.

Figure 2-18: HI-STORM 100S with MPC Partially Insert Sketch [9]

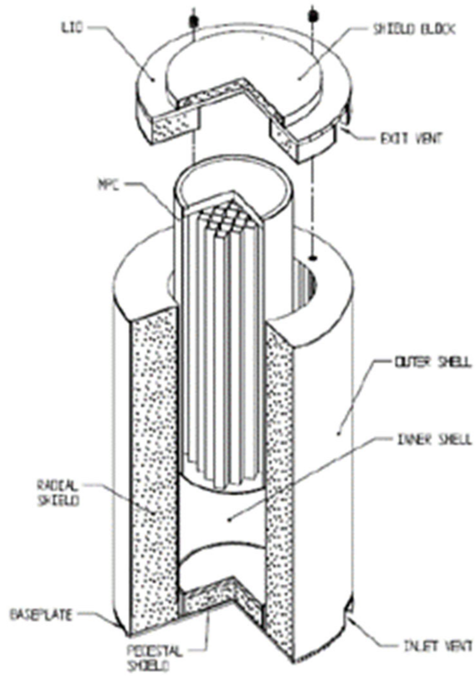


Figure 2-19: HI-STORM 100S Version B with MPC Partially Inserted [9]

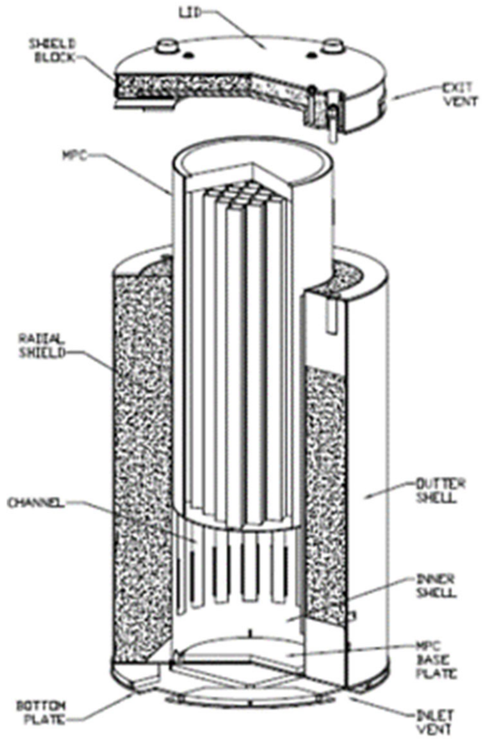


Figure 2-20: HI-TRAC 100 Elevation View [9]

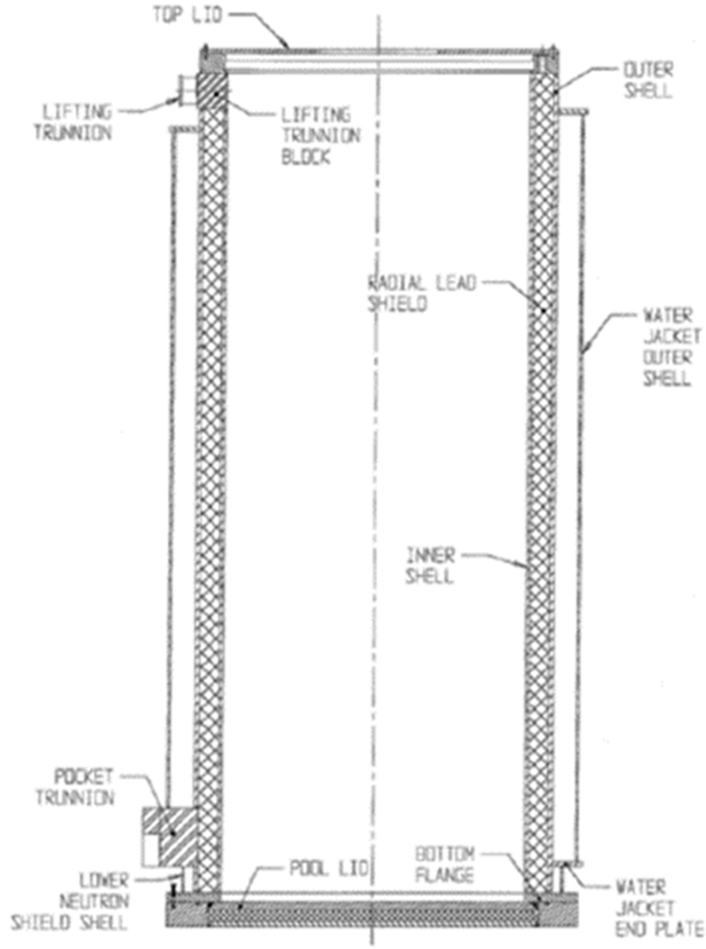


Figure 2-21: HI-STAR 100 Elevation Sketch [7]

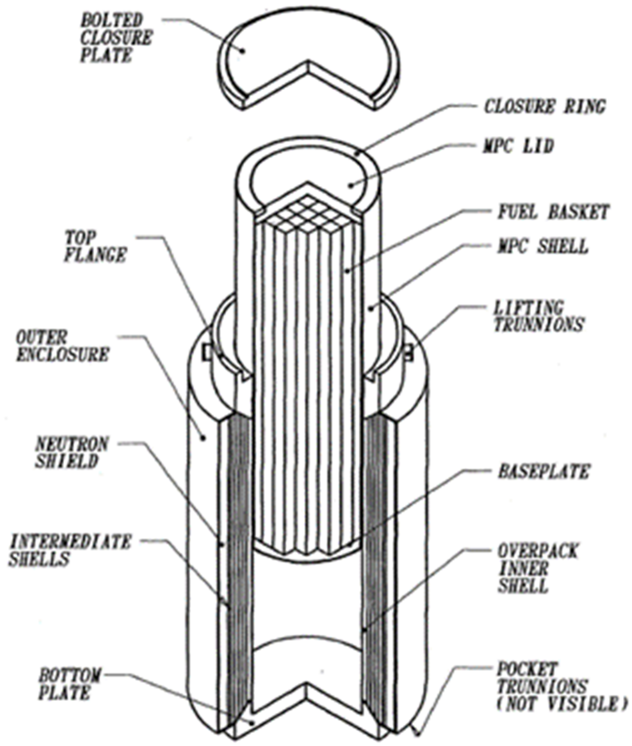


Table 2-1: Summary of VY Registration of Spent Fuel Cask Use

No.	Date	Overpack	Serial No.	MPC	Serial No.
1	5/29/2008	HI-STORM 100S	065	MPC-68	058
2	6/16/2008		066		059
3	7/1/2008		067		060
4	7/18/2008		068		061
5	7/29/2008		069		062
6	6/29/2011		240		305
7	7/12/2011		241		306
8	7/23/2011		242		307
9	8/6/2011		461		308
10	5/22/2012		569		362
11	6/5/2012		570		363
12	6/19/2012		571		364
13	6/26/2012		572		365
14	6/23/2017	HI-STORM 100S Version B	979		523
15	6/29/2017		982		527
16	7/17/2017		978		526
17	7/21/17		981		522
18	7/31/17		983		525
19	8/4/17		989		550
20	8/11/2017		986		529
21	8/18/2017		987		528
22	8/28/2017		980		551
23	9/1/2017		988		524
24	9/11/2007		984	MPC-68M	531
25	9/23/2017		985		533
26	9/29/2017		1007		530
27	10/9/2017		1004		548
28	10/17/2017		1005		547
29	10/23/2017		990		546
30	10/27/2017		997		549
31	11/2/2017		998		552
32	12/1/2017		1020		553
33	12/8/2017		999		559
34	12/14/2017		1000		554
35	1/9/2018		1001		555
36	1/12/2018		1002		556
37	1/19/2018		1003		557
38	1/26/2018		1012		543
39	2/2/2018		1013		542
40	2/9/2018		1014		532
41	2/27/2018		1015		541
42	3/5/2018		1016		534
43	3/10/2018		1017		544
44	5/5/2018		1018		564
45	5/11/2018		1019		567
46	5/18/2018		1021		558
47	5/29/2018		1022		560
48	6/5/2018		1023		565
49	6/8/2018		1024		562
50	6/12/2018		1025		563
51	6/25/2018		1026		568
52	6/29/2018		1027		561
53	7/1/2018		1028		569
54	7/5/2018		1010		572
55	7/10/2018		1011		566
56	7/15/2018		1008		545
57	7/18/2018		1009		570
58	8/1/2018		1006		571

2.1.4.1 Vertical Concrete Storage Overpack: HI-STORM 100

A single, base HI-STORM 100 overpack design, shown in **Figure 2-22**, can store both MPC-68 and MPC-68M canisters. The inner diameter of the overpack inner shell is 73½-inches and the height of the cavity is 191½- inches. The overpack inner shell is provided with channels distributed around the inner cavity to present an inside diameter of 69½-inches. The outer diameter of the overpack is 132½-inches. The overall height of the HI-STORM 100 overpack is 239½-inches.

The significant differences among the three overpacks in this report (HI-STORM 100, 100S, 100S Version B) exist in overall height, MPC pedestal height, location of the air outlet ducts, and the vertical alignment of the inlet and outlet air ducts. The HI-STORM 100 overpack is approximately 240 inches high from the bottom of the baseplate to the top of the lid bolts and 227 inches high without the lid installed.

The HI-STORM 100S and the HI-STORM 100S Version B, shown in **Figure 2-18** and **Figure 2-19**, are variations of the HI-STORM 100 overpack design, shown in **Figure 2-22**. These variations include a modified lid which incorporates the air outlet ducts into the lid, allowing the overpack body to be shortened.

There are two variants of the HI-STORM 100S overpack, differing from each other only in height and weight. The HI-STORM 100S(232) is 232 inches high, and the HI-STORM 100S(243) is 243 inches high. The HI-STORM 100S(243) is approximately 10,100 lbs heavier. Similarly, there are two variants of the HI-STORM 100S Version B overpack. The HI-STORM 100S(218) is 218 inches high, and the HI-STORM 100S(229) is 229 inches high. The HI-STORM 100S(229) is approximately 8,700 lbs heavier.

In general, all varieties of the HI-STORM 100 will be referred to as such. The HI-STORM 100S Version B is an enhanced version of the HI-STORM 100S, which is an enhanced version of the original HI-STORM 100 overpack thus, any design features can be assumed to be the same from HI-STORM 100 to HI-STORM 100S and HI-STORM 100S to HI-STORM 100S version B, unless otherwise specified.

The location of the air outlets in the HI-STORM 100S design differ in that the outlet ducts for the HI-STORM 100 overpack are located in the overpack body and are aligned vertically with the inlet ducts at the bottom of the overpack body. The air outlet ducts in the HI-STORM 100S are integral to the lid assembly and are not in vertical alignment with the inlet ducts.

The HI-STORM 100S Version B overpack design does not include a concrete-filled pedestal to support the MPC. Instead, the MPC rests upon a steel plate that maintains the MPC sufficiently above the inlet air ducts to prevent direct radiation shine through the ducts. To facilitate this change, the inlet air ducts for the HI-STORM 100S Version B are shorter in height but larger in width. In addition, the HI-STORM 100S Version B has an optional girdle beam structure that fits around the exterior circumference of the overpack.

Lifting of the HI-STORM 100 overpack, while loaded or empty, may be accomplished either by attachment at the top of the storage overpack or by attachment at the bottom. For a top lift, the storage overpack is equipped with four threaded anchor blocks arranged circumferentially around the overpack see **Figure 2-23**. These anchor blocks are used for overpack lifting as well as securing the overpack lid to the overpack body. The storage overpack may be lifted with a lifting device that engages the anchor blocks with threaded studs and connects to a crane or similar equipment.

A bottom lift of the HI-STORM 100 storage overpack is affected by the insertion of four hydraulic jacks underneath the inlet vent horizontal plates. A slot in the overpack baseplate allows the hydraulic jacks to be placed underneath the inlet vent horizontal plate. The hydraulic jacks lift the loaded overpack to provide clearance for inserting or removing a device for transportation. The loaded HI-STORM can only be handled vertically.

Figure 2-22: HI-STORM 100 with MPC Partially Inserted Sketch [9]

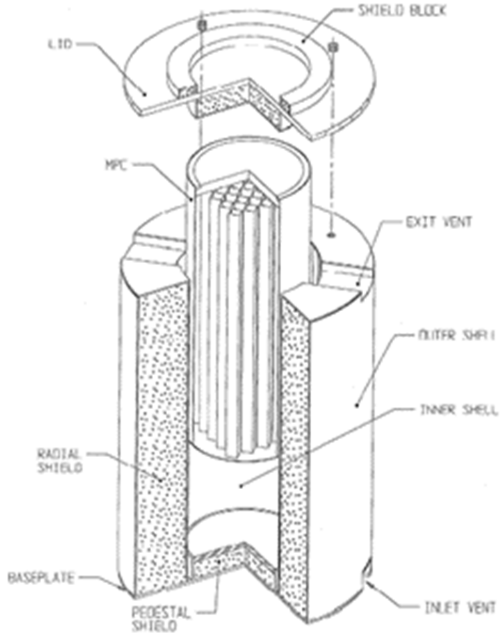
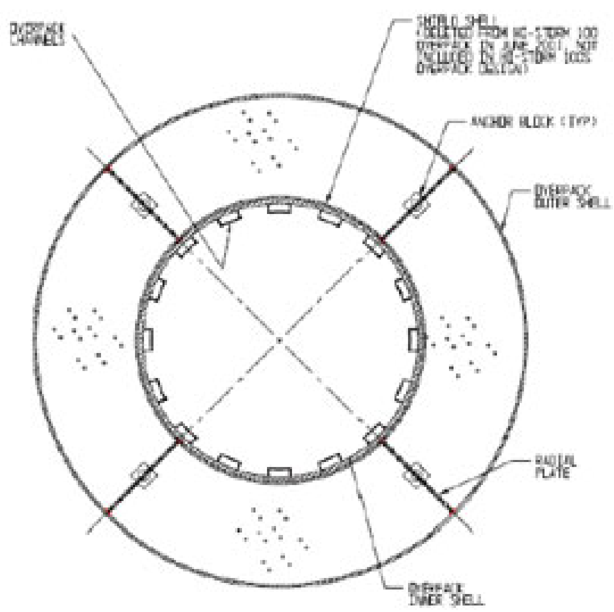


Figure 2-23: HI-STORM 100 Top-Down View Showing Four Anchor Blocks [9]



2.1.4.2 Multipurpose Canister: MPC-68

The MPC for all HI-STORM/HI-STAR systems consists of two principal components, namely the enclosure vessel (EV) and the fuel basket. The MPC-68 and MPC-68M multipurpose canisters hold 68 boiling water reactor SNF assemblies and are part of the HI-STORM 100S System. Due to the differing storage contents of each MPC, the maximum loaded weight differs among MPCs. However, the maximum weight of a loaded MPC is approximately 44½ tons.

All MPCs have identical external diameters. The outer diameter of the MPC is 68-3/8-inches and the maximum overall length is approximately 190½- inches. The MPC-68 fuel basket is assembled from a rectilinear gridwork of plates so that there are no bends or radii at the cell corners. The MPC fuel basket is positioned and supported within the MPC shell by a set of basket supports welded to the inside of the MPC shell. The MPC fuel basket may also be positioned and supported by basket shims welded directly to the MPC fuel basket or by extruded aluminum shims that are installed in the annular space between the MPC fuel basket and the enclosure vessel.

The MPC cavity is dried using either a vacuum drying system or a forced helium dehydration system (see **Figure 2-24**). The MPC is backfilled with 99.995% pure helium in accordance with the limits in the Final Safety Analysis Report for the HI-STORM 100 cask system [9] during canister sealing operations. The top of the MPC lid is equipped with four threaded holes that allow lifting of the loaded MPC. These holes allow the loaded MPC to be raised/lowered from the HI-STORM overpack (see **Figure 2-25**).

Lifting lugs attached to the inside surface of the MPC canister shell serve to permit placement of the empty MPC into the HI-TRAC transfer cask. The lifting lugs also serve to axially locate the MPC lid prior to welding. These internal lifting lugs are not used to handle a loaded MPC. Since the MPC lid is installed prior to any handling of a loaded MPC, there is no access to the lifting lugs once the MPC is loaded.

The MPC lid is a circular plate edge-welded to the MPC outer shell. The lid is equipped with vent and drain ports that are utilized to remove moisture and air from the MPC and backfill the MPC with a specified amount of inert gas (helium). The closure ring is a circular ring edge-welded to the MPC shell and lid. The MPC lid provides sufficient rigidity to allow the entire MPC loaded with SNF to be lifted by threaded holes in the MPC lid.

In alloy X baskets, such as those found in the MPC-68, the Metamic or Boral neutron absorber panels are completely enclosed in stainless steel sheathing that is stitch welded to the MPC basket cell walls along their entire periphery. The edges of the sheathing are bent toward the cell wall to make the edge weld.

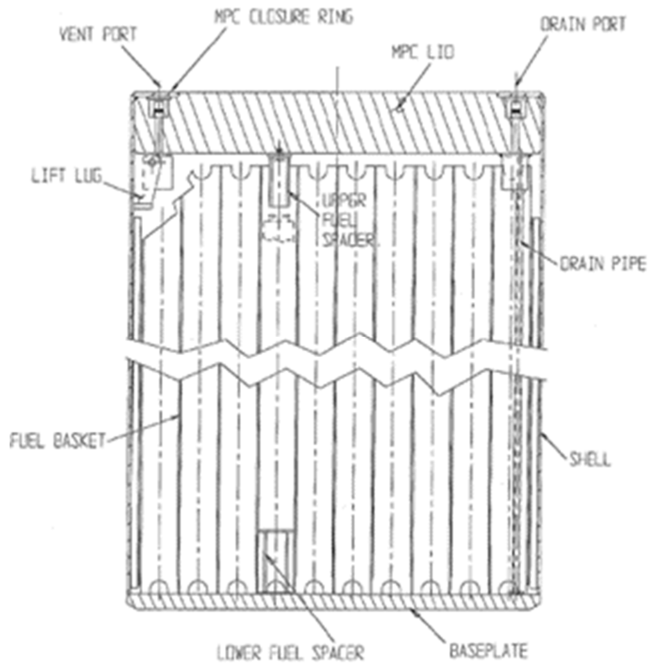
The MPC-68M is an enhanced version of the MPC-68, all design features that apply to MPC-68 apply to MPC-68M, unless otherwise specified. The operational characteristics of the HI-STORM overpack are unaffected in switching from MPC-68 to MPC-68M.

The MPC-68M employs Metamic-HT fuel basket instead of the alloy X stainless steel used in the MPC-68. The MPC-68M includes extruded aluminum shims which are installed in the peripheral space between the fuel basket and the enclosure vessel. The standard MPC-68M design consists of loosely installed conformal aluminum shapes that conduct heat from the basket to shell. All short-term operations remain unchanged from the MPC-68, except that the dried and helium filled

MPC-68M may reside indefinitely in the HI-TRAC transfer cask without the aid of the supplemental cooling system, unlike the MPC-68.

Figure 2-24: Holtec Forced Helium Dehydrator [42]

Figure 2-25: MPC Elevation View [9]

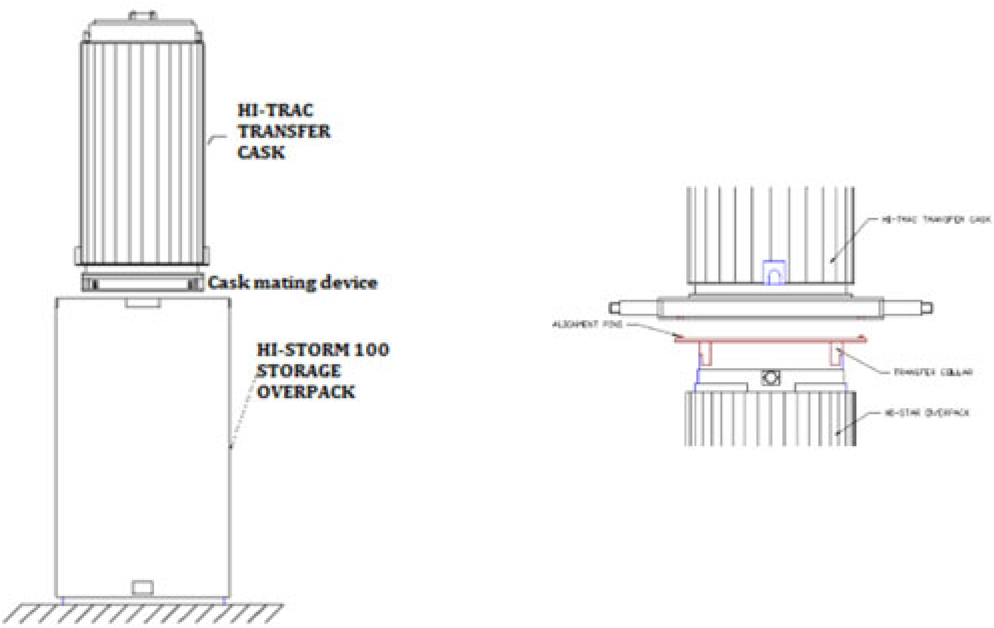


2.1.4.3 Transfer Cask: HI-TRAC 100

The HI-TRAC 100 transfer cask, shown in **Figure 2-20**, provides shielding to maintain occupational exposures as low as reasonably achievable (ALARA) while also maintaining the maximum load on the plant's crane hook to 100 tons. MPC handling operations are performed using a HI-TRAC transfer cask of the HI-STORM 100 system and allows the sealed MPC loaded with spent fuel to be transferred from the HI-STORM storage overpack to the HI-STAR transport overpack or vice versa. An example of a potential transfer station that could be used to transfer the MPC between storage overpacks and transport overpacks using the transfer cask is shown in **Figure 2-26**, which is a transfer station designed for the Trojan ISFSI site to perform the same transfer using a modified HI-TRAC system [13]. **Figure 2-27** provides a depiction of the stack-up operation needed to transfer the MPC from the storage overpack to the transfer cask and from the transfer cask to the transport overpack.

Figure 2-26: Example of a Transfer Station (used at Trojan with modified HI-TRAC) [13]

Figure 2-27: Depiction of HI-STORM 100 Stack-Up Operation [7]



2.1.4.4 Transport Cask: HI-STAR 100

The HI-STAR 100 (Holtec International Storage, Transport, And Repository) is an SNF storage and transport system, the annex "100" is a model number designation which denotes a system weighing in the range of 100 tons. A sketch of a HI-STAR 100 Overpack is shown in **Figure 2-21**.

The HI-STAR 100 transportation cask 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 CoC for the HI-STAR 100. The CoC for either the HI-STAR 100 [49] or HI-STAR 100MB [50]could be revised to include these contents. The HI-STAR 100 is designed for both storage and transport. In the storage mode, HI-STAR can be positioned in either the vertical or horizontal or an inclined orientation. The HI-STAR 100 System's ability, if implemented, to both store and transport SNF could eliminate the need for future repackaging.

The HI-STAR 100 overpack is a heavy-walled steel cylindrical vessel. The overpack helium retention boundary is formed by an inner shell welded at the bottom to a cylindrical forging and, at the top, to a heavy main flange with a bolted closure plate. The closure plate has a vent port and the bottom plate has a drain port both of which are sealed by a threaded port plug with a seal.

Radial channels are vertically welded to the outside surface of the outermost intermediate shell around the circumference. The enclosure shell is formed by welding enclosure shell panels between each of the channels to form additional cavities. The exterior flats of the radial channels and the enclosure shell panels form the overpack outer enclosure shell. Atop the outer enclosure shell, rupture disks are positioned in a recessed area.

Lifting trunnions and pocket trunnions are attached to the overpack for lifting and rotating the cask body. The trunnions are manufactured from a high strength alloy and are installed in tapped openings. The trunnions are secured in position by a locking pad shaped to make conformal contact with the curved overpack. Once the locking pad is bolted in position, the locking pad inner diameter is sized to restrain the trunnion from backing out.

The lifting, upending, and down-ending of the HI-STAR 100 requires the use of external handling devices. A lift yoke is connected to the lifting trunnions and a crane hook is used for upending or down-ending the HI-STAR 100.

HI-STAR 100MB is the model name of a transport package engineered to serve as a type B(U)F-96 package for transporting radioactive material including commercial spent fuel, reactor-related non-fuel waste, and high-level waste. There are two sub-types called standard length (SL) and extended length (XL) differing only in length and weight, measuring at 165-inches and 191-inches, respectively. The HI-STAR 100MB is an enhanced embodiment of the HI-STAR 100 transport cask initially licensed in docket 71-9261 in 1998. The fuel storage cavity of HI-STAR 100MB is designed, but not licensed, to be fully compatible with all MPCs previously licensed in the HI-STAR 100 Final Safety Analysis Report (FSAR [8]). HI-STAR 100MB can be used to transport high burnup (HBU) fuel. For transporting moderate burn-up fuel a single containment barrier suffices, for transporting HBU fuel a double containment barrier system is required. The double containment system for HBU fuel is provided by the MPC lid and cask lid.

All design and design concepts of the HI-STAR 100MB package are directly adapted from Holtec's various licensed transport, storage, and transfer cask systems. There are no important design concepts utilized in HI-STAR 100MB that have not been previously utilized and licensed in a Holtec storage or transport system. The design of the HI-STAR 100MB impact limiters differ from the HI-STAR 100 impact limiters in that the outer surfaces of the top and bottom forgings provide the cylindrical interface to the impact limiter "skirt" with a tight annular clearance. The top and bottom forgings present conformal bearing surfaces for the impact limiters' skirts.

There currently are no transport casks at VYNPS, the HI-STAR 100MB is covered above as it is the recommended method of transport for the loaded MPCs currently stored in the HI-STORM 100 overpacks. The HI-STAR 100MB was selected as the best choice for transport due to its expected compatibility with the current loaded MPCs, but currently it is not certified to transport either the MPC-68 or the MPC-68M. The HI-STAR 100 is currently certified to transport MPC-68 but not MPC-68M. A table of the relevant certification statuses is in **Table 2-2**.

Table 2-2: Certification Status of Different Overpack - Multipurpose Canister (MPC) Combinations for Storage and Transportation

Overpack	Storage			Transport		
	MPC-68	MPC-68M	GTCC	MPC-68	MPC-68M	GTCC
HI-STORM 100	True [9]	True [9]	False	False	False	False
HI-STORM 100S	True [9]	True [9]	False	False	False	False
HI-STORM 100S Version B	True [9]	True [9]	False	False	False	False
HI-STAR 100	True [7]	False	False	True [10]	False	False
HI-STAR 100MB	False	False	False	False	False	False

2.2 Characteristics of SNF and GTCC LLW to be Shipped

Vermont Yankee ceased operation on December 29, 2014, and all SNF has been removed from the Vermont Yankee reactor vessel [11]. On January 12, 2015, VYNPS certified to the NRC that all nuclear fuel had been permanently removed from the reactor vessel and placed in the spent fuel pool [12]. Removal of SNF from the Vermont Yankee spent fuel pool was completed on August 1, 2018 [12]. A total of 3,880 SNF boiling water reactor assemblies and one fuel debris canister (a GE-9 Hole container) are in dry storage at the Vermont Yankee ISFSI.

Nuclear fuel previously used for power generation consists of slightly enriched uranium dioxide pellets contained in sealed zircaloy tubes. The fuel spacer grids, which are positioned along the length of the fuel bundle, are made of zircaloy with inconel springs. These fuel rods are assembled into individual fuel assemblies. 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. The number of assemblies by discharge year and burnup are depicted in **Figure 2-28** and **Figure 2-29**, respectively.

A fuel assembly consists of a fuel bundle, channel fastener, and the channel which surrounds it. A fuel bundle contains fuel rods and water rods, spaced and supported in a square array by a lower tie plate, spacers, and an upper tie plate. The lower tie plate for the GE13, GE14 and GNF2 fuel bundles also includes a debris filter. The upper tie plate has a handle for transferring the fuel bundle from one location to another. The identifying assembly number is engraved on the top of the handle and a boss projects from one side of the handle to aid in assuring proper fuel assembly orientation. The fuel spacer grids, which are positioned along the length of the fuel bundle, are made of zircaloy with inconel springs. The GE13 and GE14 fuel spacer grids are made of zircaloy with alloy X750 springs. The GNF2 spacer is made entirely from alloy X750.

A plenum spring, or retainer, is provided in the top plenum space to minimize movement of the fuel column during handling or shipping. Plenum may include a hydrogen getter to absorb hydrogen accidentally admitted during the fabrication process. Eight fuel rods in each bundle have end plugs which thread into the lower tie plate and extend through the upper tie plate. Stainless steel nuts and locking tab washers are installed on the upper end plugs to hold the assembly together. The remaining fuel rods in a bundle have end plug shanks which fit into locating holes in the tie plates. An inconel expansion spring located over the top end plug shank of each full-length fuel rod keeps the fuel rods seated in the lower tie plate. Part length rods use a threaded lower end plug which screws into the lower tie plate. The average density of the pellets in the core is approximately 96.5% of the theoretical density of UO_2.

Several different U-235 enrichments may be used in each fuel assembly. The fuel rods have unique identification numbers. Selected fuel rods contain gadolinia as a burnable poison for reactivity control. The fuel channel enclosing the fuel bundle is fabricated from zircaloy. The channel makes a sliding seal fit over finger springs attached to the lower tie plate. The channel is attached to the upper tie plate by the channel fastener assembly which is secured by a cap screw. Spacer buttons are located on the two sides of the channel adjacent to the channel fastener assembly. GNF2 fuel assemblies are arranged in a 10 x 10 array with two central water rods, as well as both short and long partial length rods. A non-zircaloy 2 zirconium alloy, Ziron, is used for the fuel cladding material for 24 rods in 2 of the 4 GNF2 lead use assemblies (LUAs). The external envelope of GNF2 is virtually identical to GE14 and the nuclear characteristics of the GNF2 are compatible with current vintage GE14.

There are 163 fuel assemblies considered to be “failed fuel” that were evaluated and sleeved in stainless steel damaged fuel containers (DFCs) provided with mesh screens having between 40x40 and 250x250 openings per inch, for storage in the HI-STORM 100 System. The MPC-68 and MPC-68M are designed to accommodate BWR damaged fuel and fuel debris. For the MPC-68M, if the damaged fuel assembly can be handled by normal means and its structural integrity is such that geometric rearrangement of fuel is not expected, then the device known as the Damaged Fuel Isolator (DFI) can be used in place of the DFC. Fuel debris (3 partial rods from source assemblies) is stored in a GE-9 Hole container that is stored in a basket location of Cask 56. There are also 4 sub-assemblies from a damaged source assembly that have been placed in basket locations within Cask 55 and Cask 58.

Like the DFC, the DFI prevents the migration of fissile material in bulk or coarse particulate form from the nuclear fuel stored in its cellular storage cavity. The DFI can be used only if the fuel can be handled by normal means but is classified as damaged because of a physical defect. Damaged fuel stored utilizing the DFI may contain missing or partial fuel rods and/or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks as long as the fuel assembly can be handled by normal means.

Figure 2-28: Number of Assemblies per Discharge Year

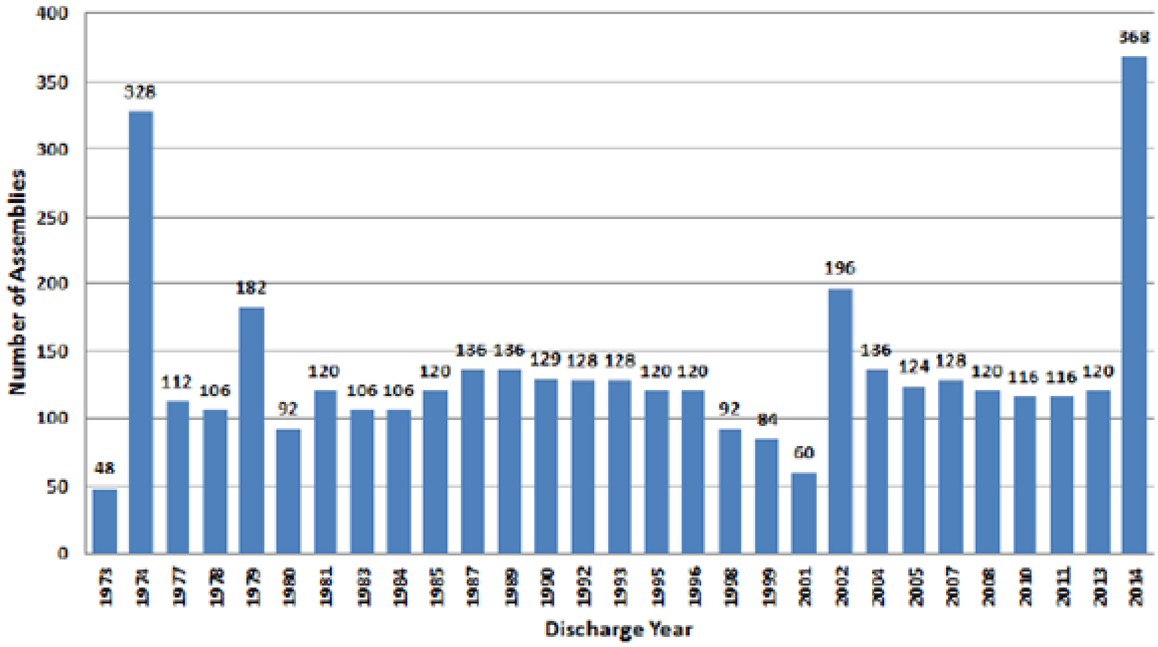
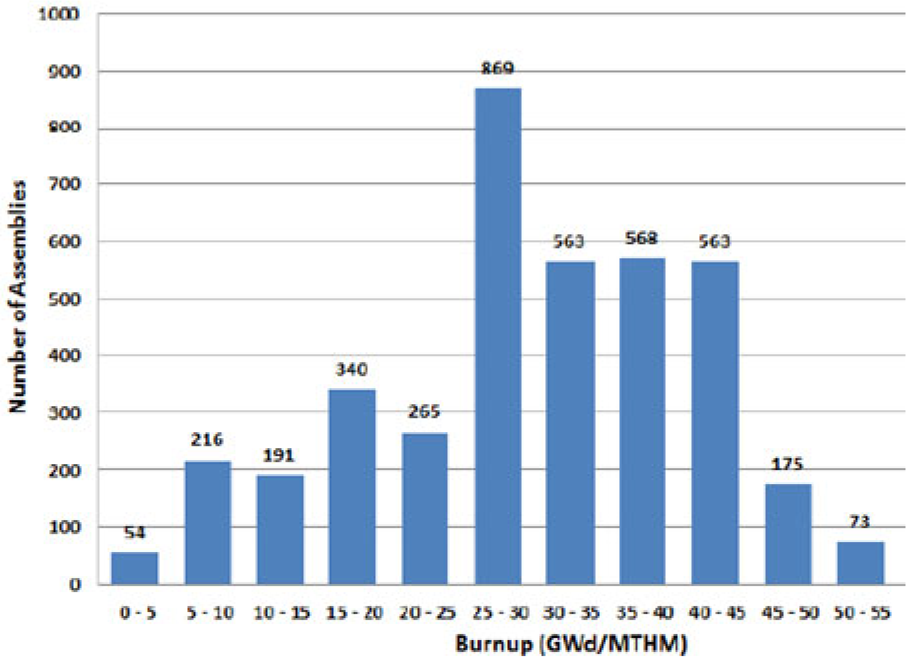


Figure 2-29: Number of Assemblies Versus Burnup



2.3 Description of Canisters/Overpacks to be Shipped

There are currently no certified overpacks ready for transport at VYNPS. Due to its compatibility with the HI-STORM 100 system for transport, the HI-STAR 100MB transport overpack has been selected as the most likely candidate for transport and thus is the focus of this portion of the report. However, since the HI-STAR 100MB is not currently certified for transport of the VY MPCs, much of the information that is necessary to complete this section of the report is Holtec Inc. proprietary. The design of the HI-STAR 100MB [8] will closely resemble the HI-STAR 100 [10] transport cask, which would be used for the de-inventory of the Trojan ISFSI in Oregon [13], thus gaps in information will be filled with HI-STAR 100 information where necessary.

When transporting SNF, the cask containment system is considered the outer containment boundary. The containment of the radiological contents is provided by a nickel steel shell welded to a nickel steel bottom flange at the base of the cask and a suitably machined nickel steel top flange at the top, which is equipped with machined surfaces to fasten a high integrity closure lid system equipped with concentric elastomeric seals. When transporting an MPC a single closure lid is adequate to serve in the role of the outer containment. The overall dimensions and weights of the HI-STAR 100 overpack are found in **Table 2-3** and **Table 2-4**.

For purposes of description, the HI-STAR 100MB cask is divided into six constituent parts, each with distinct roles and features, as follows:

1. The Containment Shell: The innermost cylindrical member of the cask containment system.
2. Cask Bottom Region (CBR): The CBR consists of a thick nickel steel flange, equipped to enable a high integrity butt weld joint with the containment shell.

3. Cask Top Region (CTR): The CTR consists of a massive nickel steel forging, the Containment Top Flange.
4. Closure Lid System (CLS): The CLS consists of up to two specially shaped lids, each with two machined concentric grooves to provide containment protection.
5. Gamma Capture Space (GCS): The GCS refers to the annular space around the Containment shell containing lead, which is enclosed by the "intermediate shell" (IS) and strengthened by radial gussets.
6. Neutron Capture Space (NCS): The NCS is the outermost annular space, which is enclosed by a ductile shell buttressed by radial gussets and filled with Holtite-B whose principal function is to block the neutrons released by the contained SNF.

Two AL-STAR MB impact limiters are installed at the two extremities of the HI-STAR 100MB Cask which provide energy absorption capability for transport. The impact limiters feature extremely rigid cylindrical backbones that engage the top and bottom of the cask with a snug fit. Each impact limiter backbone is enveloped by crushable material, which in turn is enclosed by a stainless-steel skin. The following key design features typify the AL-STAR MB impact limiters:

1. Each impact limiter is configured such that under all free-fall scenarios, the collision of the package with the regulatory target surface will always occur in the crush material space.
2. The impact limiter will protect the cask under all angular drop orientations onto the regulatory strike surface.
3. The external surface of the impact limiter surrounding the crushable material is made of stainless steel- a ductile, corrosion-resistant material.
4. Axial (longitudinal) tension rods of high-strength material fasten the impact limiter to the two extremities of the cask body.
5. Both impact limiters feature a skirt (shell) that fits the outside of the cask forging with a small radial clearance.
6. Each impact limiter is designed to render its intended function in the entire range of applicable ambient temperature conditions of the package.

During transport, the cask lies in a horizontal orientation with the two impact limiters on its two extremities. The personnel barrier is placed over the cask to provide a physical barrier to prevent manual access to hot areas of the cask when configured for transportation. The personnel barrier for HI-STAR 100MB only envelopes the cask body, not the impact limiters. The personnel barrier is not a structural part of the HI-STAR 100MB Packaging but is designated as a packaging component when in use.

A depiction of the HI-STAR 100MB, and associated impact limiter and personnel barrier, on a railcar is shown in **Figure 2-30** and **Figure 2-31**.

To transfer an MPC from the storage cask to a HI-STAR 100MB overpack and then prepare the overpack for transportation, the following high-level activities would be required [10]:

1. Remove the storage cask lid and shield ring.
2. Install a transfer cask mating device onto the storage cask.
3. Using the air pad system, transfer the loaded storage cask to the transfer station.

4. Using the transfer cask lifting yoke, or suitable lifting slings, position the transfer cask into the transfer station.
5. Secure the transfer and storage casks as required by the facility SAR.
6. Install supplementary shielding between the transfer and storage casks.
7. Open the transfer cask shield doors.
8. Raise the MPC from the storage cask into the transfer cask.
9. Close the transfer cask shield doors and lower the MPC onto the shield doors.
10. Remove the supplementary shielding and storage cask from the transfer station.
11. Remove the lid from the HI-STAR 100MB overpack.
12. Install a transfer cask mating device onto the HI-STAR 100MB overpack.
13. Using an air pad system, transfer the HI-STAR 100MB overpack to the transfer station.
14. Install supplementary shielding between the transfer cask and HI-STAR 100MB overpack.
15. Raise the MPC off of the transfer cask shield doors.
16. Open the transfer cask shield doors and lower the MPC into the HI-STAR 100MB overpack.
17. Remove the supplementary shielding and loaded HI-STAR 100MB overpack from the transfer station.
18. Install the HI-STAR 100MB overpack lid.
19. Vacuum dry the interior of the HI-STAR 100MB overpack and then backfill with helium.
20. Perform required leak testing of the containment boundary seals.
21. Install containment boundary port plugs and covers.
22. Using the lifting yoke, transfer the HI-STAR 100MB overpack to the down-ending location.
23. Down-end the HI-STAR 100MB overpack using an up/down-ending device.
24. Transfer the HI-STAR 100MB overpack to the transportation cradle and secure.
25. Install the HI-STAR 100MB impact limiters and personnel barrier.
26. Transfer the loaded cradle to the conveyance.
27. Secure the cradle to the conveyance.
28. Install axial end stops to the conveyance.

To perform the above activities, a number of ancillary devices would be required. These devices, along with a description of their purposes, are listed below.

A. Transfer Station (**Figure 2-26**) and Transfer Cask (**Figure 2-20**): These items are not currently available at VYNPS and will need to be received prior to transfer.

B. Transfer Cask Mating Devices (**Figure 2-32**): These items are installed onto either the storage cask or the HI-STAR 100 overpack to mate with the transfer cask during transfer operations. This device includes the hydraulic system required to open and close the transfer cask shield doors. These items are not currently available at VYNPS and will need to be received prior to transfer.

C. Storage Cask Air Pad System (**Figure 2-34**): Previously used to move the storage casks, this system will be required for unloading operations. The air pad system is stored on-site. However, it should be planned to replace the air bladders and all of the air supply system due to deterioration. A mobile air compressor should also be planned to supply the compressed air.

D. HI-STAR 100MB Overpack Air Pad System: To move the HI-STAR 100 overpack in and out of the transfer station, it will be necessary to use an air bag system, installed under the overpack [10]. According to the site, the same air pad system, as was used for moving the storage casks, can be used for moving the overpacks.

E. Transfer Cask Lift Yoke (**Figure 2-33**): Previously used to move the transfer cask, this lifting yoke could be used again to install the existing transfer cask onto the transfer station; however, its current condition and location is unknown.

F. HI-STAR 100MB Lift Yoke: To lift and perform the up/down-ending activities, a lifting yoke is required for the HISTAR 100MB overpacks. This item should be available for lease or purchase from Holtec soon after certification of the HI-STAR 100MB.

G. Leak Test System: Prior to transport of the HI-STAR 100MB overpacks containing SNF, the containment boundary seals will need to be leak tested [8]. To test these seals, a basic helium leak testing system can be utilized.

H. Replacement Seals for Overpack Lid and also for the Vent, Drain, and Test Port Plugs: In the event that the overpack leak tests do not achieve the results prescribed in the SAR [10], the seals that are part of the containment boundary would likely need to be replaced. The devices to be replaced would be identified in the licensing drawings included in the eventual CoC and would be available from the vendor.

I. New Relief Devices for the Neutron Shield Vessel: Neutron vessel relief devices are required to be replaced every 5 years [10]. As discussed in the safety analysis report (SAR) [10], these devices are only required during transportation operations, as they are credited to relieve pressure buildup during a hypothetical accident fire. The replacement neutron vessel relief devices would only be required if using pre-existing HI-STAR 100MB overpacks where the 5-year replacement window has been, or maybe, exceeded. The devices to be replaced would be identified in the licensing drawings included in the eventual CoC and would be available from the vendor.

J. Up-/Down-ending Device (**Figure 2-35**): This device is an L-shaped frame that can be connected to the overpack and includes lifting points for 2 cranes to attach to it, such that the overpack can be rotated 90 degrees. The device, designated as a piece of ancillary equipment under 10CFR Part 72 regulations, would be designed to allow it to fit around the overpack and be secured with straps, without having to set the overpack in it. Holtec has stated that this type of device has been used at numerous sites with good results [10], so operational experience should be available.

K. Cranes: A number of overhead lifting devices would be needed for the operations. A mobile crane could be set up on the reactor building base mat that can reach the transfer station and the railcar or HHT. Two cranes would be required to down-end the overpack. One of these could also be used for lifting ancillary items, such as the impact limiters and personnel barrier.

L. Rigging: A number of suitable lifting sling sets and associated hardware would be required for handling various components, in particular; the storage cask lid, storage cask shield ring, MPCs, overpack lid, overpack spacer, personnel barrier, and the impact limiters.

M. Impact Limiters: A pair of impact limiters per cask would need to be fabricated according to the requirements of the SAR [8]. Holtec, as the overpack vendor, would be the most likely supplier for these items. There has been no evidence located to suggest that impact limiters exist already, and it is not known what the lead time is to fabricate them.

N. Transportation cradle, cradle straps, and axial end restraints: A transportation cradle, associated straps, and axial end stops per cask would need to be fabricated for the HI-STAR 100 overpacks. These devices would be specific for the HI-STAR 100MB and are not believed to currently exist.

O. Personnel Barrier (**Figure 2-30**): As required by the HI-STAR 100 CoC, a personnel barrier per cask would be placed around the loaded overpack. The barrier, which attaches to the cradle, spans the distance between the impact limiters and matches the outer diameter of the impact limiters [10]. It is believed that this device does not currently exist, so it would need to be designed and fabricated. There are no unique requirements that would present expected complications with the lead time and cost of obtaining personnel barriers.

Table 2-3: HI-STAR 100MB System Weights

Attribute	Weight [lbs]	Ref.
Empty Overpack Weight (Includes Overpack Lid)	153,710	[10]
Top Impact Limiter Weight	19,187	[10]
Bottom Impact Limiter Weight	17,231	[10]
MPC-68 Weight	44500	[9]
Loaded Overpack Weights	198,210	[10]
Loader Overpack with Impact Limiters Weight	234,628	[10]
Maximum Cradle Weight (Estimated)	40,000	[10]
Maximum Transport Load	350,000	[10]

Table 2-4: HI-STAR 100MB System Dimensions

Attribute	Length [in]	Ref.

Overpack Length SL/XL	165/191	[8]
Overpack Length with Impact Limiters	305.88	[10]
MPC-68 Length	190.5	[9]
MPC-68 Diameter	68.375	[9]
Impact Limiter Diameter	128	[10]
Overpack Diameter	96	[10]

Figure 2-30: General Arrangement Depiction of Transporting HI-STAR100MB [40]

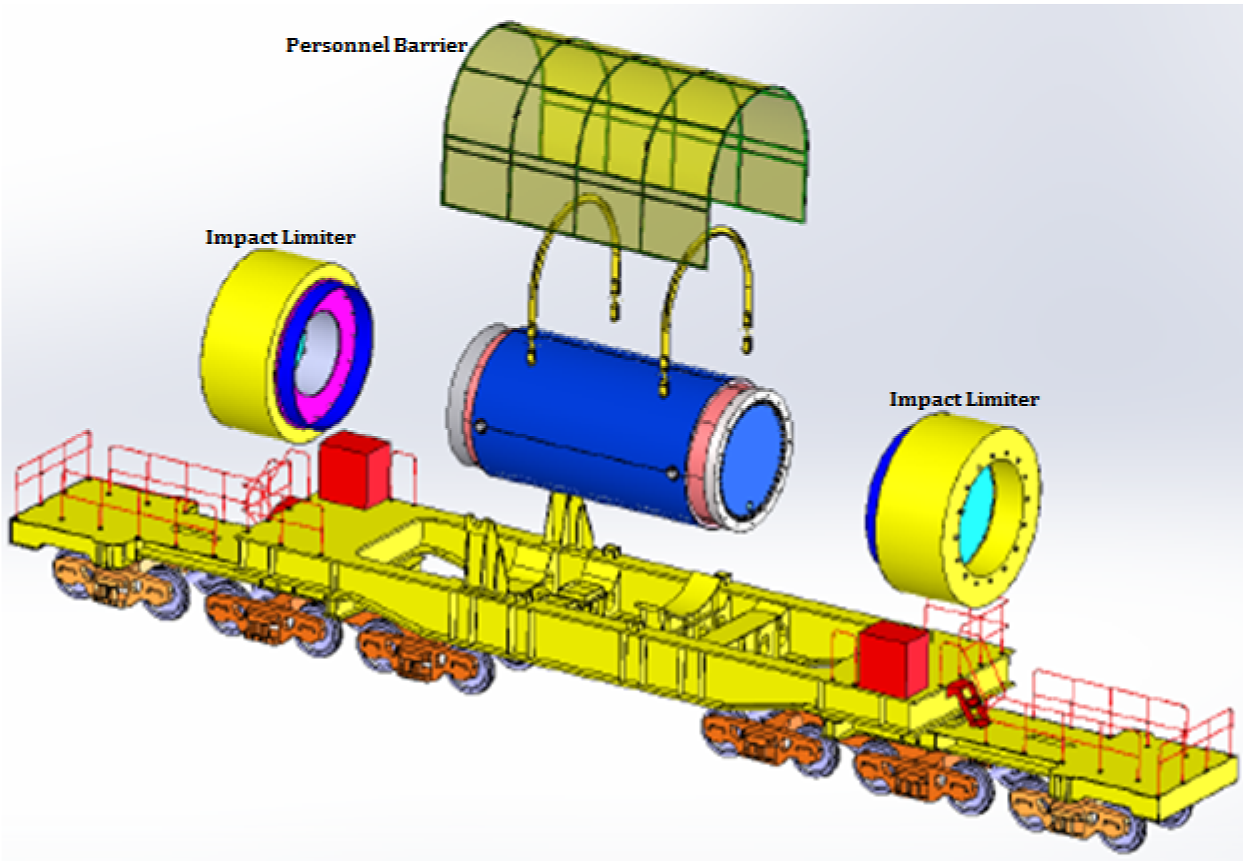


Figure 2-31: Depiction of HI-STAR 100MB On Railcar [40]

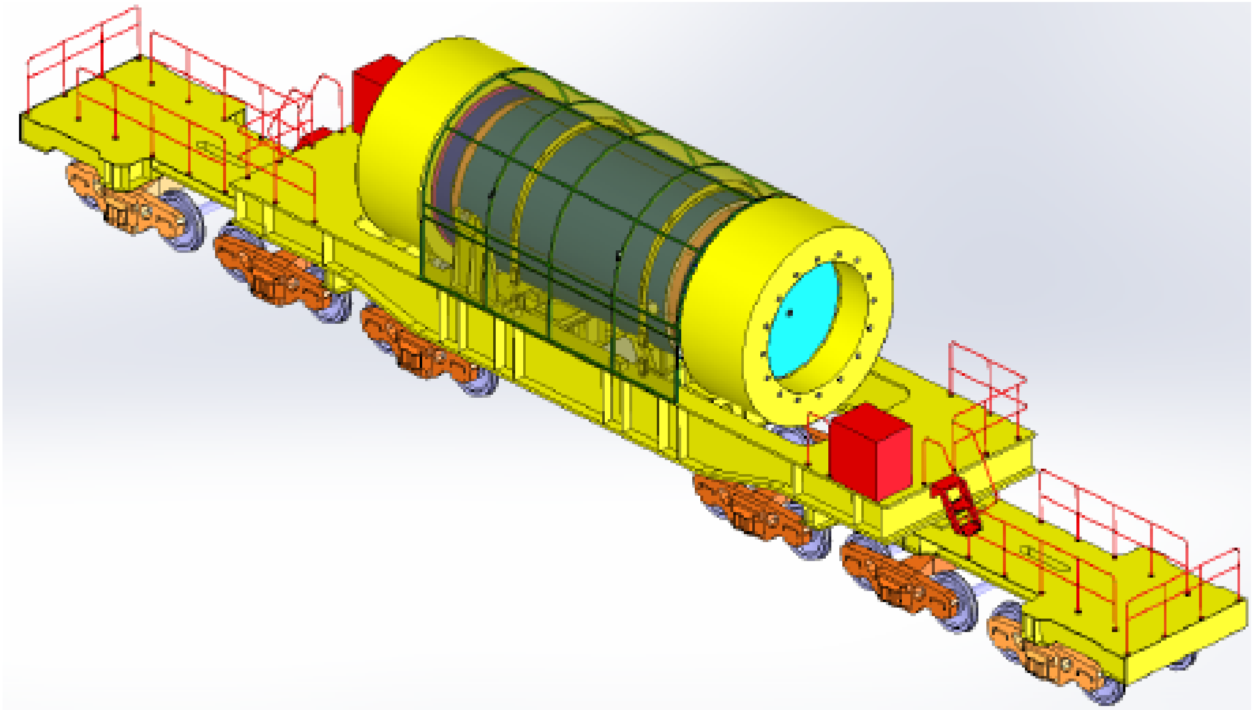


Figure 2-32: HI-STORM System Mating Device [9]

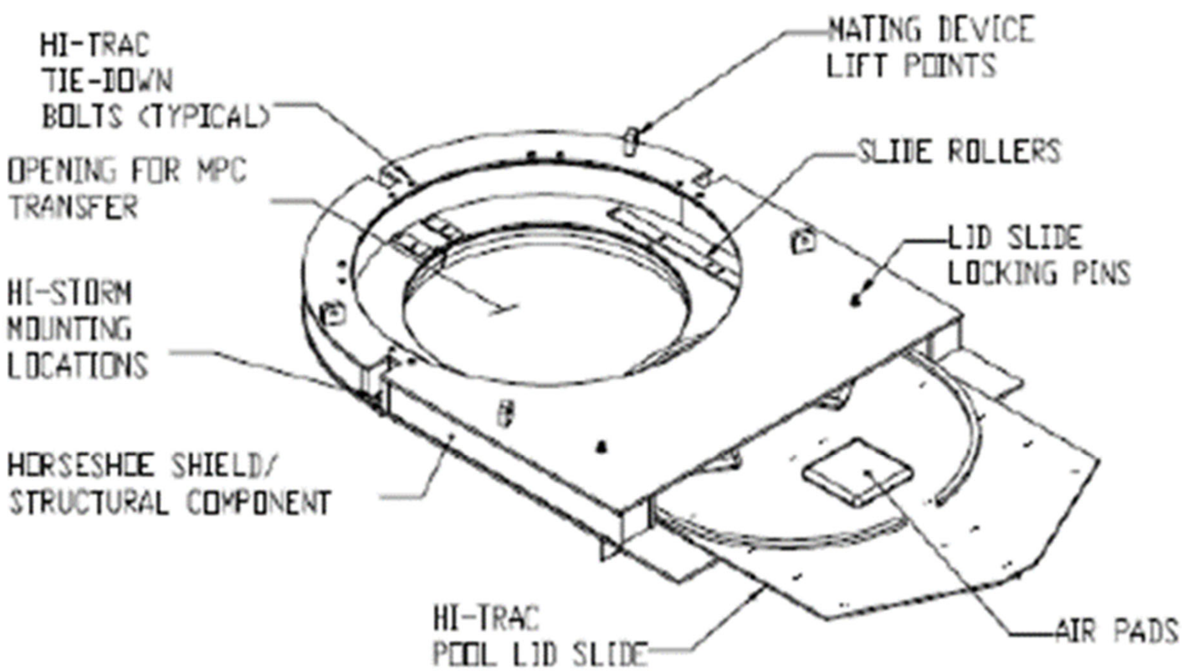


Figure 2-33: HI-STAR/HI-STORM System Lift Yoke [9]

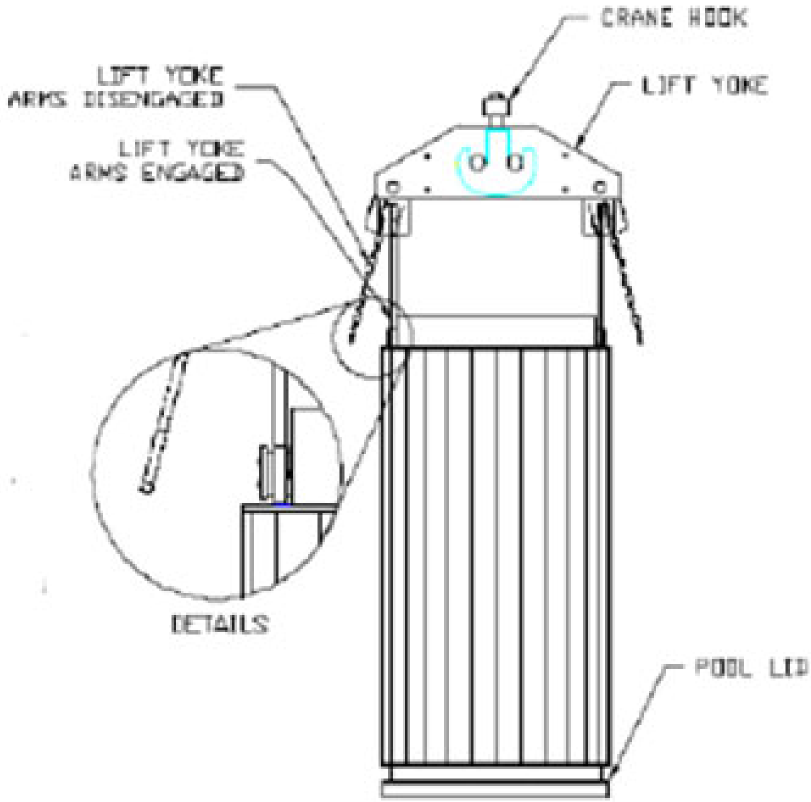


Figure 2-34: Example Air Pad System (used by NAC) [24]

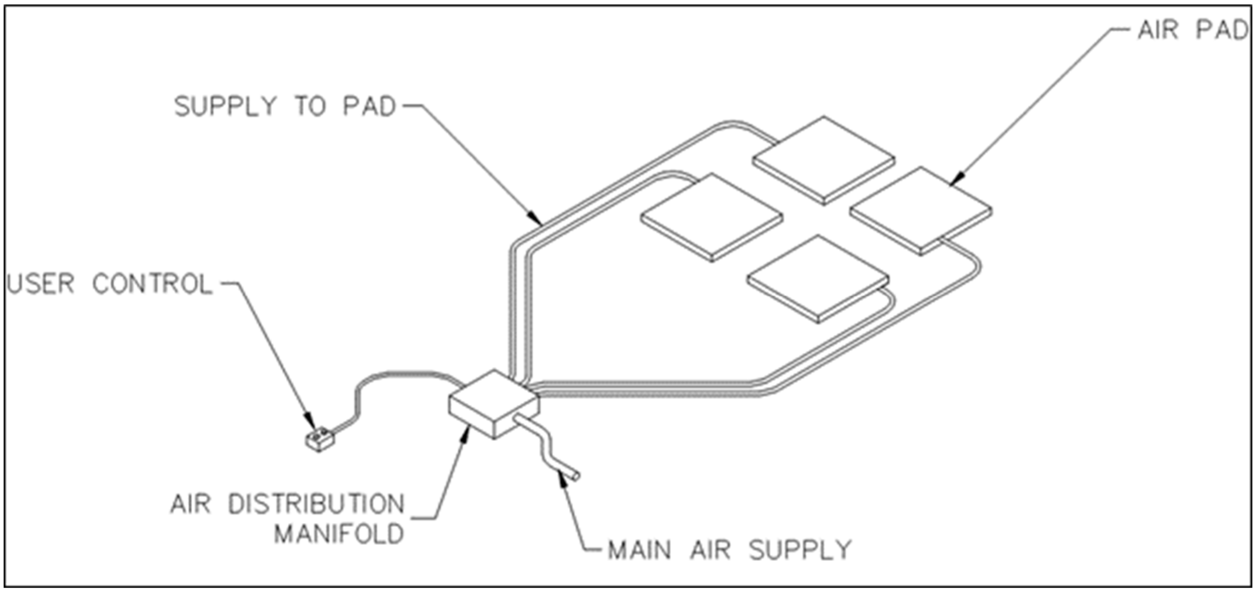


Figure 2-35: Example of Holtec Variable Elevation Cask Pedestal (Up-/Down-Ender) [43]

3.0 TRANSPORTATION ROUTE ANALYSIS

This section describes the available routes investigated to transport the loaded transportation casks from VY for delivery to the closest Class I railroad and the subsequent movement to GCUS. Although there is ample rail infrastructure at the site to conduct on-site transloading of the casks onto railcars, all potential transportation modes were considered for outbound movement of the loaded casks. A number of routes were identified and as discussed in **Section 3.5**, the options available were down-selected using specified criteria, resulting in a total of five scenarios to consider further using the MUA process, as covered in detail in **Section 5.0**, including 3 direct rail, 2 HHT-to-rail, and 0 barge-to-rail routes.

3.1 Heavy-Haul Trucking Routes

VY is located in Vernon, VT, just 6.3 miles south of Battleboro, VT and approximately 5 miles north of the Vermont/Massachusetts state border. The access road from the site leads to Governor Hunt Road. Following Governor Hunt Road south leads to Route 142 (see **Figure 2-5** and **Figure 2-6**). Following 142S to Rt 10 west leads to Interstate 91. It is 6.53 miles from the Vermont state line to the Rt 91 on- ramp.

Both interstate highways and county routes are close to the site. Alternate routes to exit the area are available using county roads. No Vermont state designated truck routes exist for heavy haul, restricted, Hazardous Materials (HAZMAT), Highway Route Controlled Quantity (HRCQ) of Class 7 radioactive materials (RAM), or non-radioactive hazardous materials (NRHM) in VY. There are restricted routes in neighboring states and along the route from VY to GCUS, particularly in the following states: MA, NY, PA, OH, IN and IL which are along reasonable HHT routes to the GCUS.

The private paved roads on the VY site appear to be in good condition. There is good access to and from the ISFSI. HHT ingress and egress to the site is via Vermont Yankee Drive which can be accessed from Governor Hunt Road from both directions, north and south, of the plant.

HHT has been used in the past to remove radioactive waste from VY and transported to Waste Control Specialists’ disposal site in Andrews, TX. During decommissioning, from 2015 to 2022, 86 truck shipments departed the site for WCS. The majority of these shipments moved in type A packages; two were in type B packages and there were four components of unpackaged waste that moved on flatbed trucks. These were all low-level radioactive shipments and were not dimensional or heavy shipments.

Although not entirely practical, HHT direct routes from VY to GCUS were investigated but were screened due to the length and duration of the transits and direct HHT movement is inconsistent with the study parameters of moving the casks from the ISFSI to a Class I railroad. START identified three HHT routes ranging from 1,097 miles to 1,979 miles with transit times varying from 61 hours to 326 hours. Due to the speed and permit restrictions and based on practical experience moving dimensional cargo over-the-road, it is unlikely that this cargo would be able to move this distance within the START identified timeframe, due to the fact that multiple states must be traversed, and coordination of State Police escorts and inspections would be required when trucks enter each state along the route. The direct HHT route would encompass travel through seven states and one tribe.

Another drawback for moving the casks by HHT is the fact the trucks can only haul one cask at a time. HHT is also subject to frost laws in Vermont and surrounding states which will impact the transit time of the movement as speed and weight restrictions are imposed twice a year during spring thawing and winter inclement weather. The frost laws are instituted as needed, which means they are subject to change with little notice based on current road conditions.

There is no existing on-site HHT road which leads to the waterfront portion of the site because there is no barge slip or area for grounding the barge. The roads leading to the ISFSI are in place and appear to be in good condition.

START identified two HHT routes to reach two potential transload locations (see **Table 3-1**) if loading outside the VY site is required (see **Figure 3-19** and **Figure 3-20**).

Two private rail tracks were identified for possible use as off-site transload areas for loading the train consist[1] purely as options in the event there were an unforeseen problem with the existing rail track, which is not anticipated at this time as it has recently been refurbished and is currently being used for outbound shipments from the site. In an effort to investigate all modes available for shipment, the two closest rail tracks with the ability to load trains were identified and are reflected in **Table 3-1** below.

Table 3-1: Nearest Rail Tracks Outside of Vermont Yankee Site Appropriate for Transloading

Track Location	Siding Length (ft)	HHT Mileage to Track	Site Description	Challenges/Considerations
Riverside Transload Center 46 Steamtown Road Bellows Falls, VT	1190’	34 miles	Private facility: Transload facility	Served by VTR, 34 miles north of VY, active rail shipper, somewhat congested site, limited track to build trains, no staging area, possible interferance with existing business.
Green Mountain Rail yard 54 Depot Street Bellows Falls, VT	2454’	31 miles	Private track: Railroad yard-active	Extensive rail infrastructure with several tracks that are long enough to load the entire train consist and which likely could be isolated to avoid interference with rail operations for the short line.

START [1] was utilized to create truck routes to the two rail served sites identified within close proximity to the VY site that had the infrastructure to load trains for the outbound shipping campaign. Only one of these locations is considered a viable option for establishing an off-site transload location because of interfering with the existing customer base.

[1] The “train consist” is considered made up in this report of a locomotive, two buffer cars, one to five cask cars, and a rail escort vehicle.

Routes were configured to utilize interstate highways wherever available to avoid using two-lane country or local roads and potentially alleviate road congestion during tourist seasons.

The Riverside Transload Center is located off US Route 5 in Bellows Falls, VT which is 34 miles north of VY. The transload site is switched twice a day by short line, GRMC (part of VRS), 6 days a week. There are 17 rail spots and 40 storage spots. This is an active business so it may be difficult to run a shipping campaign from this site without interrupting existing lumber, metals, and building materials business currently moving through the facility. This would also introduce additional handling to load and unload the trucks and insert another rail carrier and interchange into the route, which will increase both the cost and transit time of the train shipment to GCUS. This site provides options to another Class I carrier, the Canadian Pacific (CP), but there is no advantage to inserting additional carriers in the route with a viable option to reach a Class I carrier within 50 rail miles of the VY site.

The second site is a private rail yard for Green Mountain Railroad (GRMC), now part of VRS, which is also located north of the VY site. The advantage of this site is that it is an old railyard and there appears to be plenty of track to conduct transloads and build trains without interfering with existing train operations. Some track work may be required before use. Using this site would also require insertion of an additional rail carrier into the route and involves traveling north and having to "backtrack" past the VY plant to reach the Class I interchange, which adds cost and time to the transit schedule.

A third site was identified that is the closest rail track to VY, but it was eliminated because it is an existing private business that currently loads up to 30 cars on a regular basis and conducting a shipping campaign for the SNF trains would interfere with the existing loading operation and effectively, prevent it from operating during the campaign. There is not enough room or track on site for both operations to co-exist.

Although these sites may provide good alternate options for establishing an off-site location for a transload, the fact remains that VY has sufficient useable rail in place on the site to allow for conducting an efficient transloading campaign entirely on the VY property. This would eliminate the need for HHT permits and additional transit time and costs for additional critical lifts. It would also save the costs of using another company's private rail infrastructure to load the trains, cost for upgrades to the transload sites and costs to enhance or establish acceptable security for handling SNF/HAZMAT at the sites.

3.2 Rail Routes

As described in **Section 2.0**, the VY site is directly rail served by the NECR railroad, which is a Class III railroad owned by the GWRR Inc. It is the only railroad directly serving the site. There are no other freight railroads located in the immediate vicinity.

The mainline switch is still in place and is actively being used by NorthStar for outbound rail shipments during the decommissioning process. There is a long lead from the NECR mainline point of switch (POS) to the gate (1,633'), which has a sweeping curve and runs parallel to the plant for a distance before turning again to cross Vermont Yankee Drive to enter the outer fenced perimeter area of VY. The track crosses barriers (two fences and a Jersey wall) to reach the turbine building. The total length of this track from the gate to the turbine building entrance is 2142.12'. A third switch comes off the track just after the second fence line and runs parallel to the track to the turbine building and has a length of 892’. An old switch located 64.23’ past the gate leads to the only remaining portion of an old track (73’ long) which used to cut through the property where the switch yard is currently located and through to the water side of the plant. Part of the track was removed but according to plant personnel, the majority was paved over in 2007 when the switch yard was built.

The well-known Amtrak passenger train, the “Vermonter”, operates on the NECR mainline track passing the plant twice daily using trackage rights granted by NECR. The train operates from Washington, DC (via New York City) to St. Albans, VT. This passenger train has been running along this route since 1995. The Amtrak route for this popular passenger train is shown on an Amtrak system map in **Figure 3-1**.

Figure 3-1: Vermonter Track (highlighted) Using Mainline Track Adjacent to VY (Amtrak.com)

In preparation for decommissioning, the tracks at VY were upgraded to allow for loading different types of railcars, providing room for staging empty railcars awaiting loading and for loaded railcars awaiting pick up from NECR. A temporary shed was erected over the newly installed track to provide a location to load or conduct other work like testing, that is protected from the elements.

The majority of outbound shipments during decommissioning have been transported from the site by rail. From 2015 through the end of 2022, there have been 425 outbound rail shipments departing VY, mostly destined for Waste Control Specialists (WCS) in Andrews, TX. These shipments were comprised of LLW, wastewater, contaminated soil and Category 1 and Category 2 radioactive materials.

The original wastewater shipments moved to two destinations in Midlothian, TX and Simco, ID by tank car. In 2020 the rail destination shifted to WCS in Andrews, TX for disposal.

Seven of the outbound shipments were transported in the MP197HB cask (see **Figure 3-2**) and were Category 1 and Category 2 radioactive materials shipments, which involved providing advance notification to the states and one tribe (the Seneca Nation of Indians) along the route. The shipments involved extensive coordination among the rail carriers participating in the route. The shipments occurred over a period of 18 months and the cask moved in regular train service.

Figure 3-2: MP197HB Used to Make Shipments to WCS (Orano Provided)

Earlier this year, the plant completed some trackwork on the siding after extensive rain which led to a minor derailment of the NECR engine when it arrived to switch the plant. The engine had one wheel leave the track and needed to be reset on the tracks. There was no damage to the gondola railcars or the engine involved in the derailment. The engine was quickly repositioned, and the track was repaired and back in use in one week. The plant continues to maintain the rail tracks and inspects them on a weekly basis.

Table 3-2 lists the rail carriers in the geographic area.

Table 3-2: Class I, II and III Railroads Near Vermont Yankee [1]

Rail Carrier	Railroad Class	Notes
NECR	Class III	The NECR is a short line rail carrier that serves the VY site. It is the only rail carrier capable of switching the site.
CSXT	Class I	CSXT is the closest Class I carrier to the site. It regularly interchanges traffic with the NECR in Palmer, MA. The interchange takes place 3 days per week.

Rail Carrier	Railroad Class	Notes
NS	Class I	Interchanges with NECR at Brattleboro, VT & Millers Falls, MA.
CPKC	Class I	Interchange with NECR at Burlington, VT and Bellows Falls, VT.
CN	Class I	Interchanges with NECR at East Alburgh, VT
VTR	Class III	Part of the Vermont Rail System, it interchanges with NECR at Burlington, Montpelier and White River Junction, VT- all north of the site.
GMRC	Class III	Owned by VRS, operates on tracks that used to be owned by Rutland Railroad and Boston & Maine Railroad mostly running excursion or passenger trains on the VRS tracks.
MCER	Class III	Interchanges with NECR at Palmer, MA
PAS	Class II	Interchanges with NECR at Brattleboro, VT and Millers Falls, MA; with NS in Mechanicville, NY; CSXT in Rotterdam Junction, NY; and VTR in Bellows Falls, VT

Vermont has several Class I and Class III railroads operating in the state and one Class II railroad.

The indicated on-site track in **Figure 3-3** and **Figure 3-4** was selected for loading the outbound SNF trains. It is close to the ISFSI and allows for building the train with minimal switching, while allowing two tracks to be used for staging empty cars and, the buffer and security cars away from loading operations.

The HHT distance from the ISFSI to the on-site loading track is approximately 981'. A new gate will be installed to allow the movement of the cask transport from the ISFSI to the train loading site. The fence surrounding the facility will also need to be expanded to enclose the train loading operations.

Figure 3-3: VY On-Site Rail

Figure 3-4: Recommended On-Site Train Loading Location

Several direct rail routes were considered from the VY site to GCUS as identified in **Table 3-5**. There were slight differences between the routes. The most significant difference between the three rail routes (A, B, C) is the number of rail carriers and interchanges involved in the routes to reach the Class I carrier. This is important because it directly impacts the handling of the train, transit time, distance travelled, and the cost for movement of the outbound trains.

One small deviation occurs in the route around Rochester, NY because the route for dimensional cargo physically takes a different path than non-dimensional cargo. Regardless of the commodity (HAZMAT or non-HAZMAT), standard sized cargo has different rules and requirements associated with the handling and physical movement of the cargo. Dimensional cargo has additional limitations associated with it, most importantly, "will it fit"? The actual route will initially be determined based on whether the cargo can clear the desired route.

See **Figure 3-5** to see the differences in the routes around Rochester, NY.

Figure 3-5: Deviation Around Rochester, NY [1]

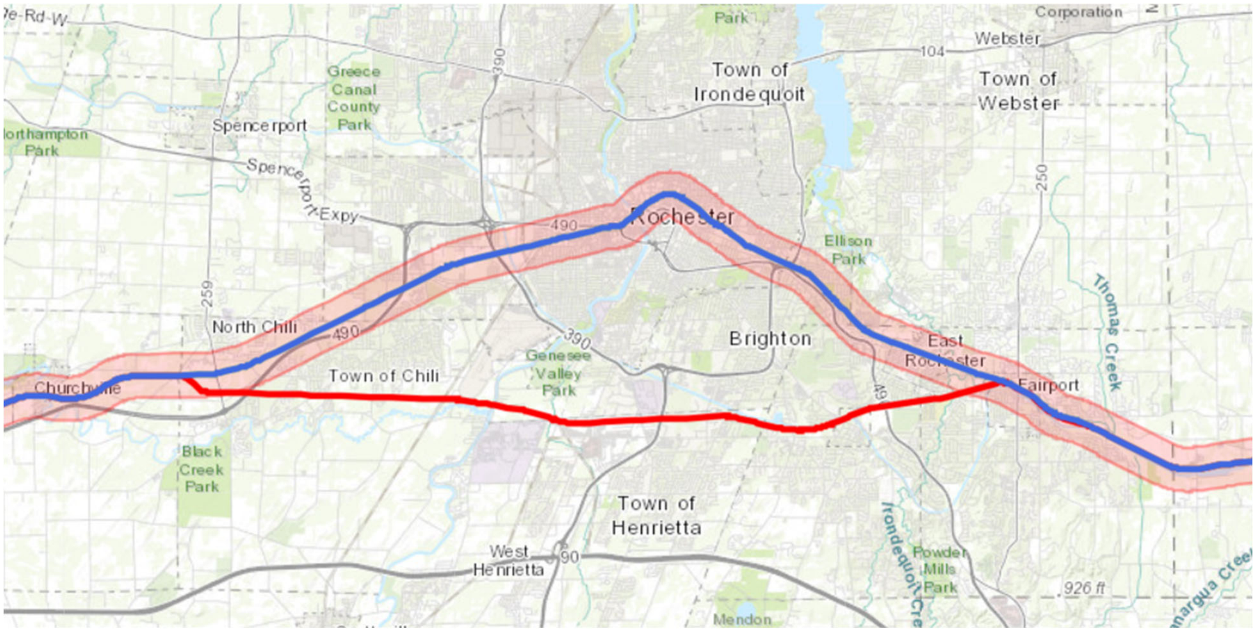


Table 3-3: Potential Rail Routes to GCUS

Route Identification	Total Distance (Miles)	Total Travel Time (min/hrs)	Route Description	Challenges/Considerations
A. Direct rail-minimium transit time	Rail 1,147 miles to GCUS	1,993/33	Railcars loaded on-site, shipped via START route minimizing time to GCUS	Developed using START. Route: NECR-PAS-PVRR-CSXT. Not a direct route, additional carriers in route. **Total of 9 rail carriers in this route with at least 8 interchange points.**
B. Direct rail-minimium distance	Rail 1,145 miles to GCUS	2,122/35	Developed using START to minimize distance to GCUS	Developed using START. Route: NECR-PAS-PVRR-CSXT. Not a direct route, additional carriers in route. **Total of 10 rail carriers in this route with at least 11 interchange points.**
C. Direct rail from VY site to Palmer, MA	Rail 1,164 miles to GCUS	1,946/33	Developed using START from expert rail route knowledge	Route: NECR-Palmer, MA-CSXT. Most direct route, actual route used for outbound rail shipments during de-commissioning. **Total of 2 rail carriers in this route and 2 interchange points.**

Route Identification	Total Distance (Miles)	Total Travel Time (min/hrs)	Route Description	Challenges/Considerations
D. HHT to Riverside Transload Center, Bellows Falls, VT	HHT 34 miles north of site & Rail 1,195 miles to GCUS	2,199/37	START developed HHT route to transload and rail to GCUS	VTR-NECR-CSXT. Total of 3 rail carriers in the route and 3 interchanges with potential clearance issue at Bellows Falls tunnel.
E. HHT to Green Mountain Rail Yard, Bellows Falls, VT	HHT 31 miles north of site & Rail 1,193 miles to GCUS	2,197/37	START developed HHT route to transload and rail to GCUS	GMRC-NECR-CSXT. Total of 3 rail carriers in the route and 3 interchanges with potential clearance issue at Bellows Falls tunnel.

The first two routes in **Table 3-3** were generated by START [1] using the parameters for minimum transit time and minimum distance. Both routes involve multiple interchanges and handoffs between rail carriers which add to the handling of the train and will result in additional transit time due to the number of rail carriers in the route and the required positive interchanges. These additional delays are not accounted for by START and are not reflected in the stated transit times. The route descriptions indicate more rail carrier and interchanges than would actually take place from a practical and operational standpoint, so it is inaccurate.

The routes for A, B, and C vary slightly from one another once the Class I carrier has possession of the train. Routes A & B interchange the train with the Class I carrier at a different location (further west) than the Route C interchange. All three routes encounter a deviation approaching Rochester, NY. The dimensional traffic will move via the "short-cut" and will not enter the Rochester rail yard, where all non-dimensional trains will travel.

Prior to the interchange with the Class I carrier, Routes A & B take more circuitous routes from the site to the Class I interchange which results in additional carriers being involved in the route along with more interchanges compared to Route C. From the START derived routes, it appears there are 9 carriers in the route with at least 8 interchange points. This is because the program continues to hand off the train at various places along the route which are not actual interchange points. These routes have 4 interchanges and 4 carriers in the route to reach GCUS.

Route A: START [1] identified this route as having 1,146 miles with a total rail transit time of 33 hours. This route runs from the site to West Northfield, MA, to Holyoke, MA to Westfield, MA to reach the Class I carrier, CSXT. From this point until approaching GCUS, the route is consistent with Routes B and C. It varies near the destination where additional carriers are introduced to the route.

Route B: START [1] identified this route as having 1,145 miles with a total rail transit time of 35 hours. This route also runs from the site to West Northfield, MA, to Holyoke, MA to Westfield, MA to reach the Class I carrier, CSXT. From this point until approaching GCUS, the route is consistent with Routes A and C. It varies near the destination where three additional carriers are introduced to the route which goes further west than Routes B and C.

Route C: This is the rail-expert developed route, which is the most direct route with the least number of rail carriers and interchanges from VY to GCUS. The two rail carriers involved are NECR and CSXT. This is the actual operational route for railcars moving from the site during decommissioning. The normal interchange between NECR and CSXT occurs three times a week and takes place in Palmer, MA. This route can accommodate dimensional cargo and the loaded train configuration had been cleared on both the Atlas and Fortis railcars on this route. In addition, this is the cleared route the MP197HB Category 1 and Category 2 radioactive materials shipments used in the recent past.

START [1] indicates the total mileage is 1,164 rail miles and the transit time is 33 hours.

Routes D and E: These are the transload routes that involve a HHT movement north from the site to two rail served locations in Bellows Falls, VT which appear to be viable options for transload the casks onto a train for the outbound rail shipment (see **Table 3-1**). This START [1] generated route involves:

> **Route D**: 2,199 miles and 37 hours transit time from north of the VY site at an existing transload center where casks would be loaded onto the train. The assembled train would move south, past the VY site to Palmer, MA to interchange with the Class I carrier. The route involves three carriers to GCUS and two carriers before reaching the Class I interchange.
>
> **Route E**: 1,224 miles and 37 hours, five rail carriers in the route, four before delivering the train to the Class I interchange.

Both Routes D and E also involve transit through a short, narrow tunnel (see **Figure 3-6** and **Figure 3-7**) which goes below grade in Bellows Falls and may present a clearance issue for the loaded cask train due to the width and height of the loaded cars.

Figure 3-6: Bellows Falls Tunnel [44]

Figure 3-7: Bellows Falls Tunnel with the Vermonter Coming Through [45]

In 2007, engineering firm, ECI from Williston, VT, was hired by NECR to lower the tunnel approximately 2.5' to increase the clearance window so modified double stack containers could move through the tunnel [46]. The 150-year-old tunnel is 280 linear feet long and had been lowered twice in the past. This project included the following scope of work:

- Relocation of underground utilities.
- Cutting the tracks into 13’0” jointed sections to allow for partial removal of the tracks during construction.
- Internal strengthening and repairs of the tunnel with shotcrete.
- Underpinning of the tunnel walls with soldier pile and steel lagging plates with cross struts buried below the proposed profile.
- Reconstruction of existing retaining walls with both shotcrete and traditional cast-in-place concrete.
- Drainage improvements inside of the tunnel.
- Dapping of bridge timbers at the north approach to allow for a grade transition.
- Utility relocation at the Mill Street grade crossing (south end of tunnel).
- Paving and reconstruction of the grade crossing.

Although double stack containers can now move through the tunnel (see **Figure 3-8**), clearances would have to be submitted to confirm the loaded cask car train would clear the tunnel. In the past, dimensional traffic has had to be rerouted around this tunnel using other railroads in the region.

Figure 3-8: Bellows Falls Tunnel with Double Stack Containers Coming Through [47]

As previously discussed, there is sufficient rail infrastructure on site at VY to conduct a rail shipping campaign directly from the site. This would involve the least amount of handling and a very short HHT movement from the ISFSI to the on-site transloading location.

The indicated track in **Figure 3-3** was selected for loading the outbound SNF trains. It is close to the ISFSI and allows for building the train with minimal switching, while allowing two tracks to be used for staging empties and the buffer and security cars away from loading operations.

The HHT distance from the ISFSI to the on-site loading track is approximately 981'. A new gate will be installed to allow the movement of the cask transport from the ISFSI to the train loading location which is at the existing parking lot across from the ISFSI, but outside the current protected area. The fence surrounding the facility must be expanded to enclose the train loading operations.

3.3 Barge Routes

VY is located directly on the Connecticut River; however, there is no existing barge slip at the site and the river is dammed in at least 16 locations in Vermont, two of which isolate the site from ingress and egress by water. Thirteen dams are owned and operated by Great River Hydro, LLC, which is the largest producer of conventional hydropower in New England, according to its website, and the closest dams to VY are located both below and above the site at Vernon, VT and Bellows Falls, VT (see **Figure 3-9** and **Figure 3-10**). Other dams are owned and run by the Corps of Engineers.

Figure 3-9: Great River Hydro, Vernon Dam, Vernon, VT [48]

Figure 3-10: Great River Hydro, Bellow Falls Dam, Bellows Falls, VT [48]

Due to the many dams on the river near the site, it is impossible to ship directly from VY by barge, but it would be possible to transport the casks from the site to other established barge facilities located outside of the dammed areas, where barges can freely move on the waterways without impediment.

To ship by barge from the plant, casks would have to move from the site by HHT or rail to reach a viable part of the river to conduct outbound shipments. As part of the analysis, several ports were identified that currently have appropriate facilities (summarized in **Table 3-6**) and infrastructure in place to properly transload the casks from HHT or rail to barge for the outbound water movement to GCUS. HHT or rail shipments to these barge sites would involve obtaining clearances for the rail movements and heavy-haul road permits for the over-the-road transportation.

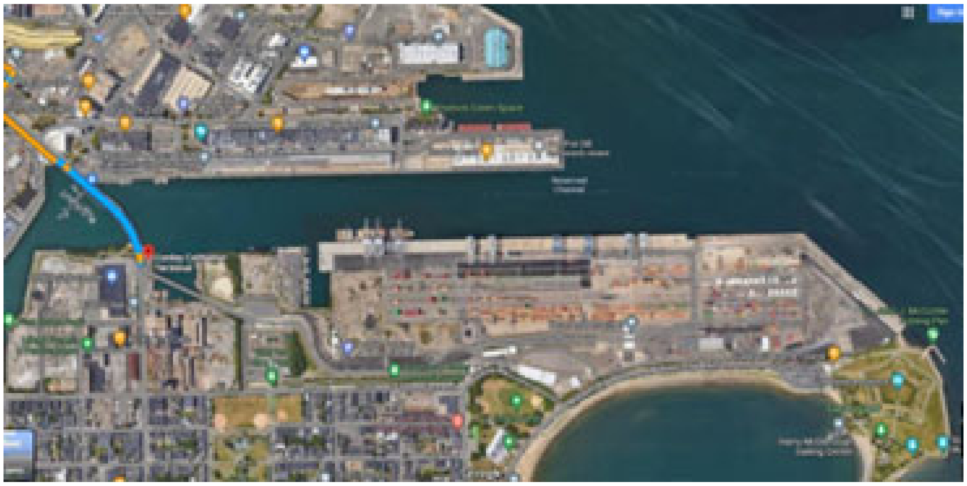
Table 3-4: Potential Barge Routes

Route Identification	Total Distance (Miles)	Total Travel Time (min/hrs)	Route Description	Challenges / Considerations
HHT from VY to Portland, CT, barge to GCUS, rail to final	N/A	N/A	HHT from VY to Portland, CT for transload to barge, barge to GCUS vicinity via Atlantic Ocean, around Key West to the Mississippi River.	START generated barge route - no viable place to transload the cask from HHT to barge.
HHT to Port of Boston, MA, barge to GCUS, rail to final	HHT= 116 Barge= 3304 Rail= 4 Total= 3,424	HHT= 11 hrs Barge = 469 hrs Rail= 21 min Total= 480.5 hrs	HHT from VY to Port of Boston, for transload to barge, barge to GCUS vicinity via Atlantic Ocean, around Key West to the Mississippi River.	Busy commercial port, good infrastructure, several locks in route.
HHT to New London Port, CT, barge to GCUS, rail to final	HHT= 176 Barge= 3304 Rail= 4 Total= 3,484	HHT= 12 hrs Barge = 469 hrs Rail = 21 min Total= 481.5 hrs	HHT from VY to New London, CT for transload to barge, barge to GCUS vicinity via Atlantic Ocean, around Key West to the Mississippi River.	CT Port Authority, good infrastructure, several locks in route.
HHT to Port of New Haven, CT, barge to GCUS, rail to final	HHT= 131 Barge= 3,341 Rail= 4 Total= 3,476	HHT= 11.5 hrs Barge = 472 hrs Rail =21 min Total = 484.0 hrs	HHT from VY to New Haven, CT for transload to barge, barge to GCUS vicinity via Atlantic Ocean, around Key West to the Mississippi River.	Several private terminals, adequate infrastructure, potential interference with existing business, flexibility with private terminals. Several locks.

Option 1 (**Figure 3-11**): Truck to Port of Boston which is a commercial port with good infrastructure. It is unknown if the Port of Boston accepts radioactive waste, but the Conley Container Terminal has the space to do the transload and barge loading operation. It may be congested, but there are advantages to loading within an established port.

This HHT would involve passing multiple locations to transload to rail before reaching the port.

Figure 3-11: Option 1 (Boston) for VY to Barge Location



Option 2 (**Figure 3-12**): The Port of New London, CT is run by the CT Port Authority.

Figure 3-12: Option 2 (New London, CT) for VY to Barge Location

Option 3 (**Figure 3-13**): Port of New Haven, CT. There are four potential piers here, with the fourth pier considered a separate option. They appear to be private slips/terminals:

1. LaFarge North America slip
2. Gateway Terminals
3. American Green Fuels

Figure 3-13: Option 3 (New Haven, CT) for VY to Barge Location

Option 4 (**Figure 3-14**): Port of New Haven, CT. Quarters are tight here and there is concern about interfering with existing operations.

4. All American Waste

Figure 3-14: Option 4 (New Haven, CT) for VY to Barge Location

These potential barge locations are active ports, and any cask shipping campaign would require the ability to fit into the established port schedule. Some of the identified port locations are privately owned and permission would be required to move the casks through these sites. Capacity and the ability/willingness for the port to accept radioactive materials is unknown.

START [1] calculated the overall transit times and related distances per leg of the transportation. The transit times are unrealistic because the time it will take to conduct the transload operations at the ports is not included in the transit times.

As with all barge shipments, weather conditions must constantly be monitored to ensure safe passage from the origin port to destination port.

3.4 Barge Unloading Locations

Several options for potential barge unloading locations were identified in the vicinity of GCUS. The majority of the barge slips in this area are privately owned. Interference with ongoing operations would therefore need to be coordinated with the owners and current users of these sites. Permission must also be obtained from the owner of the private slips. **Table 3-5** lists the potential barge unloading locations that provide close proximity to rail loading tracks near the barge site. The most feasible docking location near the GCUS is shown in **Figure 3-15**. Additional lifts which will add cost and time are required for a barge shipment from the site to the identified locations for loading onto rail.

Table 3-5: Possible Barge Unloading Sites at GCUS

Rail Transload Facility	Distance from Barge	Comments / Details
Intersection of Hog Haven Road & rail yard Sauget, IL 62201	1,333 ft	Portion of track inside rail yard Not secured by a fence Congested
Gavion 10 Pitzman Ave Sauget, IL 62201	2,392 ft	1,490 ft of private track
Lawn & Garden Midwest 3414 Hog Haven Road Sauget, IL 62201	1.09 miles	3,392ft of track
Eastman Chemical Plant /Solutia 500 Monsanto Avenue Sauget, IL 62201	2.1 miles	Secure

Note: the use of any existing barge slip or dock should be evaluated and a marine survey conducted to determine if submerged conditions would present complications to the operation. If a pier is used, its condition to hold the combined weight of the cask, cradle, and Goldhofer would need to be evaluated. A pier or dock was not considered in either the loading or unloading operations for this barge campaign.

Figure 3-15: Hog Haven Road Barge Off-Load in the Vicinity of GCUS

3.5 Down-Selected Transportation Routes

Considering the large number of potential transportation routes identified in the previous sections, a set of screening criteria was developed and applied to downselect a small group of options considered to be viable for further investigation. This down-selection was based on comparing routes containing the same modes of transport (i.e., truck routes were not screened based on characteristics of barge routes). The result is that one or more routes are identified for each viable mode of transport from the site to be evaluated by the MUA. The criteria utilized are as follows:

1. The time and/or distance to be traveled by the conveyance/barge would be significantly more than alternate viable routes without significant/substantial benefit.
2. Clearance limits on routes (e.g., through tunnels, around curves, or through heavily forested roads) are not met without significant/substantial upgrading.
3. Sustained travel on routes with steep grades.
4. Bridge(s)/overpass(s) to be used would not sustain weight of conveyance without significant/substantial upgrading.
5. Natural features make barge landings, overpack loading, etc. difficult to perform without significant/substantial upgrading or infrastructure development.
6. No available loading facility or insufficient track for performing loading of a full consist.
7. Transload and/or port facility does not permit receipt of Class 7 materials.

8. Number of interchanges between carriers.
9. Avoidance of high-density transit areas (i.e., regions with significant rail traffic) that would require interruption of traffic if shipment were to transit region.
10. Characteristics of HHT that would require preapproval for Highway Route Controlled Quantity (HRCQ) shipments.[2]

Some of the potential transportation routes had unique characteristics that did not correlate with any of the ten listed criteria above. These characteristics greatly reduced the viability of the transportation route; therefore, an 11th category, "Other", was added to the screening criteria so that the unique criterion could be captured.

[2] For routes where HRCQ applies, screening may occur due to the more restrictive requirements of NRC approval of such a route and its associated requirements for armed security, disabling devices, secure communication, HAZMAT bill of laden, safe-haven identification, safe-secure shipments, emergency response planning, etc.

Table 3-6: Routes Versus Screening Criteria

Route	Screening Criteria										
	1	2	3	4	5	6	7	8	9	10	Other
HHT closest track to VY- Vernon, VT using NECR						X					
HHT to 2nd closest track to VY: feed & fertilizer company 9.6 miles							X				
HHT to 330 Riverside Drive, Brattleboro, VT, active NECR Rail Yard, 6.1 miles north of VY		X		X							
HHT to Kringle Candle Company, 31 Kringle Drive, Bernardstown, VT						X					
HHT to Deerfield, MA industry Trew Stone PAS, CSXT								X			Active plant
HHT to Deerfield, MA Crop Production Services, 25 Elm Street South Deerfield 27.3 miles south of VY PAS, CSXT						X		X			Active plant
HHT to Marty's Local (Produce) 28.5 miles from VY, 10 Greenfield Road, South Deerfield, MA						X					No mainline switch
HHT to Harris Rebar/Baker Steel 73 Old State Road, Deerfield, 27.8 road miles from VY (PAS)						X		X			
HHT to CSXT rail yard East Deerfield, MA 32 Railroad Yard Road, Deerfield, MA-active classification yard, CSXT							X				

Route	Screening Criteria										
	1	2	3	4	5	6	7	8	9	10	Other
HHT to JB Hunt Warehouse, Brattleboro, MA, siding intersects parking lot, 53.8 miles from VY						X					
HHT to Turf Care Supply - 59 Dwight Street, Hatfield, MA - 36.3 miles south of VY (PAS)						X					
HHT to Packaging Corp of America, 36.3 miles south of VY						X					
HHT to Westfield, MA Savage Arms, 100 Springfield Road, Westfield, MA	X										
HHT to Long Falls Paperboard POS						X					
HHT from Grain elevator- animal feed- North Bennington, VT served by VTR, 52 miles from VY							X	X			Congested
HHT to Old train station- North Bennington, VT, 51.5 miles from VY								X			
HHT to Ballston Spa, NY 93 miles from VY2809.64' of track	X							X			
HHT to Curtis Lumber Company, 101 miles from VY	X										
HHT to Riverside Transload Center, 46 Steamtown Road, Bellows Falls, VT using GMRC, NECR, CSXT											
HHT to Green Mountain Rail Yard, 54 Depot Street, Bellows Falls, VT using GMRC, NECR, CSXT											

Route	Screening Criteria										
	1	2	3	4	5	6	7	8	9	10	Other
HHT from VY to Portland, CT, barge to GCUS, rail to final	X					X	X				
HHT to Port of Boston, MA, barge to GCUS, rail to final	X										Busy commercial port
HHT to New London Port, CT, barge to GCUS, rail to final	X										
HHT to Port of New Haven, CT, barge to GCUS, rail to final	X										Interference with existing business
Rail - Route A-START Direct Rail from Site minimum time using NECR, PAS, PVRR, CSXT											
Rail - Route B- START Direct Rail from Site minimum distance using NECR, PAS, PVRR, CSXT											
Direct Rail from VY using NECR and CSXT											

Note: The highlighted rows indicate routes that have not been screened out and will be further analyzed in the MUA in **Section 5.0**.

Screening Criteria Legend:

1. The time and/or distance to be traveled by the conveyance/barge will be significantly in excess of another route
2. Clearance limits on routes
3. Sustained travel on routes with steep grades
4. Bridge(s)/overpass(s) weight limitation
5. Natural features make barge landings, overpack loading, etc. difficult
6. No available loading facility or insufficient track for performing loading of a full consist
7. Transloading and/or port facility does not permit receipt of Class 7 materials

8. Number of interchanges between carriers
9. Avoidance of high-density transit areas
10. Characteristics of HHT Requiring Preapproval for HRCQ

Figure 3-16: A. Rail - Minimum Travel Time

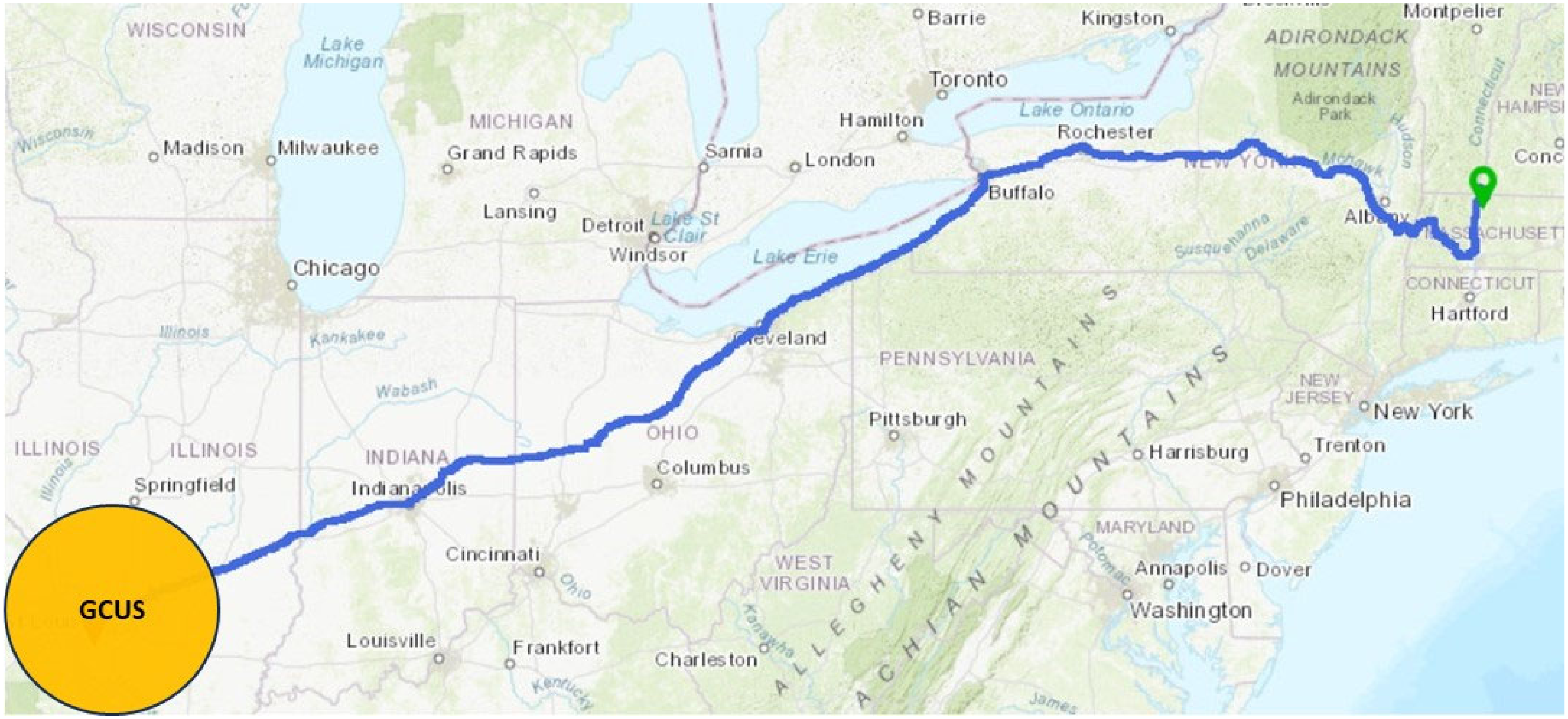


Figure 3-17: B. Rail - Minimum Distance

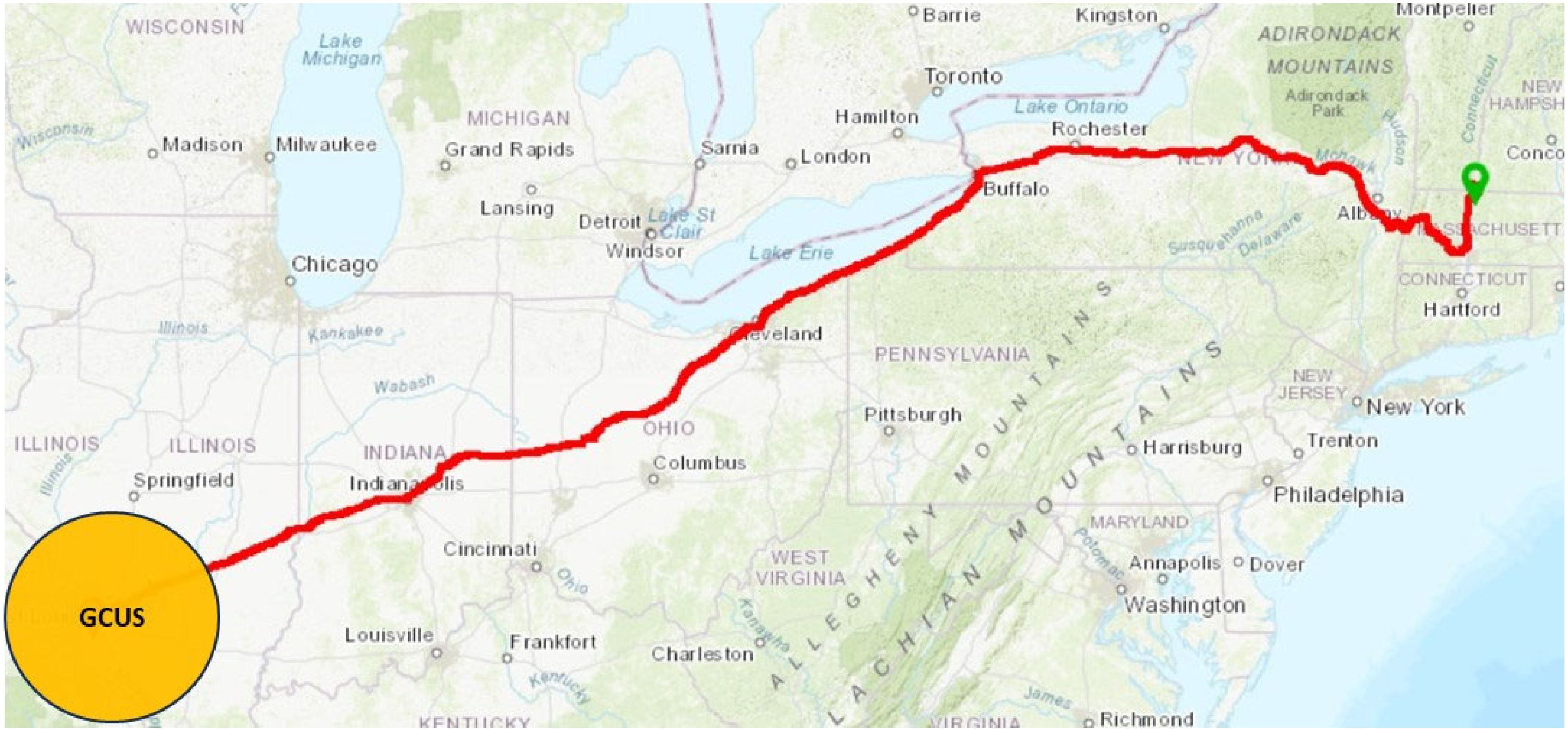


Figure 3-18: C. Rail via Palmer

Figure 3-19: D. HHT & Rail from Riverside Transload Center

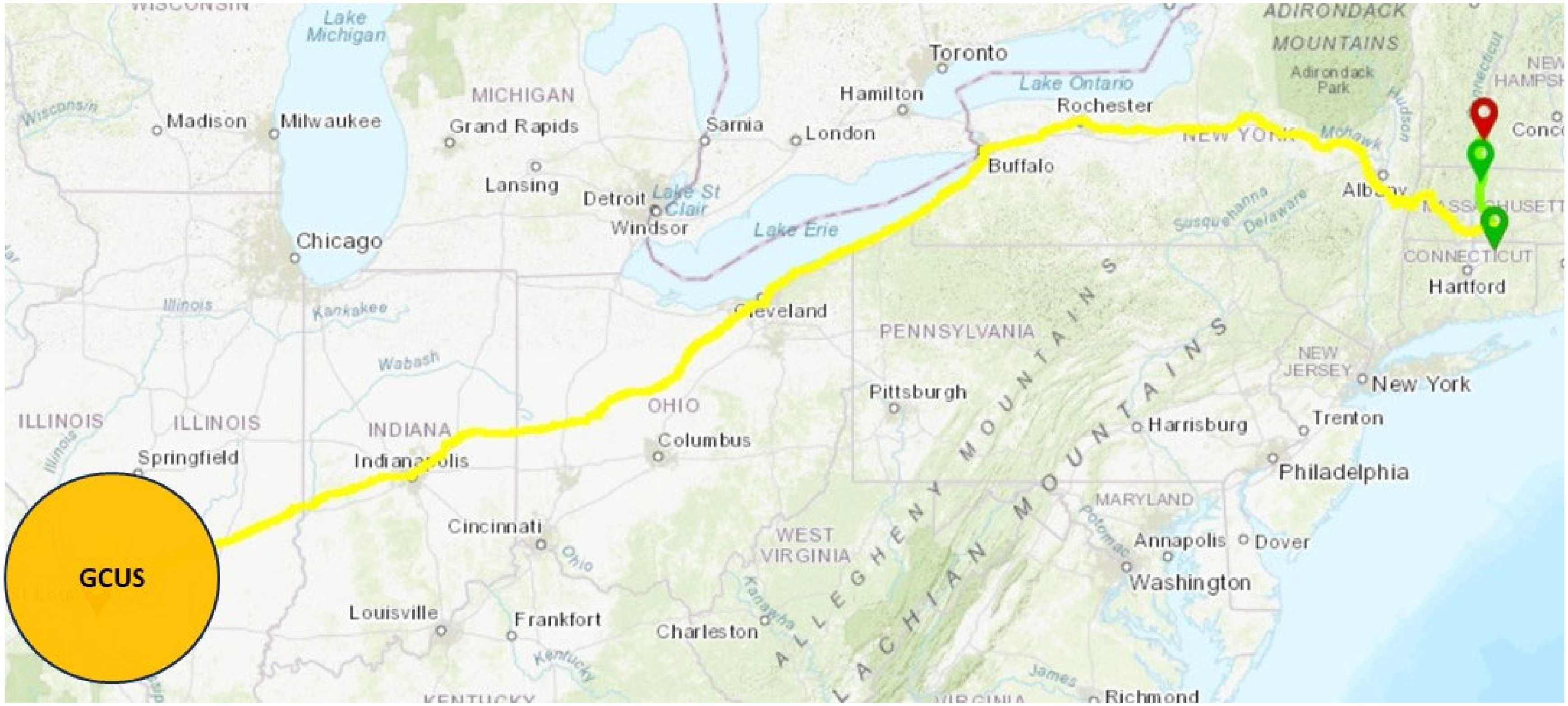


Figure 3-20: E. HHT & Rail from Green Mountain Rail Yard

[Page Intentionally Blank]

4.0 PARTICIPATING ENTITIES

This section identifies participating entities/persons this report assumed would be involved in the overall de-inventory implementation for the VY ISFSI and summarizes some aspects of their potential roles. By providing this information, which is current as of the date of this report but may need to be updated at the time that shipments will occur, an initial means for identifying these entities/persons in the future is considered to be provided.

Various federal agencies would have regulatory authority over the types of shipments of SNF and GTCC contemplated by this report. This report assumes that DOE would be responsible for a future federal consolidated interim storage facility or geological repository to which the material would be shipped from the nuclear power plant site and that DOE would be the shipper. DOE has broad authority under the Atomic Energy Act of 1954, as amended (AEA), to regulate activities involving radioactive materials undertaken by DOE or on its behalf, including transportation of radioactive materials. However, in most cases not involving national security, DOE typically uses commercial carriers for its shipments and does not exercise its AEA authority. The DOT and the NRC jointly regulate commercial transportation of radioactive materials in the United States. Most DOE radioactive materials shipments are typically transported by commercial carriers and are subject to regulation by DOT and NRC, as appropriate.

Assuming DOE would use commercial carriers to conduct the shipments, regulatory authority over the shipments can be summarized as follows. In general, DOT would regulate the areas identified in the Memorandum of Understanding between the NRC and the DOT [15], including package and conveyance radiological controls, routing, hazard communication, and carrier training. Assuming DOE takes custody of the material at the nuclear power plant site, DOE would have authority to regulate other aspects of the shipments (e.g., physical security), except as otherwise required by law.[3] Even where DOE does exercise its AEA authority over its shipments, DOE's general policy is that all DOE shipments must be conducted in a manner that achieves an equivalent level of safety and security to that required by DOT and NRC for comparable commercial shipments (see for example DOE Order 460.2B "Departmental Materials Transportation Management" [39]). For purposes of this report, it is assumed that the shipments to de-inventory the site would be conducted like typical commercial shipments in accordance with DOT and NRC regulatory requirements.[4]

In addition to the federal agencies described above, the list of participating entities and persons expected to be involved in the de-inventory of the site would include:

---

[3] For example, one such exception is the requirement in Section 180(a) of the Nuclear Waste Policy Act of 1982, as amended (NWPA), which requires DOE to use casks certified by the NRC for NWPA shipments (42 U.S.C. 10175(a)). In addition, Section 180(b) of the NWPA requires DOE to follow the NRC regulations on providing advance notification of shipments to jurisdictions through which the shipments will be transported (42 U.S.C. 10175(b)). For further discussion, see letter from Chairman Richard A. Meserve, Nuclear Regulatory Commission, to Senator Richard J. Durbin (May 10, 2002), https://www.nrc.gov/docs/ML0210/ML021060662.pdf.

[4] Although this report assumes that DOE would be the responsible entity for a federal consolidated interim storage facility or geological repository, this report also recognizes that if a separate management and disposal organization were to be responsible for such a facility some aspects of the regulatory regime for the shipments could differ from that which would apply if DOE were the responsible entity.

- Utility employees
- Subcontractors: crane suppliers, riggers, etc.
- Transportation: truck operator, rail carrier, barge transportation operator, private escorts for dimensional loads, State Police and Local Law Enforcement Agency (LLEA)
- Cask suppliers
- U.S. Coast Guard (USCG) (if a marine mode of transport is used, or if the rail transload facility is located on or adjacent to water)
- Security personnel
- Communication personnel associated with participating entities (e.g., local authorities, escorts, etc.) needed for advance notification of shipments in accordance with 42 U.S.C. 10175(b), 10 CFR 73.37, 10 CFR 71.97, and/or NUREG-0561 Revision 2 [14] , as appropriate
- TRANSCOM or similar satellite and associated continuous in-transit communication service provider(s)
- Transportation emergency responders

The participating entities/persons can be categorized into the functional groups identified in **Table 4-1**. An evaluation of Tribal entities that might be impacted during de-inventory operations was performed, and one was identified within the transportation routes selected for this report. This will need to be evaluated further once destination facilities are identified.

Table 4-1: Participating Entity Functional Identification

Function Group	Entity
Site	Site Management
	Safety
	Quality
	Document Control
	Security
	Craft Support
	Support Functions
Transportation	Transportation Supervision
	Equipment Operator (driver)
	Security

Function Group	Entity
	Shipment Response/Tracking
	Support Functions
Rail Transload Facility	Operations Supervisor
	Security
	Craft Support
	Shipment Response/Tracking
	Quality
Authorities	DOE
	State
	Local
	Federal Railroad Administration (FRA)
	U.S. Transportation Security Administration (TSA)*
	U.S. Coast Guard (USCG)
	NRC
	Pipeline and Hazardous Materials Safety Administration (PHMSA)
Site & Route Communities	Tribal Nations
	Community Engagement/Advisory Boards

**TSA operates under the direction of the Department of Homeland Security and acts on their behalf.*

Per NRC's regulation 10 CFR 71.97 "Advance notification of shipment of irradiated reactor fuel and nuclear waste," the following would be required:

(a)(1) As specified in paragraphs (b), (c), and (d) of this section, each licensee shall provide advance notification to the governor of a State, or the governor's designee, of the shipment of licensed material, within or across the boundary of the State, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

(a)(2) As specified in paragraphs (b), (c), and (d) of this section, after June 11, 2013, each licensee shall provide advance notification to the Tribal official of participating Tribes referenced in paragraph (c)(3)(iii) of this section, or the official's designee, of the shipment of licensed material, within or across the boundary of the Tribe's reservation, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

(b) omitted as for other than irradiated fuel

(c) Procedures for submitting advance notification. (1) The notification must be made in writing to:

(i) The office of each appropriate governor or governor's designee;

(ii) The office of each appropriate Tribal official or Tribal official's designee; and

(iii) The Director, Office of Nuclear Security and Incident Response.

Therefore, in accordance with the above regulation, advance notification would be provided to the following groups to coordinate transport in an actual de-inventory campaign. For transport of radioactive material [32], interface is required with the entities listed in **Table 4-1** ("*Authorities*" and "*Site & Route Communities*"), as applicable, for various purposes including exchanges of planning information, requests for and receipts of authorizations/approvals, and receipt of applicable rules and guidance.

Listed below is contact information for some of the relevant state (Vermont) governing authorities and transportation services for the various modes of transport anticipated. During the development of this report, most information was obtained through public domain. In preparation for an actual de-inventory campaign, this contact information would need to be updated with current information closer to the time of shipments, as coordination and communication with appropriate participating entities would be instrumental in the execution of the shipments.

Vermont – Office of the Governor

Listed below is the contact information for the Vermont Governor's Office.

https://governor.vermont.gov
Office of the Governor
109 State Street, Pavilion
Montpelier, VT 05609
Phone: 802-828-333
Fax: 802-828-3339

Vermont – Governor's Designee for Notification of SNF Shipments

Listed below is the contact information for the Governor's designee for notification of SNF shipments.

Governor's Designee for Notification of SNF Shipments:
Lieutenant Colonel Thomas A. Powlovich
Deputy Director of the Vermont State Police
802-858-9011
802-244-7345 Vermont State Police Headquarters, Waterbury, VT

William Irwin, ScD, CHP Radiological & Toxicological Sources Program Chief
Vermont Department of Health (Part 37)
108 Cherry Street
Burlington, VT 05401-3818
Phone: 802-863-7238
24 Hour Phone: 802-316-0119
Email: William.irwin@vermont.gov

Anthony R. Leshinskie, State Nuclear Engineer & Decommissioning Coordinator
Vermont Public Service Department (Part 71 & Part 73)
112 State Street, 3rd Floor
Montpelier, VT 05620-2601
Internal Extension 828-1784
Office/cell: 802-272-1714
VT Yankee Site Office: 802-451-5354 ext. 2564
Email: Anthony.leshinskie@vermont.gov

Seneca Nation of Indians

Michael Gates
Director Emergency Management Department
12879 Route 438
Irving, NY 14081
Phone: (716) 532-8178 x8891
Fax: (716) 532-3231
Cell: (716) 244-0820
Email: mike.gates@sni.org

Anthony Memmo
Project Manager, Seneca Energy Seneca Nation of Indians
219 Thomas Indian School Drive
Irving, NY 14081
Phone: (716) 532-4900 ext. 5022
Cell: (716) 801-1290
Email: a.memmo@sni.org

Vermont – Department of Transportation

https://vtrans.vermont.gov
Vermont Agency of Transportation
219 North Main Street
Barre, VT 05641
(802) 391-5559 or (802) 917-2458

Joe Flynn
Secretary of Transportation
Email: Joe.flynn@vermont.gov
(802) 476-2690

The Transport Permits Unit issues permits for oversize/overweight loads to travel on state and federal highways. For more information, contact:

Vermont Agency of Transportation
Department of Motor Vehicles
Oversize & Overweight Permits
120 State Street
Montpelier, VT 05603-0001
Telephone: (802) 828-2064
https://dmv.vermont.gov/

Vermont Yankee ISFSI Site Management

Corey Daniels / VY ISFSI Senior Manager
NorthStar Nuclear Decommissioning Co., LLC
NorthStar Vermont Yankee
320 Governor Hunt Rd, Vernon VT 05354
802-451-5354 Ext. 2501
Cell: 603-313-0944
Email: cdaniels@northstar.com

Site HHT-Crane & Rigging Providers

Renaud Brothers
283 Fort Bridgman Road
Suite 2
Vernon, VT 05354
802-257-7383

Barnhart Crane
25 Mill Street
Middletown, CT 06457
860-347-0827

Railroad Transportation Contacts

NECR local office:
310 Vernon Street

Brattleboro, VT 05301

Assistant General Manager:
Bob Richardson
Email: Bob.richardson@gwrr.com

Barge Operators

Barge shipment from VY is not feasible because the Connecticut River is dammed; if used from another location refer to the contacts below:

Bos Smith
Stevens Towing Company
4176 Highway 165
Yonges Island, SC 29449
843-889-2254

Cask Supplier

Listed below is the contact information for suppliers of the transport casks and related equipment discussed in this report.

Holtec International
https://holtecinternational.com/
1001 N US Highway 1
Jupiter, FL 33477 USA
Tel: +1.856.797.0900

5.0 MULTI-ATTRIBUTE UTILITY ANALYSIS

As noted in **Section 3.0**, there are several potential routes for shipping the HI-STAR 100MB's from the VY ISFSI to a railcar on a Class I railroad that can take these HI-STAR 100MB's to their penultimate or ultimate destination (i.e., a federal consolidated interim storage site or a repository, respectively). The diversity of these routes reflects the multiple viable approaches to shipping the HI-STAR 100MB's (i.e., by direct rail, HHT, or barge), and the access of VY to these modes of transport. Furthermore, these routes potentially have both positive attributes (e.g., safe and secure transport) and negative attributes (e.g., expense) meriting an assessment approach that can evaluate these attributes in a combined manner that may distinguish one route from another and/or rank and prioritize routes.

The MUA is a structured methodology designed to handle the trade-offs among multiple objectives (e.g., attributes). The MUA provides a transparent, rational, and defensible analysis that is easy to communicate. MUA methods have been used for decades to provide logically consistent analyses of options (i.e., modes and routes) that are intended to achieve more than one objective, where no single option dominates the others on all objectives. Utility theory is a systematic approach for quantifying an individual's or team of individuals' ratings/predilection . It is used to assign a numerical value on some measure of interest (e.g., metric of an attribute) and rescale it onto a normalized (0 to 1) scale with 0 representing the worst rating/option and 1 the best rating/option. This allows the direct comparison of many diverse objectives. The result is a rank-ordered evaluation of options that reflects the evaluators' priorities.

The MUA has been selected as the assessment approach for the purpose of this report to evaluate the viable modes and routes (options) for moving the HI-STAR 100MB containing SNF and GTCC LLW from the VY ISFSI. In this section, an MUA using a value model, which identifies predilections towards attributes, relative importance of meeting an attribute, and/or tradeoffs between attributes, will be used to establish a prioritized list of modes and routes from the VY ISFSI.

5.1 Description of MUA Applied to the VY ISFSI

The three primary steps of MUA used to frame the analysis are: (1) identify a set of objectives/attributes that an 'ideal' option will achieve; (2) define a set of performance measures (i.e., metrics) that provide a clear definition of each objective/attribute; and (3) identify or define alternative options to be considered. Once alternative options (routes and modes), objectives (attributes), and performance measures (metrics) have been clearly defined, the predilections for the performance measures are subsequently established from a pairwise comparison between one another to establish a relative weight for each performance measure. The rating for each route per metric is established by performing another pairwise comparison among the performance measures for each route. The rating of each route can then be established by using a value model to create a single metric that can be used to compare each route against one another and provide a ranking of the routes.

The main steps of the MUA applied to the routes from the VY ISFSI are identified in **Figure 5-1** and are as follows:

1) Identify the potential modes and routes for transporting the HI-STAR 100MB's from the VY ISFSI; see **Section 3.0**.

2) Due to the large number of potential routes from the VY ISFSI identified in Step 1, a set of screening criteria is developed and applied to reduce the number of routes per mode to a limited group for further evaluation; see **Section 3.5** (if this step were not performed, then the pairwise evaluations of the routes by metric would be too cumbersome to be practical due to the number of evaluations that would need to be performed).3)

3) Identify the general attributes associated with the routes and the activity of shipping the HI-STAR 100MB's from the VY ISFSI; see **Section 5.3.1**.

4) For each identified attribute, identify the metrics that describe performance measures, which could contrast one mode and route from another; see **Section 5.3.1**.

5) Considering the limited list of routes to be evaluated, examine each attribute's metrics, and identify the ones that could tangibly differ between two or more of these modes and routes; see **Section 5.3.1**.

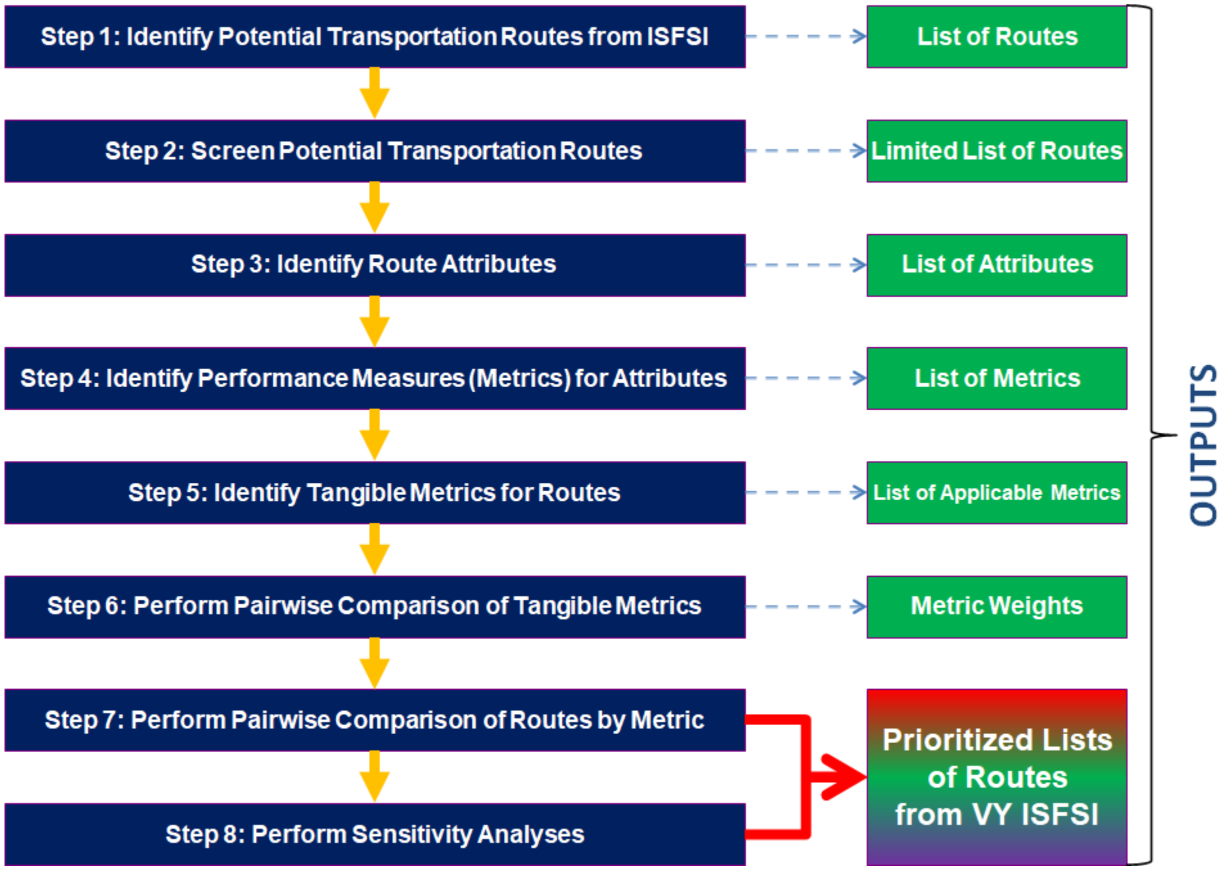
6) Each team member performs a pairwise comparison between each of the tangible metrics, which are subsequently quantified, resulting in a relative ranking of the metrics based on individual ratings and are also combined to establish a weight for each of the tangible metrics based on an equivalent team rating; see **Section 5.3.2** (the individual rankings also provided the basis for the sensitivity analyses).

7) The team collectively performs another pairwise comparison between the tangible metrics for each route (to ensure the subject matter experts' [SME] predilections are incorporated and not diluted by the ratings of other individuals), and the results are quantified and evaluated to establish a relative ranking of each of the routes based on SME ratings; see **Section 5.3.3**.

8) Finally, sensitivity analyses are performed to examine the sensitivity of the ranking to different weighting of the tangible metrics; this includes evaluating the metric weights at the minimum and maximum values identified by the individual members of the team; see **Sections 5.4** and **5.5**.

Details of the analyses and the results produced from each of these steps are described in the following portion of this section.

Figure 5-1: Overview of MUA Applied to VY ISFSI



5.2 Description of Evaluated Routes

As noted in **Section 3.0**, there are numerous possible routes from the VY ISFSI (Step 1). The general sequences of the transportation operations for these routes fall into the following categories:

- Transfer directly to on-site rail siding (on-site rail),
- Transport by HHT to an existing rail transload facility (HHT-to-rail), and
- Transport by HHT to a port, transfer to a barge and then transfer to a railcar (HHT to barge to rail).

Due to the numerous possible routes identified in **Section 3.0**, a set of screening criteria was used to reduce these routes to a number that can be reasonably evaluated by the MUA (Step 2). If the routes were not reduced by performing this screening activity, then the MUA could take an inordinate amount of time to perform and the pairwise comparison may not be able to distinguish between many of the routes due to the compression of results between the favored routes relative to the evaluated metrics. That is, if the difference between a favored route and another route that clearly has some disadvantages is identified at an extremity of the evaluation range, then the MUA will show a distinct difference between these two routes. However, if there are other favored routes with only slight differences between one another, these differences may be difficult to distinguish from one another as the large differences will have compressed the slight differences identified between two or more favored routes and thereby prevent distinguishing between them in the overall evaluation.

The following screening criteria were used per mode of transport (i.e., routes having the same mode of transport were only contrasted against one another for screening purposes)[5] to reduce the routes to the five routes identified in **Section 3.5**:

1) The time and/or distance to be traveled by the conveyance/barge would be significantly more than alternate viable routes without significant/substantial benefit.
2) Clearance limits on routes (e.g., through tunnels, around curves, or through heavily forested roads) are not met without significant/substantial upgrading.
3) Sustained travel on routes with steep grades.
4) Bridge(s)/overpass(s) to be utilized would not sustain weight of conveyance without significant/substantial upgrading.
5) Natural features make barge landings, overpack loading, etc. difficult to perform without significant/substantial upgrading or infrastructure development.
6) No available loading facility or insufficient track for performing loading of a full consist.
7) Transloading and/or port facility does not permit receipt of Class 7 materials.
8) Number of interchanges between carriers.
9) Avoidance of high-density transit areas (i.e., regions with significant rail traffic) that would require interruption of traffic if shipment were to transit region.
10) Characteristics of HHT that would require preapproval for HRCQ shipments.
11) Other.

The reasons for the screening of potential routes identified in **Section 3.0** are documented in **Table 3-6**. The routes unscreened and remaining to be evaluated by the MUA are as follows:

1) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel along multiple train lines on a minimum travel time path to GCUS as established by START (i.e., referred to as “A. Rail-min. travel time” route in the MUA);
2) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel along multiple train lines on a minimum distance path to GCUS as established by START (i.e., referred to as “B. Rail-min. distance” route in the MUA);
3) An all-rail route with the railcars loaded on the on-site VY rail spur and then travel to Palmer, MA and then to GCUS on two rail carriers (i.e., referred to as “C. Rail via Palmer” route in the MUA);
4) A HHT route of about 34 miles north to Bellows Falls, VT to the Riverside Transload Center where a transload occurs from the HHT to railcars and then travels by rail using

[5] Note the routes involving barges were all eliminated from further consideration in this assessment due to the impractical number of steps required to make these shipments since the VY site is not accessible to the barge option.

three rail carriers to GCUS (i.e., referred to as "D. HHT & Rail from Riverside Transload Center" route in the MUA); and

5) A HHT route of about 31 miles north to Bellows Falls, VT to the Green Mountain Rail Yard where a transload occurs from the HHT to railcars and then travels by rail using two rail carriers to GCUS (i.e., referred to as "E. HHT & Rail from Green Mnt Rail Yard" route in the MUA).

5.3 Evaluation of Routes

To evaluate each of these five routes, attributes used to define an 'ideal' route and associated shipping activities were identified, and for each attribute, metrics were identified that describe the performance measures and allow for the quantification of the assessment through pairwise comparisons. With these five routes in mind, the metrics were evaluated to identify those that are tangibly different between two or more routes. These tangibly different metrics were then pairwise compared against one another to identify a level of importance for each metric (i.e., a metric hierarchy) and provide a range of values against which sensitivity analyses were performed. An additional pairwise comparison was performed between the tangible metrics for each route, and using the metric hierarchy, a hierarchy for the routes was established. Finally, sensitivity analyses were performed to examine the impact of changes to the weighting of the metrics on the route hierarchy.

5.3.1 Identification of Attributes and Metrics

The attributes identified to characterize the 'ideal' route are given in **Table 5-1** (Step 3). These attributes were established based on solicitation of the members of the de-inventory team, past de-inventory studies[13][16][17][18][19][20][21][22][23][24][25], and on the large body of past MUA activities performed on nuclear waste management evaluations[26][27][37][38].

For each attribute, one or more performance measures (metrics) was established (Step 4). These metrics provide a means for estimating how well each route performs against each attribute, defined in terms that can be evaluated by technical experts and compared meaningfully by decision makers. **Table 5-1** also lists the identified metrics per attribute.

To minimize the number of evaluations performed in the next set of MUA activities, the team was surveyed to establish which metrics identify a potentially tangible difference between one or more of the remaining five routes (Step 5). **Table 5-1** shows the results of this survey and some subsequent team discussions. Those metrics identified as having the potential to differentiate between one or more of the routes are identified in **Table 5-1** with a "Y" (yes). Comments are provided in the last column of the table to indicate how the "applicable metric" assessment was performed/concluded. The results of this assessment identified at least one metric for each attribute, with the exception of the Resource Requirements, Security/Vulnerability, and Waste Generation attributes, for which no tangible differences in the resources, security, and waste production were identified between the routes (e.g., the waste generated during the de-inventory activities, such as personnel protection equipment, is considered to essentially result in the same quantity and type of waste and hence, will not identify a tangible difference between the evaluated routes). A total of 18 metrics will be evaluated for each route and contrasted against the other routes.

Table 5-1: Attributes and Associated Metrics

Attribute	Metric	Y/N	Comments
Cost[6]	On-Site Rental Equipment Costs (e.g., mobile cranes)	y	Difference between on-site equipment needed for HHT versus railcar loading activities.
	Hardware Procurement Costs (e.g., transfer cask)	N	Hardware is expected to be relatively the same for all the routes as transfer from storage overpack to transportation cask will occur for all modes of transport.
	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	N	All routes appear to not require any infrastructure improvements and all transload sites have sufficient existing rail to perform the transload activities.
	Labor and Permitting Costs	Y	Labor and permitting costs are expected to vary between the HHT and rail routes as HHT will require more labor to perform and HHT is expected to require more permitting costs over direct rail.
	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	Y	Direct rail not expected to require additional costs, whereas HHT routes will require more costs for HHT.
	Cost of Rail Transport (e.g., costs associated with use of multiple rail carriers in route)	Y	Rail routes take different length routes and will have different numbers of interchanges.
	Total Overall Costs	N	The above broken-down elements of the total cost are expected to cover this metric and hence, this metric is not expected to provide any significance to this assessment.
Environmental Impact	Gaseous Effluent Release	N	Although vehicle emissions will be different between the routes, there are no radiological releases associated with the routes and hence, this metric is not going to provide a tangible difference between the routes.
	Liquid Effluent Release	N	No liquid effluent release is associated with any route from this site.
	Route Aesthetic Changes Needed (e.g., tree trimming)	N	Aesthetic changes not needed to support the routes to be evaluated.
	Route Impact to or Proximity to Historical, Archaeological, and/or Cultural Features	N	Evaluated routes are not expected to impact historical, archaeological, or cultural features.
	Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)	Y	Some routes appear to take steep grades and potentially difficult turns by HHT (hairpin/switchback curves).
	Impact of Weather to Route (e.g., limited availability of route or instability of weather)	Y	HHT will be more impacted by the weather northern weather than the rail-only routes.

[6] Casks, railcars, and associated equipment are assumed to be government furnished equipment and therefore the cost of this equipment is not included in this assessment.

Attribute	Metric	Y/N	Comments
	Number of Water Areas Nearby Route (e.g., number of bridges crossed)	Y	According to START [1] the number of water crossings is similar to one another, but water areas per square mile doe show some differences between the routes.
	Number of Sensitive Environmental Areas Nearby Route (e.g., endangered species habitats)	Y	The sensitive environmental are per square mile is nearly indistinguishable between the routes but the protected areas between the HHT and rail routes is tangibly different according to START [1] data.
Institutional Considerations	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churches)	Y	Based on results from START [1], the routes show similar numbers of mass gathering places and educational institutions, but some tangible differences in the special populations along the routes.
	Number of Tribal Lands Crossed	N	Based on results from START [1], the routes showed no differences between the number of Tribal lands crossed by the routes.
	Public Acceptability of Route	Y	This subjective metric will be evaluated as done in the previous evaluations based on the teams experts opinions and will consider nearby features of the routes.
Permitting	Ease of Permit Procurement	Y	HHT routes are expected to have some difficulty in procuring State permits relative to the rail routes.
	Number of Permits	Y	Number of permits for the HHT route are greater than the direct rail transport routes.
	Insurability of Route	N	All routes to be indemnified by DOE (Price Anderson Act).
Resource Requirements	Number of Personnel involved in Transfer	N	Impact considered to be covered by cost and safety metrics.
	Quantity of Hardware Needed	N	Impact considered to be covered by cost metric.
	Availability of Specialty Equipment (e.g., rigging, transfer cask)	N	Specialty equipment such as a transfer cask and rigging will all be assumed available when required for each route.
Safety	Cumulative Worker Exposure (α handling time & number of workers)	Y	HHT routes are expected to have higher cumulative due to two handling events (onto HHT and onto rail) and slightly longer routes but cumulative worker exposure is expected to be low for all routes.
	Cumulative Population Dose along Route (α population density)	Y	According to START [1], the population exposed along a route may vary slightly between various routes (noting all exposures will meet regulatory limits and be negligibly small).
	Risks Associated with Number of Lifting Activities	Y	HHT routes will require an additional transload and associated lifts over the direct-from-site transloaded rail routes.

Attribute	Metric	Y/N	Comments
	Average Accident Frequency on Route	Y	According to START [1], the average accident frequency along a route may vary between various routes (noting the frequencies are very small overall).
	Hazards (Occupational Safety and Health Administration (OSHA) & Radiological) associated with Route Duration	N	The OSHA risks are expected to be negligible and comparable for each of the routes and any difference will be covered by the worker exposure and transit duration metrics.
	Number of Fire Stations & Trained Personnel Nearby Route	N	START [1] indicates no significant differences between the HHT routes.
Schedule	Transit Duration per Conveyance and Consist	Y	START [1] identified distinguishable duration differences between the HHT and rail routes.
	Duration for Infrastructure Improvement (e.g., including dredging, fixing rail line)	N	No significant infrastructure improvements are expected on any of these routes.
	Ease of Access to Transload Site (e.g., consider usage of existing site)	N	All transload sites appear to be easily accessible without significant upgrades needed.
	Immediacy of Ability to Perform Transfer (e.g., ability to train crew)	N	The team decided there was no tangible difference between the routes as all routes were deemed equally immediately ready for performing a transfer.
	Size of conveyance (# of casks per shipment)	Y	HHT routes will have 1 cask moved per shipment while loading railcar, whereas all rail routes directly from the site will be loaded at the site.
Security/ Vulnerability	Security Vulnerability of Route	N	Each route is considered to have the same security vulnerability (no barge options) in rural areas.
	Availability of Security Escort for Route	N	Security escort is assumed to always be available.
	Number of Police Stations Nearby Route	N	The number of police stations nearby each of the routes is essentially the same per START [1].
Waste Generation	Quantity of Radiological Waste Produced from Normal Ops	N	A minimum amount of radiological waste is expected and will likely be nearly the same for all routes.
	Quantity of Non-Radiological Waste Produced from Normal Ops	N	A minimum amount of non-radiological waste is expected and will likely be nearly the same for all routes.

5.3.2 Evaluation of Individual Metrics

With the tangible metrics established in **Section 5.3.1**, a pairwise comparison among these metrics was performed by each of the 11 members of the Orano-led team to establish a relative weighting of the metrics and a range for the metric weight over which a sensitivity analyses was performed (Step 6). In a pairwise comparison, each metric is evaluated for its favorability against the other metrics. This exercise was performed by each of the 11 individuals of the Orano-led team to ensure a reasonable cross-section of samples was taken from the collective team, which allowed for an average metric weighting to be established and a prioritized list of metrics identified.

An example of the pairwise comparison performed by an individual is shown in **Table 5-2**. In this example, the “Transport to Rail Class I Costs” metric (e.g., costs associated with transload activities and rental costs for a HHT, trailer, and/or barge) is pairwise compared against the other metrics on a favorability scale. For example, the “Transport to Rail Class I Costs” metric is rated mildly favorable against the “Transit Duration per Conveyance and Consist,” but is rated strongly unfavorable against “Cumulative Population Dose along Route.” These ratings are interpreted to mean that there is a slight benefit seen to reducing the monies spent on the transport to rail at the expense of increasing the duration of the transit per conveyance and consist (e.g., renting a tug that may operate at a lower speed but costs less than a tug operating at a higher speed, then this evaluator would slightly favor utilizing the slower tug even though that may increase the transit duration). However, if there were an improvement to the transport to Rail Class I that resulted in an increased cost but could be performed to improve (reduce) the cumulative population dose along the route (e.g., utilization of a more shielded trailer to reduce dose exposures to the population from the cask), and then this will be a strongly favored/encouraged outcome.

With 18 tangible metrics to be evaluated, 153 pairwise evaluations had to be performed by each individual. **Attachment A** shows the entire pairwise evaluation for these metrics. If the original 40 metrics were evaluated, then 780 pairwise evaluations will have had to have been performed to establish the weight for the metrics, which would have been very burdensome.

The favorability scale, shown in **Table 5-2**. (e.g., “Strongly Favorable”), allows for quantification of the comparison when weights are assigned to the scale. In this MUA, the relative weighting is assessed as follows:

- Strongly favorable as 11 (+5),
- More favorable as 9 (+3),
- Mildly favorable as 7 (+1),
- Neutral is rated as 6 (0),
- Mildly unfavorable as 5 (-1),
- More unfavorable as 3 (-3), and
- Strongly unfavorable as 1 (-5).

Using this weight scheme, **Figure 5-2** shows the results for the relative weighting of the tangible metrics as established from the evaluation of eleven individual pairwise comparisons. **Table 5-3** shows the numerical values associated with these tangible metrics. Three sets of data are shown in this figure and four sets of data are shown in this table:

1) The “Minimum” value as established from the eleven individual assessments.
2) The “Average Weight” value, which is an average of normalized results from each of the individual assessments (i.e., each individual’s assessment is equally weighted, and the results combined).

$$\bar{R}_m = \sum_{p=1}^{P} \left\{ \frac{\sum_{i=1}^{7} N_{m,p}^{i} W_i}{\sum_{m=1}^{M} \left[\sum_{i=1}^{7} N_{m,p}^{i} W_i \right]} \right\}$$

where R = average relative weight, N = number of times rank selected, W = weight of rank (see above), M = number of metrics to be evaluated, P = number of evaluators, m. = metric, i = rank (e.g., "strongly favorable"), p = person evaluating metrics.

3) The "Biased Weight" value, which is an average of the unnormalized results from each of the individual assessments (i.e., the raw scores are used to establish overall average values, so if an individual scored significant differences between the metrics, then these results could skew the overall average in favor of this individual's assessment).

$$\bar{R}_m = \sum_{p=1}^{P} \left\{ \frac{\sum_{i=1}^{7} N_{m,p}^{i} W_i}{\sum_{m=1}^{M} \left[\sum_{i=1}^{7} N_{m,p}^{i} W_i \right]} \right\}$$

where B = averaged biased relative weight.

4) The "Maximum" value as established from the eleven individual assessments.

Results from all eleven of the individual assessments are shown in **Attachment B**.

As shown in **Figure 5-2** and **Table 5-3**, the tangible metrics with the highest ratings (based on average weighting method) are Cumulative Population Dose, Cumulative Worker Exposure, and Risks Associated with Number of Lifting Activities which rated at about 7.7%, 7.5%, and 7.4% of the total weight, respectively. The lowest rated tangible metrics (based on average weighting method) are Number of Water Areas Nearby Route, ISFSI Rental Equipment Costs, and Transport to Rail Class I Costs, which rated at about 4.0%, 4.3%, and 4.3% of the total weight, respectively. The ranking and weights of all the tangible metrics in descending order (based on average weighting method) are shown **Table 5-3**.

Table 5-2: Example of a Portion of a Pairwise Comparison for Metrics Assessment

Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Transport to Rail Class I Costs			X					Cost of Rail Transport
Transport to Rail Class I Costs			X					Route Environment Characteristics
Transport to Rail Class I Costs				X				Impact of Weather to Route
Transport to Rail Class I Costs					X			Number of Water Areas Nearby Route
Transport to Rail Class I Costs					X			Number of Sensitive Environmental Areas Nearby Route
Transport to Rail Class I Costs						X		Number of Non-Easily-Mobilizable Populations
Transport to Rail Class I Costs					X			Public Acceptability of Route
Transport to Rail Class I Costs					X			Ease of Permit Procurement
Transport to Rail Class I Costs						X		Number of Permits
Transport to Rail Class I Costs						X		Cumulative Worker Exposure (α handling time & # of workers)
Transport to Rail Class I Costs							X	Cumulative Population Dose along Route

Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Transport to Rail Class I Costs				X				Risks Associated with Number of Lifting Activities
Transport to Rail Class I Costs			X					Average Accident Frequency on Route
Transport to Rail Class I Costs			X					Transit Duration per Conveyance and Consist
Transport to Rail Class I Costs			X					Size of conveyance (# of casks per shipment)

Figure 5-2: Weighting of the Tangible Metrics Based on Pairwise Comparisons

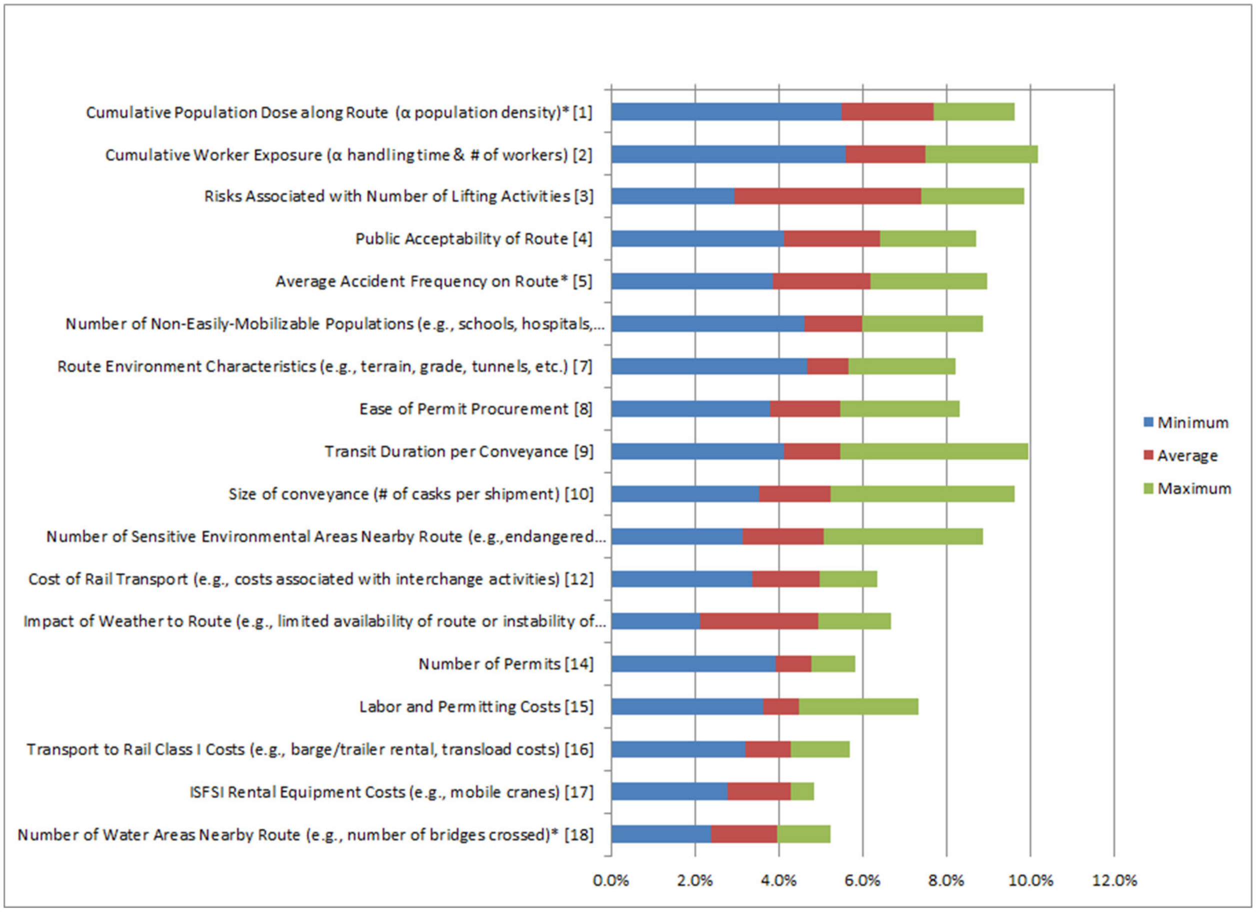


Table 5-3: Weighting of Tangible Metrics

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
1	5.50%	7.71%	7.71%	9.64%	Cumulative Population Dose along Route
2	5.61%	7.49%	7.49%	10.19%	Cumulative Worker Exposure
3	2.94%	7.42%	7.42%	9.86%	Risks Associated with Number of Lifting Activities
4	4.14%	6.44%	6.44%	8.71%	Public Acceptability of Route
5	3.87%	6.18%	6.18%	8.99%	Average Accident Frequency on Route
6	4.63%	6.01%	6.01%	8.88%	Number of Non-Easily-Mobilizable Populations

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
7	4.68%	5.67%	5.67%	8.22%	Route Environment Characteristics
8	3.81%	5.49%	5.49%	8.33%	Ease of Permit Procurement
9	4.14%	5.47%	5.47%	9.97%	Transit Duration per Conveyance
10	3.54%	5.25%	5.25%	9.64%	Size of conveyance
11	3.16%	5.09%	5.09%	8.88%	Number of Sensitive Environmental Areas Nearby Route
12	3.38%	5.00%	5.00%	6.37%	Cost of Rail Transport
13	2.12%	4.96%	4.96%	6.70%	Impact of Weather to Route
14	3.92%	4.79%	4.79%	5.83%	Number of Permits
15	3.65%	4.50%	4.50%	7.35%	Labor and Permitting Costs
16	3.21%	4.30%	4.30%	5.72%	Transport to Rail Class I Costs
17	2.78%	4.28%	4.28%	4.85%	ISFSI Rental Equipment Costs
18	2.40%	3.96%	3.96%	5.23%	Number of Water Areas Nearby Route

5.3.3 Route Assessments

With the ranking of the tangible metrics calculated, another pairwise comparison was performed to compare the tangible metrics for a route against those of each of the other routes (Step 7). Unlike the pairwise comparison performed for the tangible metrics, which were performed by multiple individuals, this pairwise comparison was performed by the collective team to ensure the responses from SMEs were properly weighted against responses from the other team members when a metric(s) (e.g., cost) was addressed in that SME's discipline(s). In this manner, for example, in the ranking of a safety-related metric, the safety SME's rating was afforded greater influence than were the ratings of the other individuals on the team if there was a difference.

An alternative approach would be to let each SME separately perform a pairwise comparison on only the metrics within the SME's discipline(s). However, by having a team assessment, productive discussions can take place on each metric, which may change, challenge, concur, etc., on the evaluation of the metric. Furthermore, by acting as a team, the rationale for the pairwise comparisons ratings can be established which will ensure a fairly consistent basis in the ranking of the metrics (e.g., this may temper extreme assessments in cases where differences in rankings of a metric may not be that significant on a relative basis).

Before performing this pairwise comparison between the tangible metrics for a route against those of each of the other routes, some cursory data is required for each of the routes to inform this assessment. **Section 3.0** contains some of this information, but a summary of the cursory data used to perform this comparison by metric is provided here.

5.3.3.1 On-Site Rental Equipment Costs

Most of the rental costs for on-site equipment are expected to be the same for each route (e.g., mobile crane and trailer). All the rail routes will have the same rental equipment and hence are no different from one another. Similarly, the HHT routes will have the same rental equipment and hence are no different from one another. However, the HHT routes have an additional transload activity which would require the rental of another set of equipment and were judged to be mildly less favorable than the rail routes.

5.3.3.2 Labor and Permitting Costs

The HHT routes are expected to have higher labor and permitting costs relative to the on-site rail costs, as the HHT routes are expected to have higher permitting costs, as local permits for the HHT are required whereas no local permits are necessarily needed for the rail routes. Furthermore, labor costs for the HHT routes are expected to be higher due to the off-site transload activities the rail routes will not have. Thus, the HHT routes would be more unfavorable compared to the rail routes. The HHT routes will not have significant differences in these costs between them and the rail routes will also have these costs similar to one another, excepting the rail via Palmer route will require fewer switches between rail carriers and hence, will be mildly favored over the other rail routes.

5.3.3.3 Transport to Rail Class I Costs

For the transport to rail costs (not including on-site costs), each of the five routes were evaluated by the team to have a cost benefit or cost penalty relative to the other routes based primarily on composite costs associated with rental of barges, tugs, and HHTs and number of transload activities. For rail routes, no transport to rail costs were identified beyond those already covered by the on-site rental costs and hence, they all evaluated neutrally against one another. For HHT routes, the costs are associated with: (1) a HHT to move one transportation cask from the ISFSI to the rail transload facility and (2) the rental of a crane to move the transportation cask from the HHT to railcar at the transload site. In addition to these rental costs, costs associated with the distance required to be covered for each route and the number of shipments required to be performed for each route will impact this assessment. Hence, the rail routes were deemed to have equivalent (negligible) costs and were strongly favored over the HHT routes for this metric and the HHT to the Riverside Transload Center was mildly favored over the other HHT route due to the shorter distance to be traveled.

5.3.3.4 Cost of Rail Transport

The two rail routes established by START [1] are nearly identical and hence, their cost of rail transport is the same. However, the number of interchanges these two rail routes take are greater than the route via Palmer and hence the Palmer route was more favored over these two rail routes. The rail portion of the HHT routes is similar to the Palmer rail route and hence, these routes rated mildly and more favorable over the two routes established by START [1], which had a significant number of interchanges. The Palmer rail route is shorter than the rail portion of the HHT routes and had one or two fewer interchanges and hence, the Palmer rail route rated mildly favored over the two HHT routes.

5.3.3.5 Route Environment Characteristics

The rail routes did not have significant environmental characteristics and hence evaluated neutrally against one another. The HHT routes included some steep grades and hairpin turns to reach their transload sites and hence rated more unfavorable against the rail routes.

5.3.3.6 Impact of Weather to Route

The HHT routes are more susceptible to the winter weather (e.g., snow, sleet, hail) than the rail-only routes and were judged to be more unfavorable than the rail-only routes. The rail only routes are not significantly impacted by adverse winter weather, whereas HHT routes are likely to be delayed due to such conditions.

5.3.3.7 Number of Water Areas Nearby Route

Using the data established by START [1] for the number of water crossings and the water areas located around the routes shown in **Table 5-4**, the results indicate the two START generated rail routes have nearly identical water crossings and water areas and are mildly favorable over the Palmer rail route. In addition, the rail routes are more favorable than the HHT to rail routes and the two HHT to rail routes are very similar to one another.

Table 5-4: Water Crossings and Water Areas Along Each Route [1]

ID	Route Description	Water Feature	Rail	HHT	Total
A	Rail-min. travel time	Water Crossings	185	0	185
		Water Areas (per mi^2)	22.45	0	22.45
B	Rail-min. distance	Water Crossings	188	0	188
		Water Areas (per mi^2)	22.56	0	22.56
C	Rail via Palmer	Water Crossings	195	0	195
		Water Areas (per mi^2)	21.85	0	21.85
D	HHT & Rail from Riverside Transload Center	Water Crossings	185	23	208
		Water Areas (per mi^2)	25.79	3.36	29.15
E	HHT & Rail from Green Mnt. Rail Yard	Water Crossings	185	23	208
		Water Areas (per mi^2)	25.36	3.39	28.75

5.3.3.8 Number of Sensitive Environmental Areas Nearby Route

Using data produced from the START program [1], each route could be evaluated for the quantity (square miles) of environmentally sensitive areas crossed. Based on these results (see **Attachment D**), the quantity of environmentally sensitive and protected areas crossed by each route ranged from 10.4 to 11.3 square miles and 155.6 to 246.0 square miles, respectively. These areas are tiny compared to the total land crossed by the entire routes. Nevertheless, according to START [1], some routes do have advantages over others: the two rail generated routes by START [1] interface with the least sensitive environment areas, the Palmer rail route has a slight increase with the sensitive environments compared to the two aforementioned rail routes, and the HHT to rail routes had the higher (relative) protected areas. Overall, the differences are very small between the routes and hence, only a mild favorability was identified in the assessment.

5.3.3.9 Number of Non-Easily-Mobilizable Populations

Using data produced from the START program [1], each route was evaluated for the number of non-easily-mobilizable populations, such as those found at schools, hospitals, malls, stadiums, churches, and retirement homes along the routes. Based on these results (see **Attachment D**), the number of non-easily mobilizable populations along each route was lowest for the rail route with the minimum distance followed by the rail route with minimum travel time and the Palmer rail route with essentially equal populations and finally the two HHT to rail routes with essentially equal populations.

5.3.3.10 Public Acceptability of Route

Public acceptability varied among some of the routes. The rail only routes were judged to be most favorable over the HHT routes due to the lack of off-site activities (e.g., trucking and transloading), utilizing rail lines with regular commercial service, and not traveling nearby public waterways and their associated environmentally sensitive areas. The HHT route to the Riverside Transload Center was mildly favored over the HHT route to Green Mountain Rail Yard as it travels over less populated areas and not through the center of Bellows Falls, VT.

5.3.3.11 Ease of Permit Procurement

The rail routes were either strongly or more favorable over the HHT to rail routes because they do not require permits, whereas the HHT portions of the routes would require state permits, which are considered not necessarily easy to procure in VT, especially for a HHT going in the opposite direction from where the SNF ultimately needs to go to.

5.3.3.12 Number of Permits

As noted in the previous section, the rail-only routes do not require permits and hence, all the rail-only routes were judged to be more favorable over the HHT to rail routes. The HHT to rail routes travel about the same distance to Bellows Falls from VY and hence are likely to require the same number of trucking permits from the state.

5.3.3.13 Cumulative Worker Exposure

The cumulative worker exposure metric assessment relies heavily on the number of handling events (e.g., transloads) involving the transportation casks and, to a lesser degree, on the distance traveled for each route. These handling events are outlined below and result in the rail routes (equivalent of one or two on-site transload activities) having a slight advantage over the HHT routes (equivalent of one on-site transload activity and one off-site transload activity). Worker exposure levels would not approach regulatory limits as the shielding afforded by the transportation casks and the remote operations involved with these handling activities would result in low exposure levels. Furthermore, a significant fraction of the cumulative worker exposure would occur at the VY ISFSI, where the stack-up transfer operations to move the canisters to the transportation casks take place and apply to each route.

- Transfer to HHT then to rail (two lifts):
  - Lift of the HI-STAR 100MB transport cask (loaded with the MPC-68) in its cradle onto the HHT trailer.
  - Lift of HI-STAR 100MB transport cask and cradle from HHT trailer to cask railcar at transload site (Note: a single lift is assumed at the HHT-to-rail transload site).
- Transfer to on-site rail (one or two lifts):
  - Lift of the HI-STAR 100MB overpack (loaded with the MPC-68) in its cradle onto the on-site trailer or directly on to cask railcar.
  - Lift of the HI-STAR 100MB transport cask from on-site trailer to cask railcar

Based on these assessments and the duration of transport on each of the individual routes, the rail only routes are mildly favored over the HHT to rail routes.

5.3.3.14 Cumulative Population Dose Along Route

The cumulative population dose along each route is expected to be negligible (comparable to background) due to the significant amount of shielding afforded by the transport overpacks and their canisters, the age of the SNF, and the minimal duration of exposure during each transport operation. Furthermore, doses to individual members of the public during normal transportation activities are expected to be below background levels. Nevertheless, the relative differences in ratings established for the assessment of this metric are based primarily on the total exposed population established from data provided by START [1] along each route as shown in **Table 5-5**. Those routes with the lowest total exposed populations are favored over the other routes, as they would result in the lowest cumulative dose to the population.

Table 5-5: Route Averaged Population Density Along Each Route

ID	Route Description	Average Population Density (Persons/Square Mile)[1]	Total Exposed Population Estimate[2] (Thousands)
A	Rail-min. travel time	826.56	945
B	Rail-min. distance	780.38	892

ID	Route Description	Average Population Density (Persons/Square Mile)[1]	Total Exposed Population Estimate[2] (Thousands)
C	Rail via Palmer	504.65/847.67	967
D	HHT & Rail from Riverside Transload Center	385.92/508.54/847.67	996
E	HHT & Rail from Green Mnt. Rail Yard	522.74/510.63/847.67	998

[1] Data established by START [1] and established by totaling the population located within an 800-m buffer of either side of the route and dividing by the area of the buffer. Note the values listed in this column are for each segment of the route.

[2] Established by multiplying the cumulative population density by the route distance and the buffer width (800 m).

5.3.3.15 Risks Associated with Number of Lifting Activities

Risks associated with lifting activities are dependent on the number of lifts made of a transportation cask, which have been identified in **Section 5.3.3.13**. Based on this assessment, the rail-only routes were deemed more favorable over the HHT routes due to the transload operation taking place off-site with different equipment and personnel. These risks are minimized by the protection afforded the transportation overpacks by the impact limiters, the design of the lifting equipment (includes multiple safety factors and avoidance of single-failure points), and the robustness of the transportation overpack system (i.e., HI-STAR 100MB). Hence, although this parameter provides some predilection to rail-only routes, the overall risk associated with a lifting device is deemed negligible.

5.3.3.16 Average Accident Frequency on Route

Using data produced from START [1], each route could be evaluated for the annual frequency of the average accident rate (accidents per mile per year) on each route by mode of transport or cumulatively for all of the modes of transport used on a route. Based on these results (see **Table 5-6**), the average cumulative accident frequency for each route was very small, but there are differences in the cumulative frequencies, which provided the information necessary to perform the pairwise comparison. **Table 5-6** provides the average accident rate by mode of transport on the route and the cumulative accident rate for the entire route, which was used to perform this evaluation.

Table 5-6: Average Accident Frequency Over Each Route [1]

Accident Rate (per mi per yr)	Route				
	A. Rail-min. travel time	B. Rail-min. distance	C. Rail via Palmer	D. HHT & Rail from Riverside Transload Center	E. HHT & Rail from Green Mnt. Rail Yard
Accident Likelihood	0.00152	0.00178	0.00138	0.00126	0.00126
Factor Increase Over Lowest Rate	1.204 x	1.414 x	1.091 x	1 x	1.003 x

5.3.3.17 Transit Duration per Conveyance and Consist

The transit duration for each route was roughly estimated during the team meeting and arrived at the following estimates and summarized in **Table 5-7**:

1. Rail-min. travel time:
    a. Loading Cask: load MPC-68 canister into HI-TRAC 100 transfer cask from HI-STORM 100 vertical storage cask (1st stack-up operation), move loaded HI-TRAC 100 transfer cask to over HI-STAR 100MB transport overpack, load MPC-68 canister into HI-STAR 100MB transport overpack from HI-TRAC 100 transfer cask (2nd stack-up operation), and down-end HI-STAR 100MB transport overpack and place into transport cradle (2 days per MPC).
    b. Prepare and load HI-STAR transport overpack in cradle onto HHT trailer and transfer onto cask railcar and secure to railcar (1 day per transport overpack).
    c. Complete Rail Consist (e.g., add buffer cars, locomotives, and escort car) (~1 day).
    d. Thus, approximately 16 days for 5 loaded HI-STAR 100MB transport overpacks to load onto a full consist.
    e. Total Rail Transit Duration from START [1]: 33 hours.
2. Rail-min. distance:
    a. Same as for the first route except Total Rail Transit Duration from START [1]: 35 hours.
3. Rail via Palmer:
    a. Same as for the first route.
4. HHT & Rail from Riverside Transload Center:
    a. Loading Cask: load MPC-68 canister into HI-TRAC 100 transfer cask from HI-STORM 100 vertical storage cask (1st stack-up operation), move loaded HI-TRAC 100 transfer cask to over HI-STAR 100MB transport overpack, load MPC-68

canister into HI-STAR 100MB transport overpack from HI-TRAC 100 transfer cask (2nd stack-up operation), and down-end HI-STAR 100MB transport overpack and place into transport cradle (2 days per MPC).

b. Prepare and load HI-STAR transport overpack in cradle onto HHT trailer, secure and prepare for HHT shipment, and attached truck to HHT (1 day per transport overpack).

c. Transport 34 miles to Bellows Falls, VT using HHT (½ day per transport overpack)

d. Lift from trailer HI-STAR 100MB and transportation cradle and place on cask rai car and secure to railcar (1 to 2 days per transport overpack)

e. Complete Rail Consist (e.g., add buffer cars, locomotives, and escort car) (~1 day).

f. Thus, approximately 23½ to 28½ days for 5 loaded HI-STAR 100MB transport overpacks to load onto a full consist.

g. Total Rail Transit Duration from START [1]: 37 hours.

5. HHT & Rail from Green Mnt. Rail Yard:

   a. Same as previous route.

Table 5-7: Route Transit Durations [1]

Distance (miles)	Route				
	A. Rail-min. travel time	B. Rail-min. distance	C. Rail via Palmer	D. HHT & Rail from Riverside Transload Center	E. HHT & Rail from Green Mnt. Rail Yard
HHT	0	0	0	34	31
Rail	1,147	1,145	1,164	1,195	1,193
Total Duration (hrs)	33	35	33	37	37
Number of Rail Interchanges	3	3	1	2	1

Note: the times provided are based on one, one-way trip and assume travel at posted speed limits, which is not realistic, but expected speeds will still result in HHT transport durations of less than 1 day since the distances are short. The values shown above do not account for the multiple trips that will be required by HHT to and from the site.

Using the data in **Table 5-7** from START [1], the above handling times, and assuming approximately 1 day to perform a rail interchange, the pairwise comparisons were performed between the various routes.

5.3.3.18 Size of Conveyance

Since the HHT can only move one cask per shipment and the rail-only routes are likely loaded directly on the site, the size of the initial conveyance will be strongly in favor of the rail-only routes.

5.4 Route Recommendations

Using the metric information identified for the routes listed in the previous section, the Orano-led team held a conference call to perform a pairwise comparison of each of the tangible metrics for each of the routes identified in **Section 5.2** (Step 7). This team evaluation, unlike the individual assessments performed for the tangible metrics, ensured SMEs' rankings and knowledge could appropriately influence the results for the SMEs' metrics used to compare the routes, while at the same time allowing those knowledgeable of the routes to provide beneficial inputs and all team members the opportunity to provide feedback to the discussion related to the evaluation of the route. **Table 5-8** provides an example of the pairwise comparison performed by the de-inventory team for the metric related to the Transit Duration per Conveyance (as denoted on the far-left column). "Column A Routes" (2nd column on left) are subsequently compared against "Column B Routes" (last column on right) for the Transit Duration per Conveyance metric. The favorability scale listed in this figure is the same as identified for the pairwise comparison of the tangible metrics (see **Table 5-2**). As an example, the fourth row of the evaluation (excluding the header row) shows that the "A. Rail-min. travel time" route is more unfavorable when compared to the "E. HHT & Rail from Green Mnt. Rail Yard" to GCUS route for the metric related to the Transit Duration per Conveyance, which is reflective of the information provided in **Section 5.3.3.17**.

With 18 tangible metrics and 5 routes to be evaluated, the team performed 180 pairwise evaluations. **Attachment C** shows the entire pairwise evaluation for these metrics.

Using the same weighting scheme as described in **Section 5.3.2** and the relative weighting of the tangible metrics identified in **Table 5-3**, **Figure 5-3** shows the resulting relative weighting of the routes in order of the highest rated (C. Rail via Palmer) to the least rated (E. HHT & Rail from Green Mnt. Rail Yard). **Table 5-10** shows the numerical values associated with each of the routes for multiple different weighting schemes:

1) The "Unweighted" results, which are based on each metric having an equal weight.
2) The "Average Weight" results, which are based on the metric weights associated with the "Average Weights" from **Table 5-3**.
3) The "Biased Weight" results, which are based on the metric weights associated with the "Biased Weights" from **Table 5-3**.
4) The "No Safety Metric" results, which are based on zeroing out the weights associated with the safety metrics and re-normalizing the "Average Weights" from **Table 5-3**.
5) The "No Public Acceptability Metric" results, which are based on zeroing out the weight for the Public Acceptability of Route metric and re-normalizing the "Average Weights" from **Table 5-3**.

6) The “No Safety or Public Acceptability Metric” results, which are based on zeroing out the weights for the safety and public acceptability metrics and re-normalizing the “Average Weights” from **Table 5-3**.

Table 5-8: Example of a Portion of a Pairwise Comparison for Routes Assessment

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Transit Duration per Conveyance	A. Rail-min. travel time			x					B. Rail-min. distance
	A. Rail-min. travel time						x		C. Rail via Palmer
	A. Rail-min. travel time					x			D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time						x		E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance						x		C. Rail via Palmer
	B. Rail-min. distance					x			D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance						x		E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center					x			E. HHT & Rail from Green Mnt Rail Yard

As shown in **Figure 5-3** and **Table 5-10**, the routes with the highest ratings (based on average weighting method) are: Rail via Palmer, Rail-min. distance, and Rail-min. travel time. The route with the least favored rating (based on average weighting method) is the HHT & rail from Green Mnt. Rail Yard. The top three routes are clearly favored over the last two routes, indicating some definitive predilection towards these three routes with direct loading of rail on the VY ISFSI site.

Figure 5-3: Resulting List of Prioritized Routes from the VY ISFSI Site

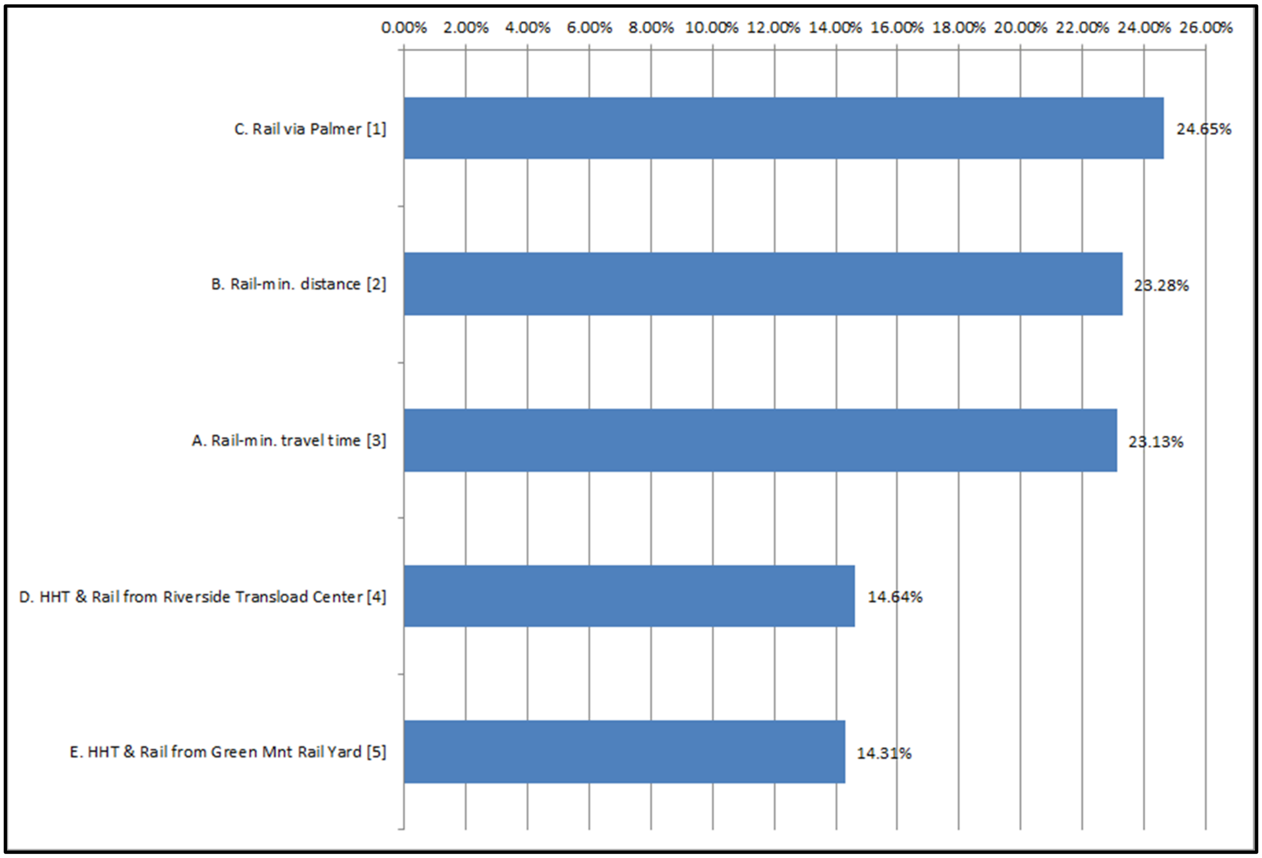


Figure 5-4 shows the impact each tangible metric had on the overall scoring of each route. There is no single dominant metric identified in this figure. However, this figure does show the three most favored routes (direct rail from the site) received significantly greater contributions from the following tangible metrics: risks associated with number of lifting activities, cumulative population dose along route, and public acceptability of routes. Whereas the HHT routes received significant contributions from the following tangible metrics: average accident frequency on route and cumulative worker exposure.

Since the safety metric will be established by regulation to be acceptable, the metrics related to safety may not be needed to distinguish routes from one another; hence, an alternative weighting scheme was examined to establish the impact of using no safety metrics. As shown in **Table 5-10**, the highest-scored route did not change position when the safety metrics are removed from the evaluation with and without removal of the public acceptability metric. Similarly, the removal of only the public acceptability metric results in no change to the top ranked of the route. Additional analyses and sensitivity results were performed on these metrics to examine their impact on the rankings in **Section 5.5**.

Table 5-10 shows the sensitivity of the rankings, in general, to the alternative weighting schemes. To further examine the impact to the ranking/scores of the routes to changes in the weighting of the metrics, a sensitivity analysis was performed using the range of the metrics identified in **Table 5-3** (Step 8).

Table 5-11, **Table 5-12**, **Table 5-13**, and **Table 5-14** present the results of the sensitivity of the route rankings to the minimization of the weighting of a metric, using the minimum metric weights from **Table 5-3**. For example, under the metric column labeled "Average Accident Frequency on Route" in **Table 5-14**, results are presented using a weight of 3.87% for the "Average Accident Frequency on Route" (instead of the 6.18% in **Table 5-3**) with the other metrics proportionally re-normalized. The results indicate no change occurs to the overall ranking. **Figure 5-5** summarizes the minimum, average, and maximum results presented in **Table 5-11**, **Table 5-12**, **Table 5-13**, and **Table 5-14** for the minimization of individual metrics. As can be seen from these results, the Rail via Palmer route from VY to GCUS remains robustly ranked as the most favored route for the removal of the SNF from the VY ISFSI (at this time).

Table 5-15, **Table 5-16**, **Table 5-17**, and **Table 5-18** present the results of the sensitivity of the route rankings to the maximization of the weighting of a metric, using the maximum metric weights from **Table 5-3**. For example, under the metric column labeled "Public Acceptability of Route" in **Table 5-16**, results are presented using a weight of 8.17% for the "Public Acceptability of Route" (instead of the 6.44%), with the other metrics proportionally re-normalized. The results indicate that there is no change in the ranking of the routes. **Figure 5-6** summarizes the minimum, average, and maximum results presented in **Table 5-15**, **Table 5-16**, **Table 5-17**, and **Table 5-18** for the maximization of individual metrics. As can be seen from these results, the top ranked routes remain robustly ranked as the most favored routes for the removal of the SNF and GTCC LLW from the VY ISFSI.

A final assessment of the results was performed by taking the results for each individual from the pairwise comparison on the metrics and using them to establish a route ranking per individual. These results also established, for each individual, the same results in the ranking as seen in the above results (i.e., the rail routes with direct shipment from the VY ISFSI as the favored routes) for the removal of the SNF and GTCC LLW from the VY ISFSI, with the Rail via Palmer route ranking the highest in all the evaluations. The other two rail-only routes ranked 2 or 3 in these results and the HHT to rail routes ranked 4 or 5 in these results.

As a result of the MUA and its sensitivity analyses, the prioritized list of routes from the VY ISFSI is found in **Table 5-9**.

Table 5-9: Prioritized list of routes from VY ISFSI

Rank	Prioritized Route
1	C. Rail via Palmer
2	B. Rail-min. distance
3	A. Rail-min. travel time
4	D. HHT & Rail from Riverside Transload Center
5	E. HHT & Rail from Green Mnt. Rail Yard

Figure 5-4: Impact of Each Tangible Metric on Each Route's "Score"

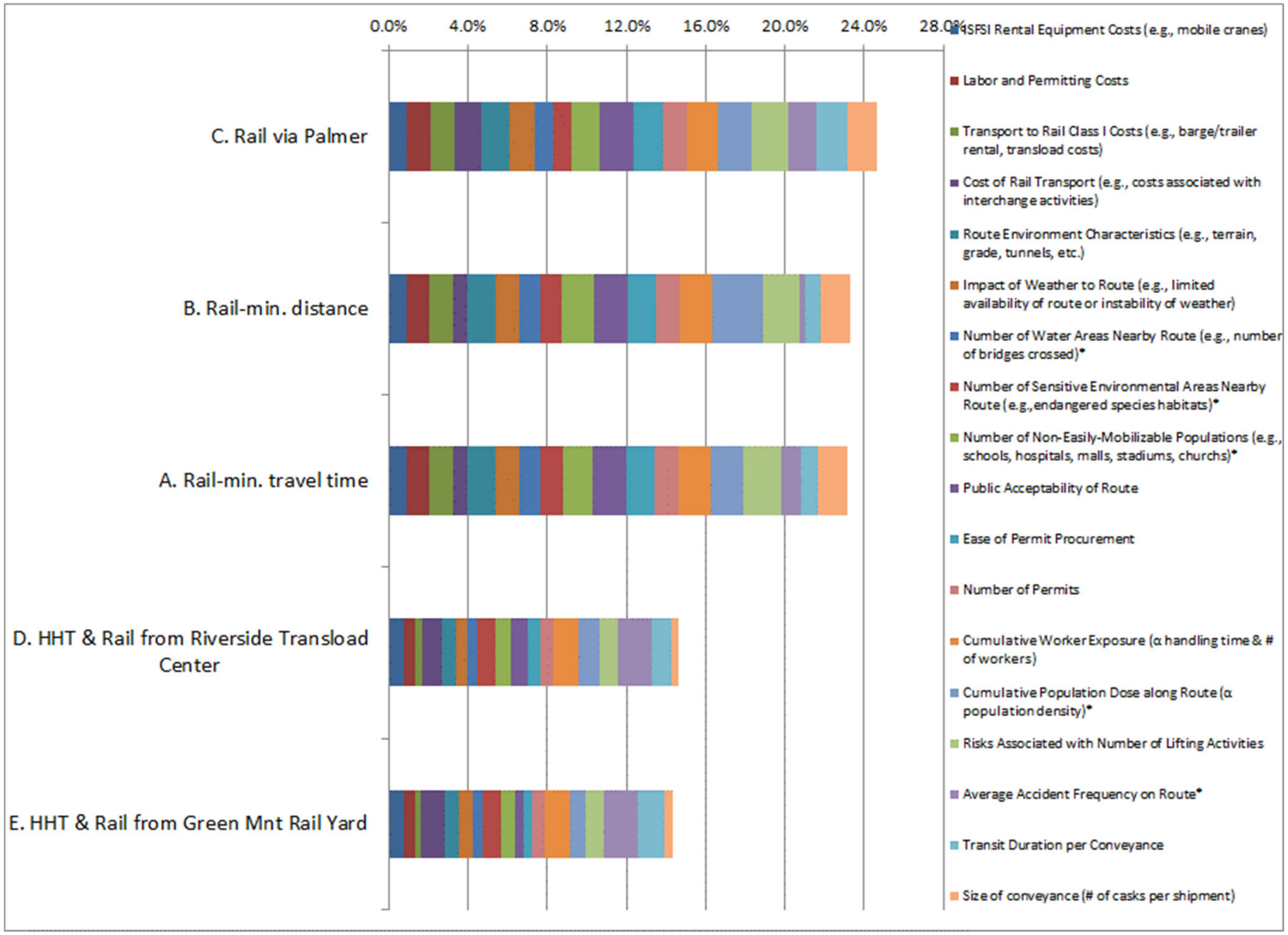


Table 5-10: Weighting of Routes

Nominal Results:	Unweighted		Average Weight		Biased Weight		No Safety Metric		No Public Acceptability Metric		No Safety or Public Acceptability Metric	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	2	23.24%	3	23.13%	3	23.13%	3	23.09%	3	22.88%	3	22.80%
B. Rail-min. distance	3	23.19%	2	23.28%	2	23.28%	2	23.27%	2	23.04%	2	22.99%
C. Rail via Palmer	1	24.77%	1	24.65%	1	24.65%	1	24.88%	1	24.51%	1	24.74%
D. HHT & Rail from Riverside Transload Center	4	14.49%	4	14.64%	4	14.64%	4	14.58%	5	14.73%	5	14.68%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.31%	5	14.31%	5	14.31%	5	14.18%	4	14.83%	4	14.80%

Table 5-11: Weighting of Routes at Minimum Metric Value (Part 1 of 4)

Metric Minimized:	On-Site Rental Equipment Costs		Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Route Environment Characteristics	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.15%	3	23.12%	3	23.07%	3	23.27%	3	23.11%
B. Rail-min. distance	2	23.30%	2	23.27%	2	23.22%	2	23.43%	2	23.26%
C. Rail via Palmer	1	24.70%	1	24.63%	1	24.61%	1	24.62%	1	24.65%
D. HHT & Rail from Riverside Transload Center	4	14.60%	4	14.66%	4	14.71%	4	14.55%	4	14.66%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.26%	5	14.32%	5	14.39%	5	14.13%	5	14.32%

Table 5-12: Weighting of Routes at Minimum Metric Value (Part 2 of 4)

Metric Minimized:	Impact of Weather to Route		Number of Water Areas Nearby Route		Number of Sensitive Environmental Areas Nearby Route		Number of Non-Easily Mobilized Populations		Public Acceptability of Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.07%	3	23.08%	3	23.12%	3	23.11%	3	23.04%
B. Rail-min. distance	2	23.23%	2	23.24%	2	23.31%	2	23.23%	2	23.20%
C. Rail via Palmer	1	24.64%	1	24.67%	1	24.77%	1	24.66%	1	24.60%
D. HHT & Rail from Riverside Transload Center	4	14.73%	4	14.68%	4	14.57%	4	14.67%	4	14.67%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.33%	5	14.33%	5	14.23%	5	14.33%	5	14.49%

Table 5-13: Weighting of Routes at Minimum Metric Value (Part 3 of 4)

Metric Minimized:	Ease of Permit Procurement		Number of Permits		Cumulative Worker Exposure		Cumulative Population Dose along Route		Risk Associated with Number of Lifting Activities	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.06%	3	23.11%	3	23.15%	2	23.16%	3	23.04%
B. Rail-min. distance	2	23.22%	2	23.26%	2	23.31%	3	23.05%	2	23.20%
C. Rail via Palmer	1	24.62%	1	24.65%	1	24.71%	1	24.72%	1	24.63%
D. HHT & Rail from Riverside Transload Center	4	14.68%	4	14.66%	4	14.59%	4	14.67%	4	14.74%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.42%	5	14.32%	5	14.24%	5	14.40%	5	14.39%

Table 5-14: Weighting of Routes at Minimum Metric Value (Part 4 of 4)

Metric Minimized:	Average Accident Frequency on Route		Time Duration per Conveyance		Size of Conveyance	
Route	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.28%	3	23.23%	3	23.03%
B. Rail-min. distance	2	23.71%	2	23.41%	2	23.19%
C. Rail via Palmer	1	24.68%	1	24.60%	1	24.59%
D. HHT & Rail from Riverside Transload Center	4	14.34%	4	14.59%	4	14.77%
E. HHT & Rail from Green Mnt. Rail Yard	5	13.99%	5	14.16%	5	14.42%

Table 5-15: Weighting of Routes at Maximized Metric Value (Part 1 of 4)

Metric Maximized:	On-Site Rental Equipment Costs		Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Route Environment Characteristics	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.12%	3	23.15%	3	23.20%	3	23.00%	3	23.17%
B. Rail-min. distance	2	23.27%	2	23.30%	2	23.35%	2	23.15%	2	23.32%
C. Rail via Palmer	1	24.63%	1	24.71%	1	24.70%	1	24.68%	1	24.66%
D. HHT & Rail from Riverside Transload Center	4	14.66%	4	14.58%	4	14.55%	4	14.71%	4	14.59%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.32%	5	14.26%	5	14.20%	5	14.45%	5	14.26%

Table 5-16: Weighting of Routes at Maximized Metric Value (Part 2 of 4)

Metric Maximized:	Impact of Weather to Route		Number of Water Areas Nearby Route		Number of Sensitive Environmental Areas Nearby Route		Number of Non-Easily Mobilized Populations		Public Acceptability of Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.16%	3	23.16%	3	23.13%	3	23.15%	3	23.20%
B. Rail-min. distance	2	23.31%	2	23.31%	2	23.22%	2	23.37%	2	23.35%
C. Rail via Palmer	1	24.66%	1	24.63%	1	24.42%	1	24.64%	1	24.69%
D. HHT & Rail from Riverside Transload Center	4	14.59%	4	14.61%	4	14.78%	4	14.58%	4	14.61%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.29%	5	14.28%	5	14.45%	5	14.26%	5	14.14%

Table 5-17: Weighting of Routes at Maximized Metric Value (Part 3 of 4)

Metric Maximized:	Ease of Permit Procurement		Number of Permits		Cumulative Worker Exposure		Cumulative Population Dose along Route		Risk Associated with Number of Lifting Activities	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	3	23.22%	3	23.14%	3	23.09%	3	23.10%	3	23.17%
B. Rail-min. distance	2	23.37%	2	23.30%	2	23.24%	2	23.47%	2	23.32%
C. Rail via Palmer	1	24.71%	1	24.65%	1	24.57%	1	24.59%	1	24.66%
D. HHT & Rail from Riverside Transload Center	4	14.58%	4	14.62%	4	14.72%	4	14.62%	4	14.59%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.12%	5	14.29%	5	14.39%	5	14.22%	5	14.26%

Table 5-18: Weighting of Routes at Maximum Metric Value (Part 4 of 4)

Metric Maximized:	Average Accident Frequency on Route		Time Duration per Conveyance		Size of Conveyance	
Route	Rank	Result	Rank	Result	Rank	Result
A. Rail-min. travel time	2	22.95%	3	22.78%	3	23.34%
B. Rail-min. distance	3	22.78%	2	22.85%	2	23.49%
C. Rail via Palmer	1	24.61%	1	24.81%	1	24.80%
D. HHT & Rail from Riverside Transload Center	4	14.99%	4	14.80%	4	14.34%
E. HHT & Rail from Green Mnt. Rail Yard	5	14.67%	5	14.77%	5	14.02%

Figure 5-5: Minimum, Average, and Maximum Results from Sensitivity Analysis for Minimization of Each Metric

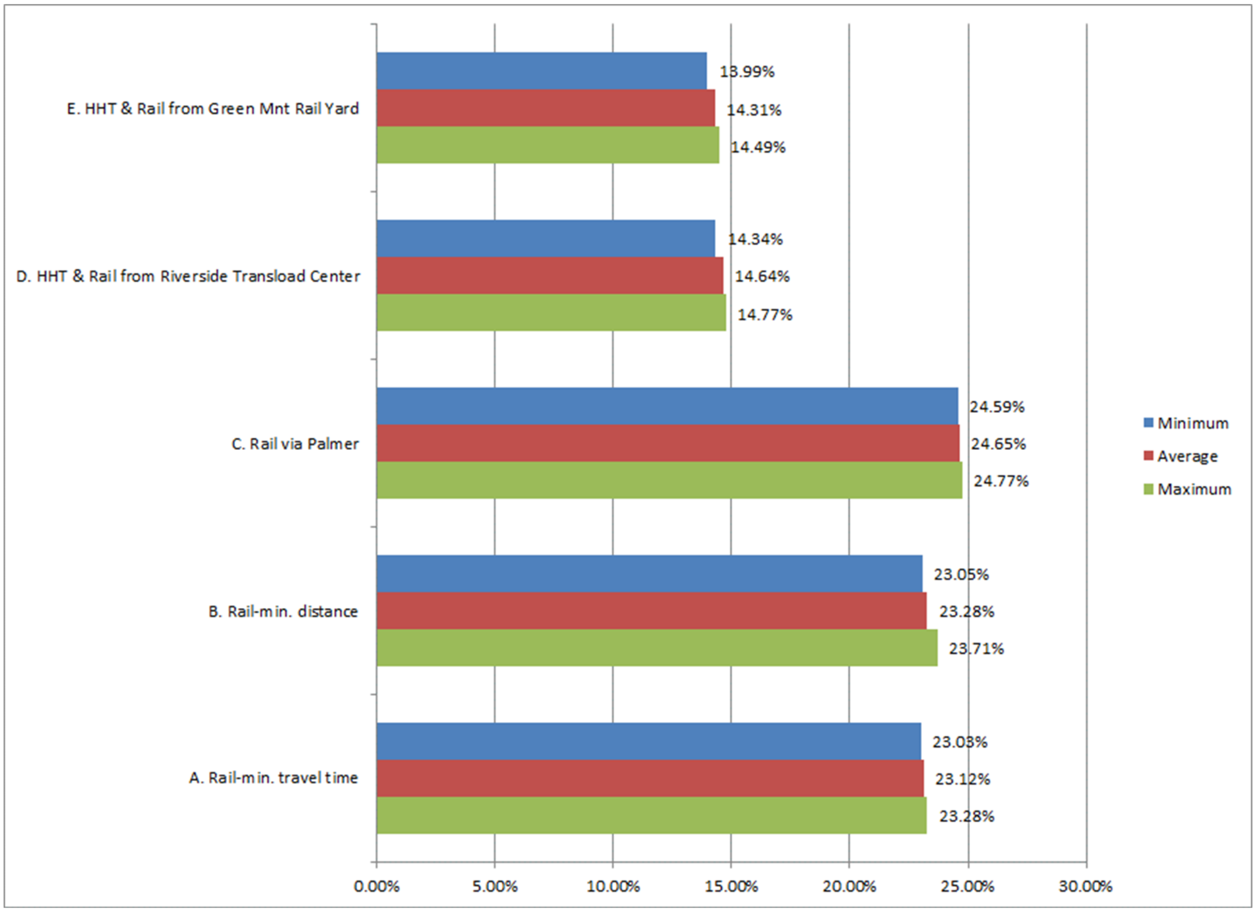
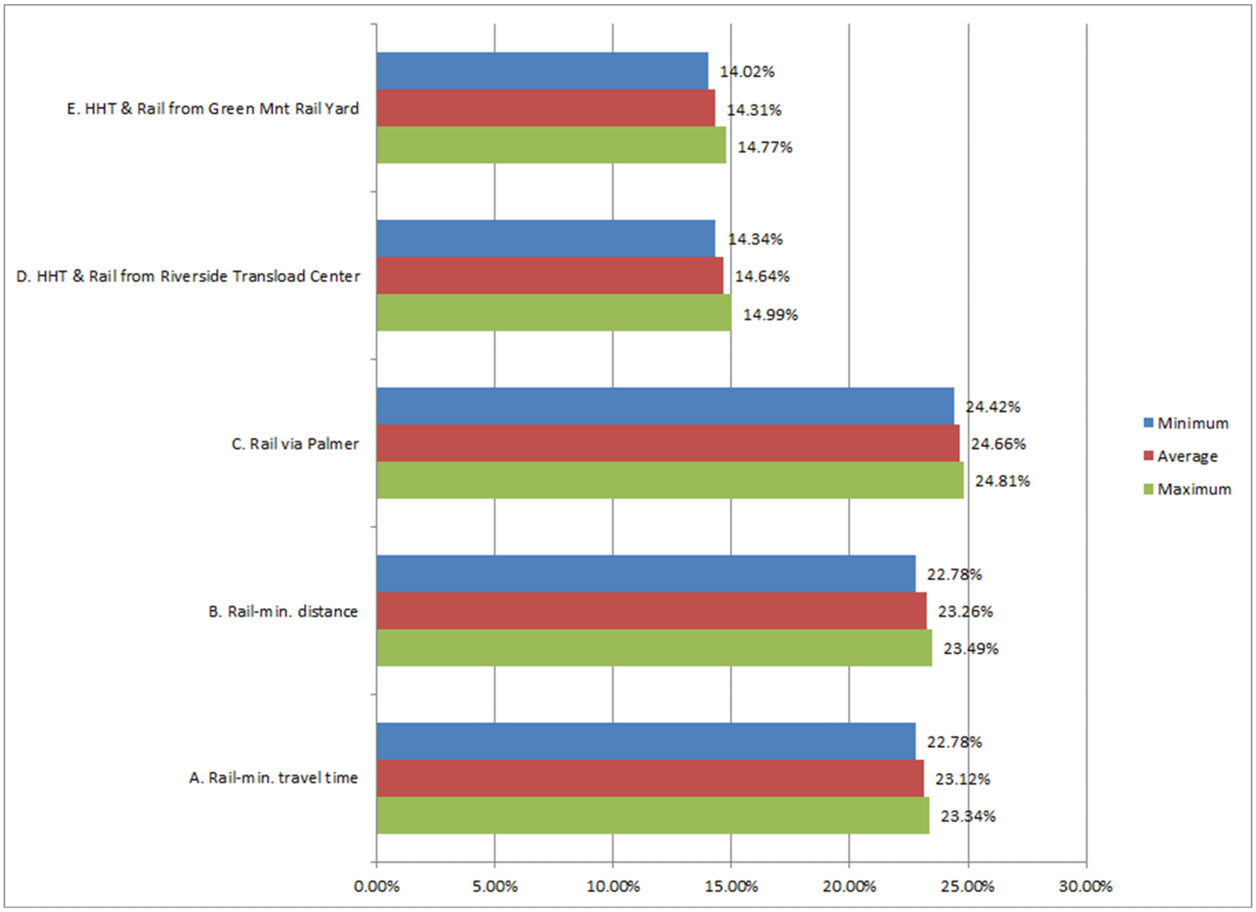


Figure 5-6: Minimum, Average, and Maximum Results from Sensitivity Analysis for Maximization of Each Metric



5.5 Additional Sensitivity Analyses

Additional sensitivity analyses have been performed to examine in more detail the impact of the results of some of the sensitivity analyses performed in **Table 5-10**. The purpose of the MUA is to use objective input, backed by numerical data generated from START [1] and evidence from other sources of information (e.g., pictures), to provide a quantitative ranking of the favorability of route scenarios. Sometimes, however, the subjective opinions of team members can span a larger range then may be necessary to distinguish between routes and may over emphasize the difference between routes. For example, as noted in **Section 5.3.3.14** the dose along the route to individuals is expected to be below background levels (i.e., essentially negligible), but nevertheless cumulative population doses along the routes were still ranked from being neutral to more favorable against one another, when in fact they should have at most spanned from neutral to mildly favorable over one another. Additional sensitivity analyses were performed which examined the impact of suppressing the range of assessments for metrics whose material results are acceptable (e.g., through regulatory requirements). Additionally, more detailed analyses of the sensitivity results presented in **Table 5-10** are provided in this section for additional assessment and one final assessment to remove potential redundancy in some of the metrics is examined.

5.5.1 Suppression of Evaluation Span for Select Metrics

As noted in **Section 5.3.3**, there are several metrics used in the MUA that realistically only vary slightly between each route, as the results will always be acceptable for regulatory reasons. The purpose of this sensitivity analyses is to examine the impact to the route rankings as a result of limiting the span select metrics can be evaluated over. These select metrics include:

- Cumulative Worker Exposure
- Cumulative Population Dose along Route
- Risks Associated with Number of Lifting Activities
- Average Accident Frequency on Route

These specific safety metrics were selected for evaluation of span suppression as a result of each of them being regulated (e.g., by the NRC) to an acceptable level. Regardless of the route selected, these identified metrics should only vary marginally, so suppressing the span of the pairwise comparison by route from between mildly favorable to mildly unfavorable, as shown in **Figure 5-7**, was examined. Since these four metrics were ranked, by average, within the top five metrics from the pairwise comparison by individual team members, the suppression of the span of the pairwise comparison likely will impact the route rankings.

Figure 5-7: Example of Suppression Span for Cumulative Population Dose Range

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Population Dose along Route (α population density)*	A. Rail-min. travel time						x		B. Rail-min. distance
	A. Rail-min. travel time			x					C. Rail via Palmer
	A. Rail-min. travel time			x					D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance		x						C. Rail via Palmer
	B. Rail-min. distance	x							D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center			x					E. HHT & Rail from Green Mnt Rail Yard

(before suppression)

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Population Dose along Route (α population density)*	A. Rail-min. travel time					x			B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time				x				D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time			x					E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance			x					C. Rail via Palmer
	B. Rail-min. distance			x					D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance			x					E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer			x					D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard

(after suppression)

In **Figure 5-7**, assessments originally identified as "Strongly Favorable" or "More Favorable" were suppressed to "Mildly Favorable" and those originally identified as "Mildly Favorable" were moved to "Neither Favorable (neutral)" to examine the impact of suppressing the span of the pairwise comparison by route for metrics whose parameters are regulated to acceptable levels.

Figure 5-8 and **Table 5-19** shows the modified rankings when the above safety metrics evaluation ranges are all suppressed. **Figure 5-9** shows the contribution each tangible metric makes to the scoring for each route.

Table 5-19 compares the results from the original assessment and the modified results using the suppressed span. These results show none of the routes change position, but the separation between the results has slightly tightened up. Hence the rail routes from the VY site remain the highest ranked routes, which is consistent with the results identified by the other sensitivity analyses included in this report.

Figure 5-8: Resulting List of Prioritized Routes from the VY ISFSI for the Suppression of Span for Safety Metrics

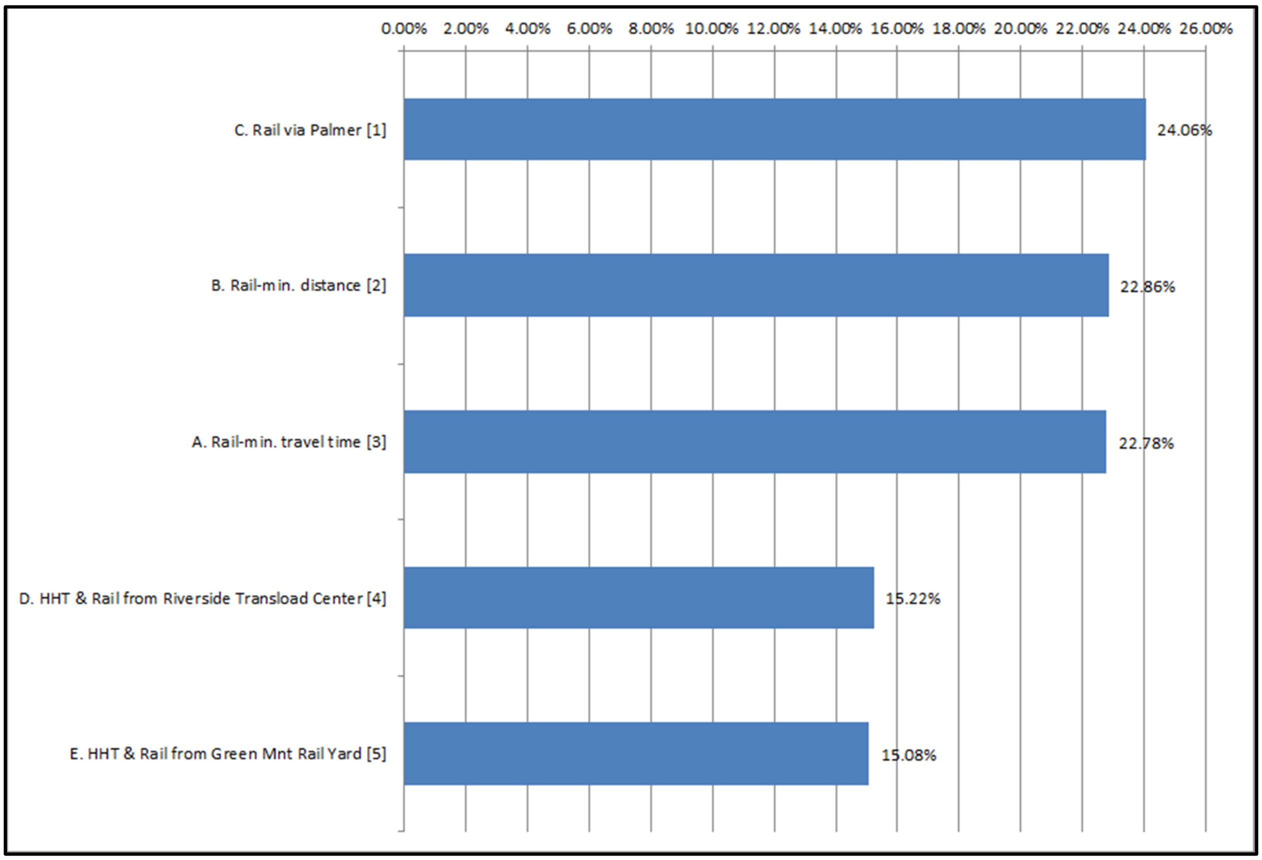


Figure 5-9: Impact of Each Tangible Metric on each Route's Scoring for the Suppression of Span for Safety Metrics

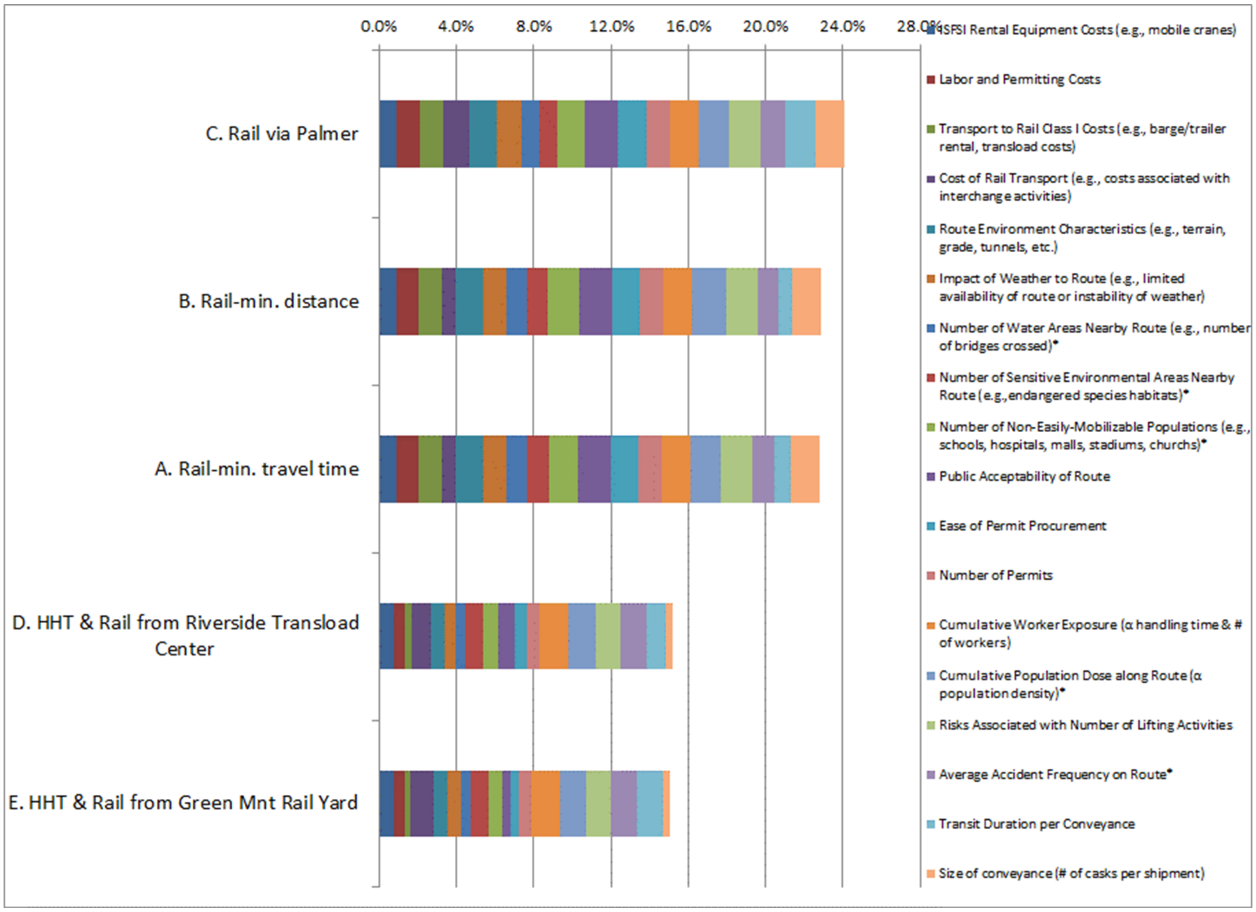


Table 5-19: Comparison of Original MUA Results to the Suppressed Span MUA Results

Suppression Results		Routes	Original Results	
Rank	Avg		Rank	Avg
3	22.78%	A. Rail-min. travel time	3	23.13%
2	22.86%	B. Rail-min. distance	2	23.28%
1	24.06%	C. Rail via Palmer	1	24.65%
4	15.22%	D. HHT & Rail from Riverside Transload Center	4	14.64%
5	15.08%	E. HHT & Rail from Green Mnt. Rail Yard	5	14.31%

5.5.2 Details of Select Sensitivity Results

Additional details of some select sensitivity results shown in **Section 5.4** are presented in this section to allow for additional assessment of the results. The specific sensitivity analyses for which additional details are provided include the impact of the removal of:

- The safety metrics including:
  - The cumulative worker exposure metric
  - The cumulative population dose along route metric
  - The risks associated with the number of lifting activities metric
  - The average accident frequency on route metric
- The public acceptability metric
- The public acceptability and safety metrics at the same time

Results shown in **Figure 5-10** and **Table 5-20** for the removal of the safety metrics show the rankings remain nearly the same (only the 2nd and 3rd routes exchanged rankings) as were established from the average weights with the rail-only routes from VY to GCUS remaining the top ranked routes. Results shown in **Figure 5-11** and **Table 5-21** for the removal of the public acceptability metric also show only minor changes from the original rankings, with the 2nd and 3rd ranked rail-only routes switching rankings and the two HHT to rail routes switching rankings. The final sensitivity analysis performed involved removing both the public acceptability and safety metrics at the same time. **Figure 5-12** and **Table 5-22** show the results of this assessment again with the same changes from the original rankings as seen for the no public acceptability metric.

Overall, the rail routes from VY to GCUS are consistently the highest-ranked routes for transloading the transportation casks, with the Rail via Palmer route finishing ranked at the top under every sensitivity assessment. However, this site does require additional assessment prior to final selection and some of the specific issues requiring resolution include but are not limited to the rail line at the on-site transload site remaining viable for use until the time they are actually required to be used and the rail routes meeting the required clearances.

Figure 5-10: Impact of Removing the Safety Metrics

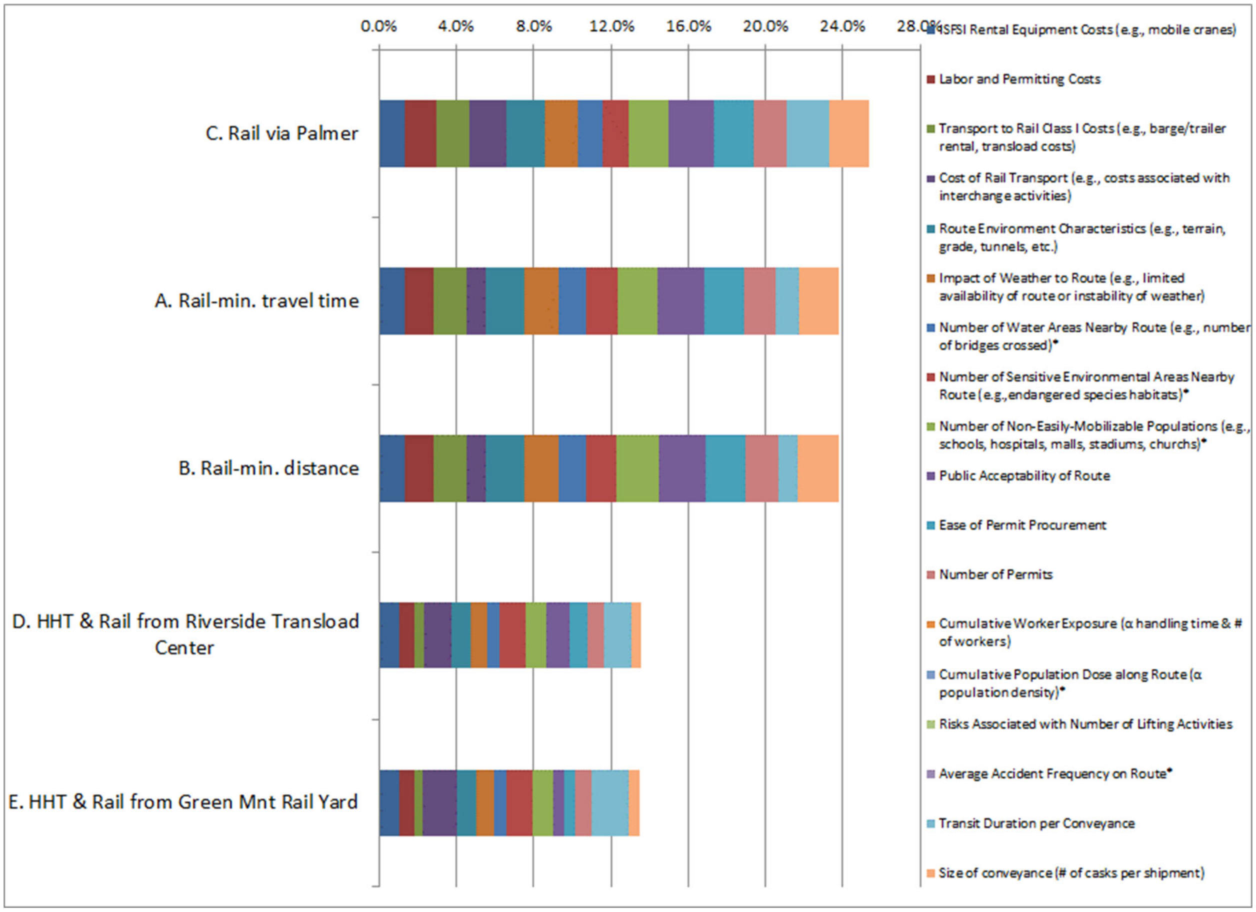


Table 5-20: Results from the Deletion of the Safety Metrics

No Safety Metrics Results			Original Results	
Rank	Avg	Routes	Rank	Avg
2	23.80%	A. Rail-min. travel time	3	23.13%
3	23.77%	B. Rail-min. distance	2	23.28%
1	25.36%	C. Rail via Palmer	1	24.65%
4	13.59%	D. HHT & Rail from Riverside Transload Center	4	14.64%
5	13.48%	E. HHT & Rail from Green Mnt. Rail Yard	5	14.31%

Figure 5-11: Impact of Removing the Public Acceptability Metric

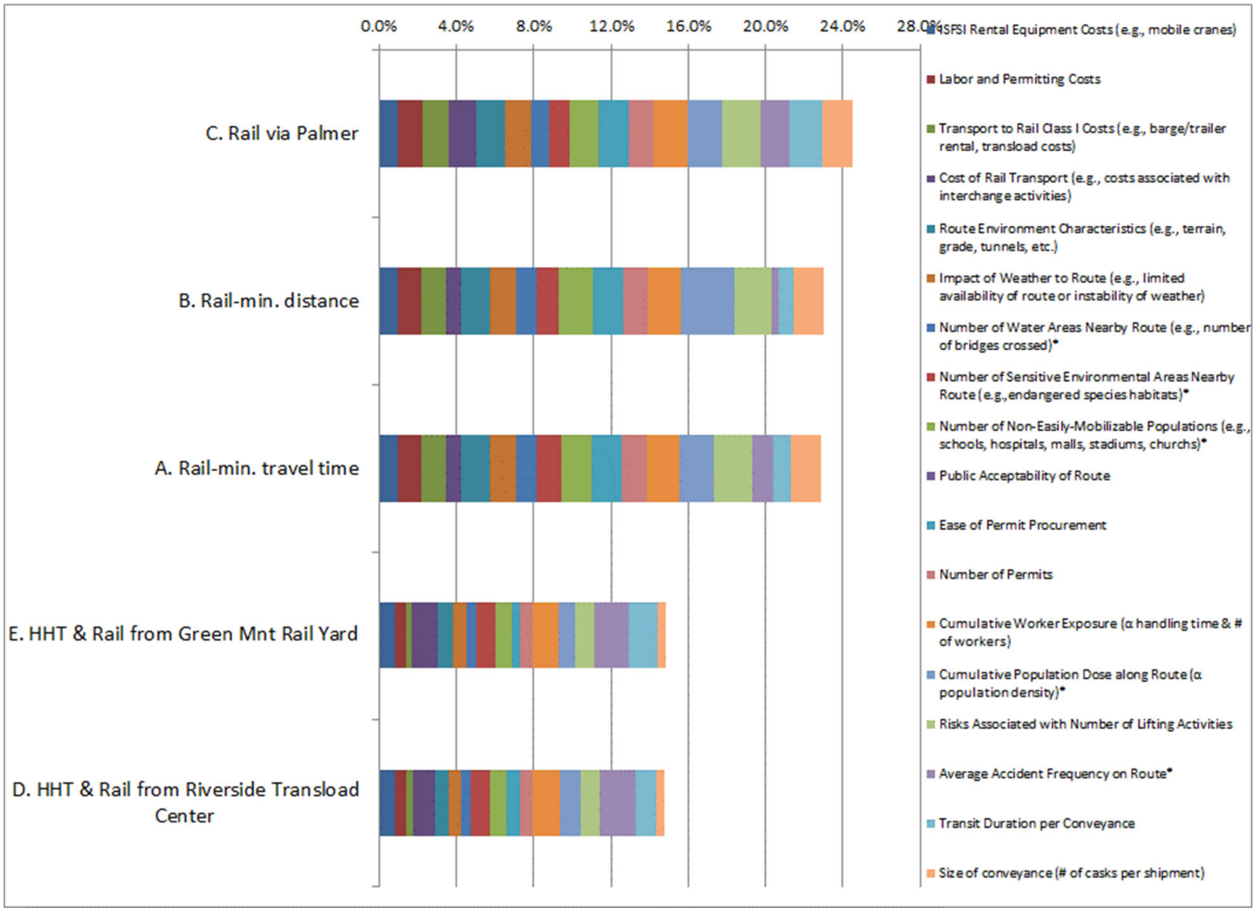


Table 5-21: Results from the Deletion of the Public Acceptability Metric

No Public Acceptability Metric Results			Original Results	
Rank	Avg	Routes	Rank	Avg
3	22.88%	A. Rail-min. travel time	3	23.13%
2	23.04%	B. Rail-min. distance	2	23.28%
1	24.51%	C. Rail via Palmer	1	24.65%
5	14.73%	D. HHT & Rail from Riverside Transload Center	4	14.64%
4	14.83%	E. HHT & Rail from Green Mnt. Rail Yard	5	14.31%

Figure 5-12: Impact of Removing the Public Acceptability and Safety Metrics

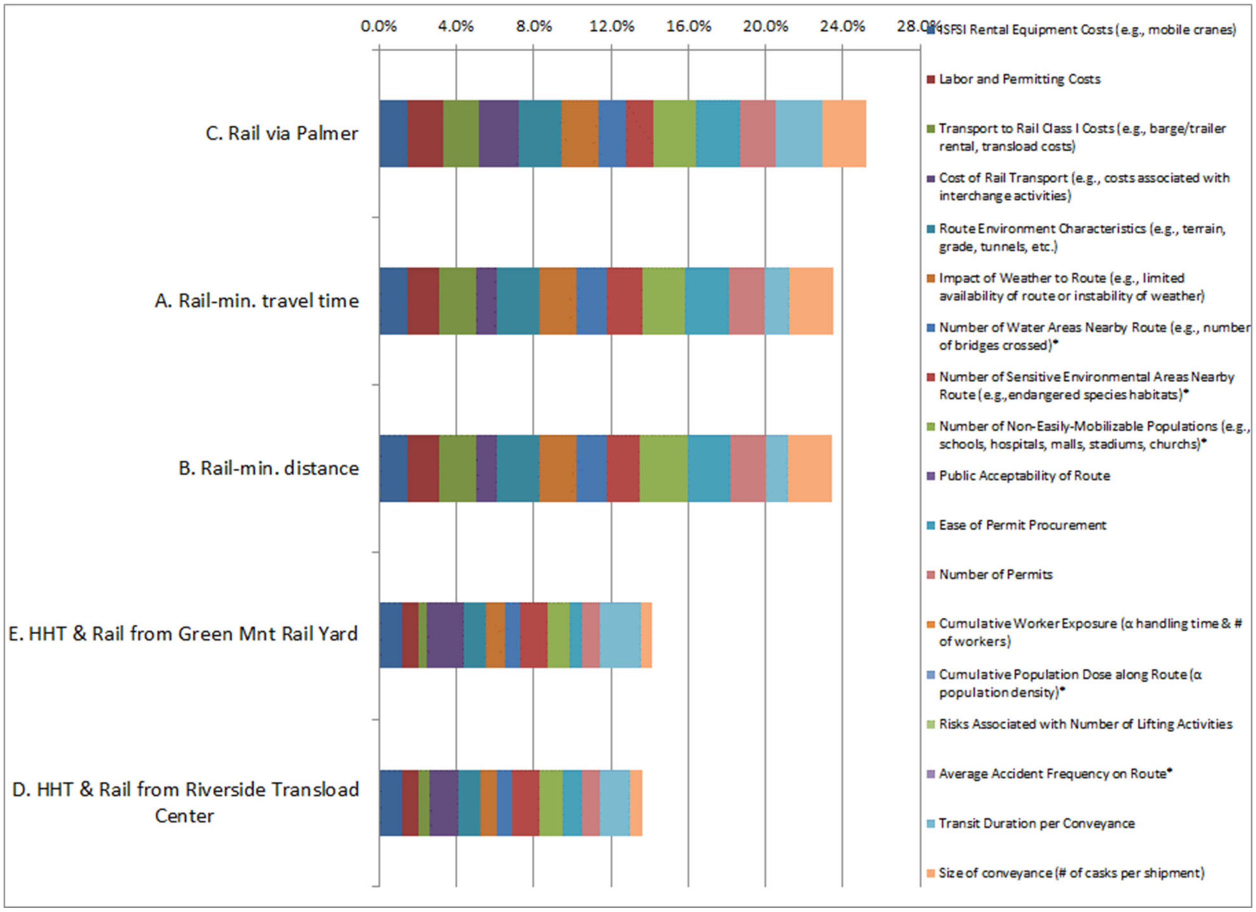


Table 5-22: Results from the Deletion of the Public Acceptability and Safety Metrics

No Public Acceptability and No Safety Metric Results		Routes	Original Results	
Rank	Avg		Rank	Avg
2	23.52%	A. Rail-min. travel time	3	23.13%
3	23.48%	B. Rail-min. distance	2	23.28%
1	25.24%	C. Rail via Palmer	1	24.65%
5	13.61%	D. HHT & Rail from Riverside Transload Center	4	14.64%
4	14.16%	E. HHT & Rail from Green Mnt. Rail Yard	5	14.31%

6.0 CONCEPT OF OPERATIONS FOR RECOMMENDED APPROACH

6.1 Overview of Operations and Assumptions

The operations associated with the de-inventory of VY SNF and GTCC LLW stored in on-site HI-STORM 100S systems will require leasing or purchasing transportation casks, on-site transfer equipment, auxiliary equipment, ancillary systems including mobile crane(s) and lifting equipment, development/confirmation of training program materials, training of operating personnel and supervisors, preparation and approval of site operating procedures, facility operational readiness review, dry run operations, de-inventory activities, and transportation operations, and demobilization of equipment from the site. Due to the complexity of these operations, the sequence of activities is divided into five groups:

1) Mobilization operations: procurement/lease and delivery of required equipment to the site;
2) Operational readiness: operating procedure preparation and approval, training program development, operator training, equipment checkouts, dry run(s), and operational readiness review(s);
3) ISFSI Site operations: performance of canister transfer operations from the storage casks to the transport casks respectively, for offsite transportation;
4) Rail transport operations; and
5) Demobilization of equipment and personnel from the VY site.

Based on the number of canisters to be loaded and shipped from the VY ISFSI (i.e., 58 MPCs with SNF and 1 GTCC LLW canister), it is recommended to load and ship five transport casks for each offsite transport campaign by rail transport with a total of five transport cask systems each committed to the de-inventory shipping campaign. Shipment of the empty casks from GCUS will be transported on a dedicated train.

The following assumptions were used in planning this canister transfer, loading, and off-site shipment campaign:

1) Five HI-STAR 100MB casks, including impact limiters, and intermodal transport cradle with integral tie-downs and personnel barrier are all available;
2) A complete set of acceptable transfer system equipment will be present and ready for use when the de-inventory operations commence;
3) The maintenance activities required to be performed in Chapter 8 of the SAR will be completed and up-to date (see **Table 6-1**);
4) Canister and contents have been evaluated and are compliant with the cask SAR;
5) Fuel/canister is assumed transportable for these activities (e.g., 10 CFR Part 71 dose and thermal limits are met);
6) Transfer operations on-site will include both the ISFSI and transloading site and will be part of the 10 CFR Part 50 assessment or Final Safety Analysis Report (FSAR) under 10 CFR Part 72;

7) The HI-STORM 100S and the HI-STAR 100MB overpack lids can be removed using a crane prior to the containers being positioned in the transfer station;
8) Movement of the HI-STORM 100S between the ISFSI and the transfer station will be performed in a vertical orientation using the air pallet and pusher vehicle;
9) Movement of the loaded HI-STAR 100MB between the down-ending area and the railcar loading area will be performed in a ready for transport configuration (secured to the transportation cradle with impact limiters installed) using a Goldhofer.
10) A HI-STAR 100MB overpack transportation cradle, two impact limiters, and one set of impact limiter metal stands will be fabricated with a base plate and vertical support to store and secure the impact limiters and overpack during the loading operations and transportation of the overpacks;
11) The loaded HI-STAR 100MB overpack, with impact limiters in place, will be secured to the transportation cradle during all phases of lifting and transfer operations of the overpack to the railcar; and
12) Dry runs of the site operations, transport operations, and the transloading operations would be conducted to ensure equipment and procedures are adequate to perform the task in a safe and efficient manner.

Table 6-1: Maintenance Program Schedule

Maintenance Program Schedule HI-STAR 100MB	
Task/Activity	**Frequency**
Visual inspection of cavity	Prior to loading
Visual inspection of O-rings	Prior to loading
Visual inspection of neutron shield shell segments for structural or penetration damage	Prior to loading
Visual inspection of neutron shield pressure relief devices	Prior to loading
Visual inspection of cask lid bolts and lid port coverplate bolts	Prior to installation (each use)
Visual and Proper Function Inspection of Cask	Prior to and during each use
Visual inspection of lifting trunnions and rotation trunnions	Prior to and during each use
Periodic leakage rate test of cask lid and lid port coverplate containment O-rings	Annually during use
Periodic leakage test of the MPC containment boundary for those MPCs loaded with HBU SNF.	Annually during use
Pre-shipment leakage rate test of cask lid and lid port coverplate containment O-rings	Prior to each loaded transport

Maintenance Program Schedule HI-STAR 100MB	
Task/Activity	**Frequency**
Pre-shipment leakage test of the MPC containment boundary for those MPCs loaded with HBU SNF.	Prior to each loaded transport
Maintenance leakage rate test of containment system	After replacement or repair of containment boundary components
Replacement of lid and lid port coverplate metallic O-rings	Prior to each loaded transport
Visual inspection of impact limiters for structural or penetration damage	Prior to each loaded transport
Impact Limiters Leak Test	Once every five years
Thermal Test	Once every five years
Bolt replacements	Based on number of torque cycles
MPC pressure boundary inspection for those MPCs loaded with HBU SNF.	Prior to each loaded transport
MPC surface defect inspection for those MPCs loaded with HBU SNF.	Prior to each loaded transport
HBU SNF Fuel integrity test	Prior to, and after, each loaded transport

6.1.1 Pre-Mobilization/Mobilization

Table 6-2 lists the activities required to prepare for and remove SNF and GTCC LLW from the VY ISFSI.

Table 6-2: Activities to Prepare and Remove SNF and GTCC LLW from VY ISFSI

Task		Task Activity Description
Programmatic Activities to Prepare for Transport Operations from the VY Site		
1	Assemble Project Organization	Assemble management teams; identify decommissioned site existing infrastructure, constraints, and transportation resource needs; and develop interface procedures.
2	Acquire Transportation Cask, Hardware, Railcars, Off-Site HHT, and Transport Services	Develop specifications, solicit bids, issue contracts, and initiate preparations for shipping campaigns; includes procurement of transport packagings including impact limiters, personnel barriers, intermodal transport cradles, if required; procurement of Association of American Railroads (AAR) Standard S-2043 railcars; and procurement of off-site transportation services including rail and HHT as applicable.

Task		Task Activity Description
Programmatic Activities to Prepare for Transport Operations from the VY Site (continued)		
3	Acquire/Lease Required Auxiliary Equipment Prime Mover, on-site Transfer Trailer and Remaining Required Auxiliary Equipment	Equipment will need to be leased and shipped to site for setup and checkout prior to start of the training program and performance of the dry run(s). In addition, there is limited staffing at the VY ISFSI site, so outside contractor crews will need to be assembled, trained, and evaluated to perform all transfer operations.
4	Prepare Transfer Area and Equipment in accordance with the requirements of the VY FSAR	There is an area of approximately 35 feet x 100 feet on the south end of the ISFSI pad allowing sufficient room for equipment staging in support of canister transfer operations (stack-up operation). A transfer station will be established adjacent to the ISFSI pad where the canister will be moved from the HI-STORM 100S to the HI-STAR 100MB. The HI-STAR 100MB will be down-ended and prepared for transport in this area. Any improvements needed to support these operations and to move the loaded HI-STAR 100MB to the railcar loading area, including any security and haul path upgrades, will be performed.
5	Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport.
6	Coordinate with Stakeholders	Coordinates with carriers, makes notifications to federal, state, and applicable Tribal nations, and shares information with other local community engagement/ advisory boards (e.g., the Vermont Yankee Nuclear Decommissioning Citizens Advisory Panel, VT NDCAP).
7	Develop Campaign Plans/Procedures (e.g., prepare, review, and approve all required site operating procedures for the MPC unloading from the storage overpacks and transfer/loading into the transportation casks, preparation and testing of the casks, and procedures for all the major and auxiliary components and systems)	Develop plans, policies, and procedures for on-site operational interfaces and acceptance, support operations, and in-transit security operations. Initial drafts of MPC unloading operations can be prepared from procedures initially prepared during the original loading campaign. Similar procedures will be required for the auxiliary equipment including transfer operations. New site procedures will be required for the handling of the transport casks, transfer operations, transfer trailer operations, proper tie-down and securing of the cask packages to the railcar/intermodal transport cradle, evacuation and backfilling of the cask cavity with helium, helium leakage testing of the cask containment boundary seals, etc. All approved procedures will require review and approval by VY Independent Safety Review (ISR).

Task		Task Activity Description
Operational Activities to Prepare, Accept, and Transport from VY		
8	Conduct Readiness Activities (e.g., In-Processing, Badging, Training, and Dry Run(s) of All Personnel, Procedures, and Operations)	Assemble and train on-site operations interface team including readiness reviews, tabletop exercises, and dry-run operations. All new de-inventory project personnel including supervisors, riggers/cask technicians, radiation protection (RP), and Quality Assurance (QA)/Quality Control (QC) personnel would need to be trained and qualified to perform the operating procedures in accordance with VY's Systemic Approach to Training Programs. Training would require classroom, on-the-job training (OJT) (operating required equipment), and formal Training Program Evaluation (TPE) effectiveness. All de-inventory project personnel would require training commensurate with their responsibilities and work scope on the project.
9	Transmit MPC load reports and transportation related documents	Assemble MPC load reports and the applicable transportation documents and transmit to the un-loading facility.
10	Load for Off-Site (ISFSI) Transport	Unload storage systems and transfer MPCs to transport casks, install loaded casks onto intermodal transport cradles, installing impact limiters and personnel barrier.
11	Accept for Off-Site (ISFSI) Transport	Accept loaded casks onto transport conveyance for offsite ISFSI transportation and shipment to the designated destination.

6.1.2 Operational Readiness

6.1.2.1 Site-related Operational Readiness Items

Prior to the performance of an Operational Readiness Review and Assessment, the assembled de-inventory project team would be required to be trained and competence confirmed in all required planned site operations and contingencies. All equipment would need to be delivered, assembled, and proper operation verified. Required procedures and project instructions would need to be approved and issued. When all preliminary activities have been completed, the Operational Readiness Review and Assessment would be performed. This is a process used to verify facility, equipment, processes, procedures, and other critical activities have been planned and executed safely. It also ensures that the project team and procedures comply with the applicable regulations, permits, authorizations, and agreements that are in effect for the shipment to meet regulatory, contract, and stakeholder requirements prior to commencing operations as part of a de-inventory of the VY ISFSI. The following subsection will discuss the operational readiness required to ensure operations at VY are ready to commence and can be performed in a safe and regulatory compliant manner.

A review of the VY FSAR, the transportation cask's SARs, and the applicable CoCs will need to be performed to verify that the contents of the MPCs meet the required content conditions and quantities listed in the storage and transportation CoCs and Approved Contents. The contents (form and quantity) of the MPCs would require verification for compliance with the current revision of the CoC for the transport cask systems at the time of shipment.

Operations management would ensure quality, safety, and operational readiness. This assessment shall include verification of the roles and responsibilities among the different organizations involved with and performing the work. Communication among the stakeholders, review and approval of procedures, and interfacing with regulators must occur to ensure the processes to execute work have been reviewed are ready to start work. Based on the assumption in this report that DOE shipments would follow the same requirements as any commercial shipper of SNF, NRC is assumed to be involved in the initial routing approval, and those approved routes will be valid for five to seven years as indicated and described below.[7] Once route approval is granted (e.g., by the NRC), notification would be provided prior to each shipment, as the campaign is longer in duration than one train movement.

6.1.2.2 Personnel-Related Operational Readiness Items

A training program would be implemented for all project personnel, which would require a qualified trainer to oversee and conduct the training on the systems with operationally qualified personnel to perform the OJT and TPE portions of the training program. The training program should include the following requirements and elements:

Classroom Training:

- Module 1 – Storage cask and HI-STAR 100MB Systems Overview,
- Module 2 – On-site ISFSI Transport Operations (storage cask movement),
- Module 3 – Canister Unloading Operations from storage cask,
- Module 4 – HI-STAR 100MB Transport Cask Handling and Loading Operations,
- Module 5 – HI-STAR 100MB Transport Cask Intermodal Transport Cradle Tie-Down and Transloading Operations,
- Module 6 – Preparation of HI-STAR 100MB Transport Cask for Transport,
- Module 7 – HI-STAR 100MB Transport Cask Containment O-Ring Helium Leakage Testing,
- Module 8 – Use of Measuring and Test Equipment,
- Module 9 – Radiological Concerns and as low as reasonably achievable (ALARA) Planning,
- Module 10 – Regulatory Requirements,
- Module 11 – Supervisor Training, and
- Module 12 – Contingency VY Procedures.

On the Job Training:

---

[7] NRC route approval is not typically required for DOE shipments; however, for purposes of this report, it is assumed that the shipments would be conducted like comparable commercial shipments.

- OJT-1 – Perform Pre-Use Inspections HI-STAR 100MB casks, Lift Yoke, Chain Hoist, and other support equipment,
- OJT-2 – Prepare a storage cask for Canister Transfer,
- OJT-3 – Off-Load Empty HI-STAR 100MB Transport Cask from Intermodal Transport Cradle,
- OJT-4 – Perform Transfer Station Setup for Canister Transfer from storage cask,
- OJT-5 – MPC Loading into HI-STAR 100MB Transport Cask,
- OJT-7 – HI-STAR 100MB Transport Cask Lid Installation and Torqueing, and Cavity Evacuation, Backfill, and Helium Leakage Testing,
- OJT-8 – On-site and Off-site ISFSI Operations, and
- OJT-9 – On-site and Off-site ISFSI Intermodal Transport Cradle Handling Operations.

At the completion of the classroom training and OJT elements, operations supervisors would perform TPE for each applicable project personnel to confirm the adequate knowledge and effectiveness of the training prior to final training certification.

Operational dry runs with an MPC mock-up to perform the transport cask loading operation will be conducted at VY for the HI-STAR 100MB cask and support equipment. This includes preparation of the transfer station and storage cask for MPC transfer, transfer of the MPC into the HI-STAR 100MB cask, testing, and transfer of the cask onto the transport skid.

Communication and interfacing with the applicable stakeholders will be needed to ensure readiness including, but not limited to, VY, DOE, State, Tribal, and local authorities. In addition, it is anticipated that the NRC on-site and Region III inspectors would observe and provide regulatory oversight throughout the entire preparation, construction, operating procedure and approval process, and training/dry run program. Some entities should be involved in all aspects of the project (i.e., planning, development of concepts, training, readiness approval, and performing oversight on any dry run operations). This includes reviewing procedures and possibly performing audits/assessments to ensure operational readiness. As additional readiness verification, an independent team of dry cask storage and transport experts should review applicable operational procedures and equipment design/function prior to initiation of the transfer program. As a last step prior to start of operations, a final dry run would be performed as specified in the HI-STAR 100MB training program and witnessed by DOE, NRC, and stakeholders. Additionally, and as applicable, these entities would be involved in event response planning and mitigation, including contingency VY emergency event training, to ensure that any event is well managed and mitigated prior to the first shipment of the campaign. This would encompass approvals to start work, training, and interaction with State and local authorities. It is assumed that VY, NRC, and DOE would participate as observer/regulator/participant for each shipment.

6.1.2.3 Transportation-related Operational Readiness Items

Equipment Readiness determined through review of the following:

- Document insurance requirements of the contract are in place,

- Transportation equipment certifications are current and would be for the duration of the VY transportation cycle,
- All vehicles have required registrations (as applicable),
- All vehicles have current inspections,
- Radiological packaging meets all current requirements,
- Packages are correctly identified (i.e., all required markings and placards are displayed properly, and are available at the site prior to beginning the operation),
- Copies of inspections are provided for equipment to be used to handle and transport the transport casks,
- Copies of all procedures associated with the transportation of the transport casks are provided, and
- Proper documentation that the required security plan is in place and has been approved.

Transportation Personnel Readiness:

- Key personnel and their qualifications are identified,
- Required background checks are current and requirements of coverage of drug and alcohol programs are met,
- Copies of the training materials are provided and required trainings are current for all employees involved,
- All personnel are in possession of and working from the correct procedures and Radiation Work Permits (RWPs) and copies are provided,
- All private security personnel have required weapons certifications to cover the VY transportation cycle,
- Transportation personnel would be monitored for radiological exposure, if required, and
- Proper equipment and personnel are available to monitor workers and equipment for contamination, if required.

Transportation Readiness Notifications:

- Proper notifications have been made to the Tribes, NRC, State and local governments, DOT, USCG, and DOE, as applicable, and copies are provided. Any water served or adjacent facility is required to have an active and updated safety and security plan, which must be reviewed and approved by the USCG. If a plan exists, it should be confirmed by the shipper and updated as to the actual operations designed to take place on the site during the campaign;
- All required permits to transport SNF are prepared and/or in place;
- Proper notification requirements are being met for the receiving facility; and
- Scheduled meetings and briefings that would be conducted for all phases of the shipments are identified.

6.1.3 Site Operations

6.1.3.1 Receiving the Cask and Preparation for Canister Loading

Prior to each HI-STAR 100MB overpack-loading operation, equipment associated with the cask transfer would need to be staged, inspected, and prepared for the transfer operation. Based on review of the ISFSI at VY, additional room would be required to stage the equipment for the transfer operation (refer to **Section 2.0**). This may be accomplished by staging equipment close to the ISFSI in the area south of the pad or other location on the site property. Site (ISFSI) modifications could include movement of the perimeter fence and security perimeter, addition of rail spurs, relocation of the transfer station, and fabrication of an equipment staging area adjacent to the ISFSI to provide this additional room.

Prior to any operation or transfer equipment handling, a pre-job briefing with the operations staff would be conducted to review procedures, verify training of staff, discuss any safety/quality-related concerns and practices, and verify adequate resources are available to support the activity. All work performed would be conducted by procedure, as required by the conduct of operations practices. Stop work authority would be implemented into the working culture to ensure safety and quality of any operation is achieved.

Prior to beginning operations, the transfer equipment would be configured and positioned as follows: the Primary Mobile Crane would be located near the railcar, the transfer station would be installed adjacent to the ISFSI, and the down-ending frame would be in the down-ending area next to the transfer station. The leak test system, and a stand for temporary storage of the HI-STORM 100S storage cask and HI-STAR 100MB overpack lids would be located near the ISFSI.

Once the transfer equipment is staged and ready, the Primary Mobile Crane would be used to remove the empty HI-STAR 100MB overpack from the railcar. The axial end stops would be disconnected and removed from the railcar deck. Then, after disconnecting the devices used to secure the transportation cradle to the railcar, the entire overpack assembly, including the transportation cradle, would be lifted off of the railcar and placed onto a Goldhofer that would move it near the down-ending area. The personnel barrier and the impact limiters would then be removed, as well as the straps used to secure the overpack to the transportation cradle.

Using the horizontal lifting fixture, the Primary Mobile Crane would be used to transfer the overpack from the transportation cradle to the up-ending device. Using the Primary and Secondary Mobile cranes, the overpack would be upended and placed in a vertical orientation.

After the empty HI-STAR 100MB overpack has been upended, the Primary Mobile Crane would attach to the transfer cask (the HI-TRAC 100) and lift, position the transfer cask on the transfer station, and secure it in the stand used to mate the HI-TRAC 100 transfer cask to the HI-STORM 100S storage cask. The Primary Mobile Crane would be disconnected from the transfer cask and rigged to lift the MPC into the transfer cask. The transfer cask neutron shield (water jacket) would then be filled with water or antifreeze, as applicable.

The HI-STORM 100S storage cask to be unloaded would then be moved and positioned near the transfer station using the air pad system and the pusher vehicle. Concurrently the HI-STAR 100MB overpack would also be positioned next to the stand using a similar air pad system and the lid bolts removed. Once the bolts are removed, the overpack lid will be removed and stored. Inspections would be performed on the cask lid bolts, the lid seal and sealing surfaces on the cask lid and body, and to ensure the overpack is free of liquids and debris. The eddy current inspection test ring and the overpack transfer cask-mating device would then be installed onto the HI-STAR 100MB overpack.

Once the HI-STORM 100S storage cask is positioned near the transfer station, the lid bolts would be moved and stored. Radiological Control Technicians (RCTs) survey the bolts for contamination. The Primary Mobile Crane would be positioned to lift the HI-STORM 100S storage cask lid and the rigging would be attached to the HI-STORM 100S storage cask lid and crane hook. During lifting operations, monitoring is required to monitor the dose rate during the lid removal. Additional shielding may be utilized around the HI-STORM 100S storage cask lid to help control the dose. All non-essential personnel would be removed from the lifting location for ALARA purposes. The HI-STORM 100S storage cask lid would be slowly lifted, monitored, and positioned in a laydown Radiation Control Area (RCA). Then the rigging would be removed from the lid and the lid would be covered for storage. The HI-STORM 100S storage cask shield ring would then be removed from the cask and the HI-STORM 100S storage cask-transfer cask mating device is connected to the top of the cask using the lid bolt holes. RCTs perform additional surveys of the open HI-STORM 100S storage cask and the top of the MPC for radiation and contamination. The bolt hole threaded plugs on the MPC would be removed and the lifting lugs installed. After preparing the HI-STORM 100S storage cask for unloading, the pusher vehicle and air pad system would be used to position and align the HI-STORM 100S storage cask in the transfer station.

6.1.3.2 Canister Loading into the Cask

The Primary Mobile Crane would be attached to the MPC lifting rigging with a dynamometer to monitor any change in weight to ensure the MPC does not bind during lifting operations. The transfer cask door would be opened. Once the door is fully opened, the MPC rigging is lowered and manually attached to the MPC lid lifting lugs. At this point, additional shielding would be positioned between the transfer cask and the open storage cask based on direction from the RCT. The MPC would then slowly be lifted a few inches and the lift would stop and hold the load to ensure that there are no issues with binding during the transfer operation. RCT monitoring of the lifting of the MPC into the transfer cask would be performed to ensure ALARA and radiological controls are maintained. The crane would continue to lift the MPC into the transfer cask. Once the MPC is fully lifted into the transfer cask, the shield door would be closed and the MPC slowly lowered onto the door until it is noted that the MPC rigging load is reduced or slack. RCTs would perform follow-up surveys for radiation and contamination.

Once the surveys are completed, any temporary shielding would be removed from around the storage cask and the transfer cask. The storage cask would be moved using the air pad system and the pusher vehicle out from under the transfer station. Based on the contamination levels of the storage cask, the lid may need to be installed. The empty storage cask would then be moved to a storage location.

Using a similar air pad system, the HI-STAR 100MB overpack would be moved and positioned in the transfer station. Additional shielding would be installed around the equipment to help control radiation streaming. Using the crane, the MPC would be lifted up slightly from the transfer cask shield door. Once it is confirmed the MPC is off the door, the door would be opened. RCT coverage during the lifting operation would be required to monitor radiation levels during transfer operations to ensure ALARA and radiological controls are met. The MPC would be lowered into the HI-STAR 100 overpack while performing the eddy current surface inspection of the MPC. The additional shielding would be removed and then the rigging would be manually removed from the MPC lid, lifted into the transfer cask, and the transfer cask door would be closed. RCT would perform radiation and contamination surveys of the transfer cask and the opening of the HI-STAR 100MB overpack for radiation and contamination.

6.1.3.3 Cask Final Assembly and Preparation for Shipment

Once the HI-STAR 100MB overpack has been loaded and prepared for movement, the air pad system and pusher vehicle would be used to remove the overpack from underneath the transfer station. An inspection would be performed on the transportation cask seal surfaces to verify the areas did not sustain any damage during transfer and loading of the MPC and spacer into the HI-STAR 100MB overpack. After the inspection is complete, the Primary Mobile Crane would rig to the HI-STAR 100MB overpack lid and position over the unit. Verification would be obtained that the lid seal is in place prior to the lid being lowered onto the HI-STAR 100MB overpack, and the lifting rigging removed. The overpack lid bolts would be installed and torqued as required in the overpack SAR.

Additional surveys would be performed by RCTs to verify contamination and radiation are within the specified values.

Once the HI-STAR 100MB overpack has been closed, the cask cavity leak test would be performed to verify the MPC integrity, and then the interior would be vacuum-dried and backfilled with helium. The leak test system for the overpack lid annulus would then be positioned and set up for use. With support from an RCT, the overpack lid annulus test port plug and seal would be removed, and the RCT would survey the items and area for radiation and contamination.

The leak test system would then be attached to the test port on the overpack lid. The testing and operation of the leak test system must be completed using approved processes and procedures provided by the system manufacturer (Holtec). If the leak test fails, work must be placed in a safe configuration and management notified. Failure of this test would be an indication that the overpack containment boundary may have failed. Once the test is completed and passed, the leak test system would be disconnected from the test port, the test port plug, and a new seal would be installed and torqued to the appropriate levels.

With support from an RCT, the overpack vent port cover plate would be removed and surveyed. An inspection of the port plug would be performed to verify the plug is not loose. Then the leak test system would be attached to the vent port test fixture and to the vent port. At this point, the leak test of the vent port seal would be performed as directed by the leak test procedure. If the test does not pass, notify management of the condition. Failure of this test would be an indication the overpack containment boundary on the overpack vent port has failed. As a contingency, the vent port plug may be removed, inspected, seal replaced, and retested. Once the leak tests have been completed, the vent cover plate would be reinstalled and torqued to the appropriate levels.

With support from an RCT, the overpack drain port cover plate would be removed and surveyed. An inspection of the port plug would be performed to verify the plug is not loose. Then, the leak test system would be attached to the drain port test fixture and to the drain port. At this point, the leak test of the drain port seal would be performed as directed by the leak test procedure. If the test does not pass, management should be notified of the condition. Failure of this test would be an indication that the overpack containment boundary on the overpack drain port has failed. As a contingency, the drain port plug may be removed, inspected, seal replaced, and re-tested. Once the leak tests have been completed, the drain port cover plate would be reinstalled and torqued to the appropriate levels.

If not previously performed, the neutron shield relief devices would be inspected and replaced if necessary. Additional tests of the overpack neutron shield and thermal performance would then be performed and the results compared against the required criteria.

Once all of the testing has been completed with acceptable results, the overpack would be moved using the crane to the overpack down-ending area in preparation for loading the overpack onto the transportation cradle. Once the overpack has been positioned and lowered by the crane, the down-ending frame would be attached to the overpack. The crane would then be disconnected from the overpack, moved to the staging area, and the Primary and Secondary Mobile Cranes would both be connected to the down-ending frame. Using the two mobile cranes, the overpack would be lifted slightly while attached to the down- ending frame. It would be rotated into the horizontal position and lowered down. Once the overpack is rotated, the cranes would be disconnected from the down-ending device.

The Primary Mobile Crane would be attached to the horizontal lifting fixture and the fixture, with associated rigging, would be positioned over the overpack and attached for transferring to the transportation cradle. The down-ending frame is then disconnected from the overpack, and the Primary Mobile Crane would lift, transfer, and position the overpack onto the transportation cradle.

Once the transfer is completed, the lifting fixture would be removed from the overpack and stored. The overpack is secured to the transportation cradle using the associated cradle securement straps and preparations would be made for the installation of the impact limiters. A visual inspection of the overpack and cradle would be performed to look for any damage that would reduce the safety function of the overpack. The RCT would perform a radiation and contamination survey of the HI-STAR 100MB overpack shell. Concurrently, a visual inspection of the two HI-STAR 100MB overpack impact limiters and bolts would be performed to look for dents, tears, and removed thread material or other damage. Prior to installing the impact limiters, security seals would be installed on the overpack lid bolts.

Using one of the mobile cranes, the riggers would attach one of the two impact limiters and position it onto the HI-STAR 100MB overpack. The impact limiter bolts would then be installed and torqued to the appropriate levels. This activity would be repeated for installation of the second impact limiter followed by security seals being installed on each impact limiter.

After both impact limiters have been installed, an inspection of the labeling and marking on the overpack would be conducted, and any additional labeling would be applied, as required by DOT. The cask trunnions would then be made inaccessible for lifting.

One of the mobile cranes would attach to the personnel barrier, and the barrier would be lifted and installed/secured to the transportation cradle. The RCT performs an additional radiation survey of the assembled transportation system to verify the radiation and contamination levels are compliant with NRC and DOT requirements.

Once the HI-STAR 100MB is configured for transportation (secured to the cradle with impact limiters installed), the Primary Mobile Crane would load the overpack onto the Goldhofer to move next to the railcar. Prior to loading the HI-STAR 100MB overpack on the railcar, verification that the railcar system has been inspected and that all maintenance is current, would be performed.

Additionally, inspections of the car would be made to verify that the required load securement hardware is properly installed.

The Primary Mobile Crane, along with the required rigging, would be attached to the four lifting attachment points on the transportation cradle. The crane would then slowly lift the overpack and position the load over the railcar, lifting the load only as high as required to safely clear the railcar deck. Once in position, the cradle would be slowly lowered onto the railcar, in alignment with the load configuration drawings being sure to account for center of gravity and overall permit dimensions when loaded onto the railcar. Then, the cradle would be secured to the railcar using the appropriate connection mechanisms. The crane and rigging would then be disconnected from the cradle and stored.

The RCT performs additional surveys of the overpack once it is loaded onto the railcar, to verify radiation levels meet the DOT requirements. Temperature measurements would also be taken to ensure the accessible surfaces of the overpack are within the acceptable limits. At this point, the two axial end stops would be lifted and positioned onto the railcar, using one of the mobile cranes, and then secured to the railcar. The shipper would do the final pre-shipment inspections of the load in preparation for shipment of the overpack.

6.1.4 Transport Operations

6.1.4.1 Special Permit Requirements

The shipper is required to obtain the following permits for transporting the loaded casks by rail from the VY ISFSI to the GCUS:

- A formal clearance submission will be submitted to the originating Class I rail carrier. For the purposes of this project, the goal is to deliver the overpacks from the VY site to the closest Class I railroad, CSX Transportation, which will clear the entire route with all participating railroads to the final destination.
- The shipper, for the purposes of this report, would be DOE, and the shipments are assumed to be conducted by commercial carriers like comparable commercial shipments. Therefore, although typically not required for DOE shipments, it is assumed for purposes of this report that DOE would file an application with the NRC for an approved rail route from the VY to the GCUS (identified destination).

Note: A formal clearance submission is required for all dimensional shipments on all railroads involved in the full route. With loading taking place at the recommended on-site track location within VY, the shipment will originate on a short line carrier which is located approximately 80 railroad miles north of the interchange point with the Class I carrier. The clearance will be submitted to CSX Transportation which will clear the entire route to the final destination, which in this case is to the GCUS.

Each Class I rail carrier has a formal procedure for clearance submissions, and all are electronically filed. Some require a fee to accompany clearance requests, and some do not. The following components must be present in each clearance submission:

1) Identification of the origin, the destination, the standard transportation commodity code, the shipper, receiver, and associated serving carriers, and the route (including interchange locations for the requested route);
2) Identification of the specific railcar to be used for the shipment;
3) All dimensions of the loaded unit on the railcar, which depict a profile of the loaded unit and car together. This is typically in the form of an engineering clearance diagram, and should also include:
    a) All offsets, ballast, or any other loading configuration specifics important to the maximum dimensions of the loaded railcar, and
    b) Center of gravity measurements, combined center of gravity and total weight of the loaded railcar, and
4) Actual placement on the selected railcar.

The more specific the information provided in the clearance submission, the better the chance of clearance acceptance. The above submission requirements are considered a minimum. Some rail carriers require additional information for clearance acceptance. The AAR Open Top Loading Rules delineate what must be submitted for acceptance at interchange between carriers.

Note: Requirements may be relaxed if movement is restricted to only one rail carrier and is not subject to interchange with another carrier. This also applies to loading and securement configurations. However, with HAZMAT, the relaxation of these requirements is not expected nor anticipated principally for safety reasons.

The approval and acceptance of the railroad clearance and the NRC route approval have different validity dates. The railroad clearance is valid for 6 months while the NRC route approval is valid for 7 years on a rail direct movement.

It is recommended that at least 6 months be allotted for the railroad clearance process in the event the intended routes have not been approved for previous shipments and the approval process takes longer than anticipate, or alternate routes must be examined. This recommendation is based on extensive experience in obtaining clearances and super-load permits for movements of similar weight and dimensions and HAZMAT (Class 7). Once the rail route is cleared by all involved rail carriers, the clearance is valid for 6 months to one year, depending on the individual rail carriers involved. If the shipping campaign is estimated to take longer than 6 months, the clearance must be resubmitted. The clearance ensures that the loaded dimensions and weights of the transportation cask and railcar (in this case the train) would traverse the railroad route without impediment. The resubmission after 6 months will ensure no changes have taken place on the rail route that would affect the ability for the dimensional load to pass the route safely (tunnels, bridges, trestles, signals, silos, or any structure that may be close to the track), including taking into consideration other dimensional traffic moving in the same lane. This process takes into consideration the constant maintenance of way work that takes place on railroad infrastructure which may impact the clearance window.

Once the clearance is obtained, and the route is approved by NRC, the NRC approval will be valid and effective for 7 years for rail routes. Combination routes are valid for a period of 5 years once approved by NRC (truck-to-rail siding, transloading, and rail to final destination). The minimum amount of time to submit routes to the NRC for approval is 90 days; however, it would prefer 6 months. Any time conditions change or are altered on an approved route, the shipper must notify the NRC and submit an amendment.

Road permits will be required for transporting cranes and other heavy or dimensional equipment being trucked to VY for use in loading the transportation casks. The permits will also dictate the requirement for private escorts (not the security team) and State Police escorts for both the mobilization and demobilization efforts. These escorts are in addition to those required by the regulations for LLEA for safety and security purposes for movement of the loaded casks. Each state DOT has different requirements for issuing permits for movement of super-load or dimensional truck loads. The permits will be valid for a specified period of time, 3-5 days for example, and will dictate valid movement parameters including allowable truck configurations, hours of operation, number of required escorts (private and State police), required signs and lights that must be displayed by the trucker, and the approved travel route.

6.1.4.2 Coordination with Mode of Transport

This section provides a description of activities necessary to coordinate with the various parties involved in preparation for the transport and transload activities. The actions necessary to prepare for and remove the SNF from VY are listed as tasks in **Table 6-2**. These identified actions are based on the assumption that DOE would be responsible for shipping and operating the federal consolidated interim storage facility or repository. Based on these tasks, the characteristics of the site's inventories of SNF, the onsite conditions, the near-site transportation infrastructure and experience, time sequences of activities, and time durations were developed to prepare for and remove the loaded transportation casks.

6.1.4.3 Additional Coordination Efforts

Description of Activities Necessary to Coordinate with Heavy-Haul Providers:

- All diagrams, including dimensions, center of gravity, and weights must be obtained, preferably in Computer Aided Drawing (CAD) format and provided to both the heavy-haul truckers and riggers for use in planning the HHT movement, securement on the trailer and the lift and rigging arrangements, if required.
- Any lift diagrams or transport diagrams from the manufacturer should be provided to both the HHT and rigging contractors for use in developing the lift plans and determining the proper rigging arrangements to be used at the ISFSI.

  This information is used by the trucker and rigger to develop accurate lifting plans for each phase of the operation, to develop engineering drawings of the transportation cask and cradle combination on the specific piece of equipment being used for the transport and for all rigging required to lift or place the casks onto the trailer. If transportation over a route requiring permits is involved, the resultant combined diagrams are used in the permit process to obtain permission to travel the desired route, particularly to demonstrate the combined load can safely travel over/under bridges, culverts, or overpasses in the route without damaging the infrastructure.
- The developed drawings will be shared with the team and used in dry run exercises.

- Load securement information, including weights of the components in transport configuration, plus the weights of the trailers, would be used to determine and verify vehicle axle weights to meet all safety requirements for the short haul from the ISFSI to the rail transload track, even if located within the VY site.
- The local utilities must be brought into the work plan for overhead and underground clearances, if any are impacted. While there are overhead wires in the vicinity, they do not appear to be over the rail track or within reach of the crane's boom at the rail transload site. The location of any obstructions will be identified and documented in the formal truck and transload site surveys.
- The transportation plan does not require VT DOT approval for any on-site truck movements from the ISFSI to the rail loading location because the transportation will be conducted on private property. Any safety concerns identified along the haul path should be documented and included in safety briefings.

Description of Activities Necessary to Coordinate with Crane Company and Rigging Providers:

- All diagrams including dimensions, center of gravity, and weights must be collected (preferably in CAD format) to be provided to the crane company for use in planning the proper lift plans and for determining the proper rigging required to safely execute the lifts. This includes crane selection for the job based on the conditions of the site and rigging plans and configurations;
- Any manufacturing lift and transport diagrams, especially regarding restrictions on pick points or special rigging required for lifts, should be collected, and distributed to the crane and rigging companies. This information will be used for plan development, including crane selection;
- Crane company/riggers would physically survey the items to be lifted (casks), confirm measurements, observe ground conditions, and other requirements (e.g., turn radius for crane and ancillary equipment) in addition to any specialized rigging provided by the site specific to the transportation casks being lifted. This is a joint effort between the crane company experts/engineers and transload operator/licensee/shipper. Coordination among the parties will ensure all aspects of the lift and securement plan are considered for optimum execution; and
- A timeline would be established for mobilization of all required equipment including all standard rigging tools, forklifts, etc., to ensure all equipment is in place and tested prior to the start of the test lift and commencement of the shipping campaign.

Description of Activities Necessary to Coordinate with Transload Site Rail Carrier (may be a different rail carrier than the Class I railroad) and these aspects also apply to the on-site rail transload operations:

The private rail siding located on the VY property is served by the NECR. Meeting with the rail carrier 6 months prior to beginning the loading operation would allow for coordinating and planning for a successful operation. These meetings will allow time to set joint expectations for the desired service levels and allow the rail carrier to "right-size" its equipment requirements and crew staffing to meet the required service levels. Special considerations and possibly budget concerns would need to be addressed by the rail carrier to ensure it has the available crews to run dedicated trains and is willing to do so. Knowing how many trains will be handled and with what frequency will be important to the rail carrier for budgeting and crew planning purposes. Other items to discuss would be security requirements for the crew entering the site, describing the intended operations, planning for the mechanics of placement of the empty train, inspection of the loaded train, and all other operations including establishing the timeline for pulling the released train from the site and obtaining the transit schedule for delivery to the Class I carrier for interchange and further movement to GCUS:

- Develop safety and security plan for the rail transload site and notify the serving carrier, NECR that VY has a plan in place and provide the required contact name and number for the site. Provide proper notification that the transload site will be designated as a "rail secure area" as required by 49 CFR Part 1580.107(i).
    - The recommended transload site is located within the VY owned property. It likely has already been designated as a rail secure site at this point, due to the nature of the HAZMAT commodities already shipped from the site. In order to ship SNF from the site, it must be declared a "rail secure area" in accordance with regulations and
    - Although not required, plan to institute the same precautions and planning as is used in Toxic Inhalation Hazards (TIH)/Poisonous Inhalation Hazards (PIH) handling and reporting for added measure of security at the rail transload site. This provides notice to the rail carrier of the level of preparation and operations planning for handling/shipping HAZMAT from the site;
- Determine if railroad police are available and will be present during the manned interchange and any other stops along the rail route on the way to the final destination. Railroad police or railroad management can provide extra observation in rail yards to deter rail fans, which typically "chase" dimensional shipments along the rail route and other trespassers in the yards, or other nefarious parties from interfering with the shipment;
- Hold initial meetings with the Class I carrier to explain the movement, provide estimated number of trains to ship, discuss the dedicated train requirement, and begin rate negotiations for the costs to move the trains;
- Mention current safety and security measures for the site to ensure the rail carrier is aware of special considerations and operating procedures in case they have no familiarity with these requirements:
    - Note and discuss safety features that will be added to the site: fence, lights, defined perimeter, etc., as required for the individual site,
    - Discuss requirements of crew entry into the site regarding security requirements (Transportation Worker Identification Credential (TWIC) cards, training, etc.), and procedures (does the rail gate have a lock, etc.),

- Confirm the physical location where the NECR crew will pick up the loaded cask train and conduct the manned interchange,
- Discuss manned interchanges with the rail carrier and record keeping requirements,
- Discuss normal times of operation for the site and any extensions in hours required for the transload campaign. Coordinating operating hours and railroad access to the site will ensure the loaded train is not sitting longer than necessary. This is important for planning release of the loaded train and consideration of the current rail operations on the division in conjunction with normal operating parameters at the site. This will avoid any party involved in the shipping campaign from waiting on other parties due to lack of coordination of efforts,
- Open communication with all rail carriers on the route to ensure a smooth transition at all interchange points. In this case, only one Class I railroad is involved in the route to the GCUS,
- Hold initial meetings with the railroad's local trainmaster and safety manager to discuss intended operations and parameters for operations, even though the transload is taking place on a private and secure site, and
- Communicate to the rail carriers that all requirements have been exceeded for the intended site and operations.

6.1.4.4 Transport Operations

Prior to any transportation operation, a pre-job briefing would be performed with the operations staff, including security escorts and staff that would be tracking the shipment. This briefing would be conducted to review procedures, verify training of staff, discuss any safety/quality-related concerns and practices, and verify adequate resources are available to support the activity including verification that prerequisite conditions are met. This would include, but not be limited to, all HI-STAR 100MB overpack inspections and testing completed, routes having been inspected and approved, and receipt of management approval to ship.

Performance of a visual inspection of the installed HI-STAR 100MB overpack, intermodal cradle, and personnel barrier assures that it is assembled correctly and in unimpaired physical condition. The visual inspection includes checking for cracks on the intermodal cradle main beam web-to-flange-welds, the beam webs, plus checking the tie-down structure for any signs of distortion or failure.

Before the rigging is removed from the cradle, while the unit is on the railcar, initial measurements are taken to confirm proper placement on the railcar with respect to center of gravity and to ensure compliance within the clearance window. Once the crew has confirmed correct placement on the car, the rigging is removed from the cradle and the boom of the crane would swing away from the loaded railcar.

The crew then proceeds to secure the cradle to the railcar ensuring compliance with the AAR Open Top Loading Rules. Specifically, all restraint values would meet the stated requirements of 7.5G x 2G x 2G [34][41], the requirement from the DOT and what is required for load securement in the HI- STAR 100 overpack SAR [8].

Once the transportation cask is secured to the railcar and internal inspections of the transportation cask and the loaded train are completed, the Rail Transload Facility Supervisor will request the railroad inspection. Once the inspector measures and approves the cars for shipment, the Rail Transload crew shall air test the train if air brakes are on the train (as with some existing Department of Defense shipments) and perform a visual inspection of the train's safety devices. The appropriate party should issue the electronic bill of lading (BOL) to the serving rail carrier, the NECR.

The crew will then attach the Global Positioning System (GPS)/Impact Recorders (or other telemetric units or similar approved devices) to the loaded train to provide 24/7 on-demand GPS location information using the most current monitoring sensor technology available at the time. The device will also record any impacts (from switching, etc.) that occur at more than 4 mph. Impact recorders are not required by regulation or the rail carriers but are commonly used by dimensional shippers for high-value and sensitive machinery to record any impacts (switching) and forces exerted on the loaded cars during transportation. Simultaneously, the Transload Facility Supervisor electronically releases the loaded train to the rail carrier.

Once all of these steps have been completed, the shipment is considered ready for transport. Additional steps to be performed prior to release of the shipment include but are not limited to preparation of transportation-related documentation BOLs, permits, and other transportation-related documents to ensure compliance with regulations, notifications of States and Tribes and regulatory agencies as required, and communication with the Movement Control Center (MCC) and security team.

Once the serving rail carrier, NECR notifies the rail transload facility of the intended switch time and the train will be prepared for movement from the private loading track. Upon arrival of the NECR train crew at the rail transload facility, the Rail Transload Supervisor will unlock the gate and allow entry of the train crew into the site. This will be a documented and manned release of the loaded train from the transload facility to the NECR train crew. The chocks should be removed, and the locomotive attached to the loaded train and pulled from the facility once the Rail Transload Supervisor unlocks the gate to allow the train to exit the transload facility property with the Rail Transload Security Team (armed security escorts) in the escort car (also known as the rail escort vehicle or REV).

The rail carrier and Transload Facility Manager will document the manned interchange in writing.

The NECR train will leave the facility and proceed to the interchange point with the Class I carrier, (located in Palmer, MA) where the CSXT crew and railroad police will await the arrival of the NECR train. The anticipated travel time from the VY to the interchange point is 6 hours. No stops will take place from the time the train leaves the VY site until it reaches the interchange with the Class I carrier. Upon arrival at the interchange, the NECR crew will document arrival and the physical manned interchange with the Class I crew, deliver the loaded train to the designated track and then disengage its locomotive. The Class I carrier will provide advance notification to the GCUS location to coordinate the arrival and manned delivery to the GCUS. It would then proceed to the GCUS with no other interchanges taking place until arrival. Any stops along the route for refueling and changing the crew would result in the train being stopped only at interim rail yards and it would be guarded by railroad police during the minimal stops. An estimated transit schedule will be provided to the shipper for the entire train movement. The ability to monitor and trace the train would be limited to need-to-know personnel.

Upon arrival at the GCUS, the CSXT train crew would document the manned interchange with the receiving carrier, deliver the loaded train to the designated track, and then disengage its locomotive. Both crews must be physically present for the handoff.

6.1.5 Demobilization

Once the de-inventory project (campaign) operations have been completed, demobilization will commence. This is the process of removing all the equipment and materials used during the operation at the VY ISFSI and returning it to its proper owner in accordance with rental/lease agreements. This includes returning any leased property to the proper owner in the agreed upon condition in accordance with the lease, which may include leaving added pads, fences, and lighting in place.

As the MPC exterior surfaces are potentially contaminated, as discussed earlier, large components, such as the transfer cask, lift yokes, chain hoists, etc. would be decontaminated as needed, approved for free release, and returned to the owner(s) for storage. Specialized equipment (e.g., the vacuum drying and leak test systems) would be decontaminated as feasible and returned to the owner.

Railcars would be shipped directly from the disposal or storage site at the completion of the project in accordance with the release criteria established by DOE. The train would be returned to its storage track until it is needed for the next shipment. The transport packaging, transport intermodal skids, lift yokes, and the like would be decontaminated, placed in an assembled condition, and returned to DOE for storage and maintenance.

Demobilization of ancillary equipment from each site would be accomplished in the same manner as it was mobilized. Forklifts, man lifts, diesel air compressor(s) and any large pieces of equipment would be surveyed and loaded onto flat beds and drop deck trailers for transport back to origin. It is customary for the leasing company to pick up the equipment once it is formally released by the contractor. Rigging, tools, and smaller articles would be surveyed and loaded into containers and flatbed trailers for transport back to the owner. Security-associated equipment, such as fences and lighting, would be broken down, surveyed, and returned to the suppliers, as appropriate. If personnel trailers, porta-johns, and storage trailers are utilized, utilities would be disconnected, and the units returned to the leasing companies. Cranes would need to be broken down and transported, as required, by the road permits to reach their next destination or be returned to the owner's storage yard. Any standard rigging rented with the crane would also be inspected for condition, documented, properly packaged to prevent damage, and returned to the owner or leaser.

The empty storage casks would remain on-site for disposition by VY as potentially contaminated and activated materials. In addition, the ISFSI site, after removal of all fuel storage systems, would be decommissioned in accordance with NRC and site regulatory requirements.

In the event any of this equipment is purchased, it would be surveyed and loaded onto trailers or containers for movement by truck to its storage facility. This process takes approximately one week to complete. The train would be returned intact to its storage location and would likely move in regular train service, which may take a few weeks depending on the distance and route dictated for the movement.

6.2 Resource Requirements / Staffing

At the VY site:

- Operations Manager;
- Cask Operations Shift Supervisor;
- Training Specialist;
- Procedure Writers;
- RP Specialist – in charge of the radiation monitoring and surveys;
- Transport and Waste Management Coordinator (TC) - provides supervision of the waste management aspects of the program and of the transport. The TC is in charge of the preparation of the shipping papers, verification of the proper labeling and placarding of the transport, and tracking and response coordination. Position may be seconded by a Transport Analyst;
- Crane Operators;
- Riggers;
- Rail Transload Supervisor;
- Rail Transload Security Team (as applicable);
- Cask Operations Technicians/Mechanics;
- Tractor, Driver and Equipment Operators;
- QA/QC Specialist; and
- Security Personnel.

6.3 List of Ancillary Equipment

Additional equipment needed is listed in **Table 6-3**, **Table 6-4**, and **Table 6-5**.

Table 6-3: Additional Equipment for VY Transfer

Additional Equipment for VY Transfer	
Standard tools	These include Personal Protective Equipment (PPE), communications equipment, wrenches.
Overpack impact limiters, cradle, and support equipment*	The overpack would be transferred to the site with the required overpack-loading support equipment in order to support dry runs.
Pusher vehicle	Used to push the Storage Cask and the HI-STAR 100MB overpack with the air pad system. Typically a modified front-end loader.
HI-TRAC Transfer Cask*	To provide shielding when moving the canister from the storage cask to the transportation cask.
Air Pad System*	Used to move the HI-STORM 100S and HI-STAR 100MB overpacks in and out of the transfer station. This includes portable

Additional Equipment for VY Transfer	
	air compressors and jacks to lift the overpacks for placement of the air pads.
Transfer cask shield door operating system*	Used to operate the transfer cask shield door.
Transfer station alignment system*	Used to align the MPC during insertion/removal of the MPC in or out of the Storage Cask and HI-STAR 100MB overpack.
MPC Spacer (VY Specific)*	Used to fill the gap between the top of the MPC and the bottom of the HI-STAR 100MB overpack lid.
Eddy Current Inspection Test Ring*	Used to inspect the MPC as it is loaded into the HI-STAR 190 cask.
Storage cask and HI-STAR 100MB overpack adapter plate*	Used for centering the Storage Cask and HI-STAR 100MB overpack in the transfer stand.
Water supply and 1,000-gal tank	Used to fill the transfer cask water jacket.
Temporary shielding	Used to provide additional shielding around the transfer cask during canister movements.
Mobile load cell	Used to verify the appropriate weights are within tolerance during transfer of the MPC.
Welding machines	Used for welding and securement.
Standard rigging and supplies	For use in lifting the overpack and cradle combination.
Specialty rigging – spreader bar or other rigging specific to the overpack or cradle*	To be provided by the site for use in lifts at the rail transload facility.
Jacks (if used)	Support loading the railcars.

* Holtec-specific equipment

Table 6-4: Equipment for the Transload Facility

Equipment for the On-site Rail Transload Area	
Primary Mobile Crane	To transfer the overpack to the transportation cradle and to load the overpack onto the transportation trailer.
Secondary Mobile Crane	For transfer of the MPC from the Storage Cask to the HI-STAR 100MB overpack. Assisting in the down-ending operation of the overpack. This crane would also be used for handling the Storage Cask and HI-STAR 100MB overpack lids, installation of the impact limiters and personnel barrier, and other lifts at the VY site.
Down-ending device*	Used with a crane to rotate the overpack from the vertical position to horizontal orientation.

Horizontal overpack lifting beam*	To transfer the overpack from the down-ending area to the transportation cradle.
Man basket/ lift	To reach the top of overpacks and assist in any operation that is required to safely extend reach.

* Holtec-specific equipment

Table 6-5: Rail Equipment (per consist)

Rail Equipment (per consist)	
Locomotive(s)	Dedicated for the train movement and at least two required per AAR S-2043.
Buffer cars	Used to provide buffer between loaded over-pack cars and all other cars, per clearances.
Load (cask) cars	Heavy duty flat cars.
Escort car (REV)	Houses the armed security team and will meet the portion of AAR S-2043 applicable to escort cars (REV).
Redundant radio equipment	Used for communication between the security team and the monitoring control center, LLEA, and other required parties. This communication system is in addition to the normal radio communication of the railroad crew with dispatch.
GPS/impact recorder units	One per loaded over-pack car. While GPS (telemetric devices) are required for SNF movements, combination units are commonly used by shippers on sensitive and high-value dimensional shipments to indicate both locations of the cars/train and to document all forces exerted on the load car while moving. These are not required by regulation or the rail carrier but are an additional means of ensuring safety and security in the handling of the units during transportation.

6.4 Sequence of Operations / Schedule

The operations would be sequenced as described in **Section 6.1**.

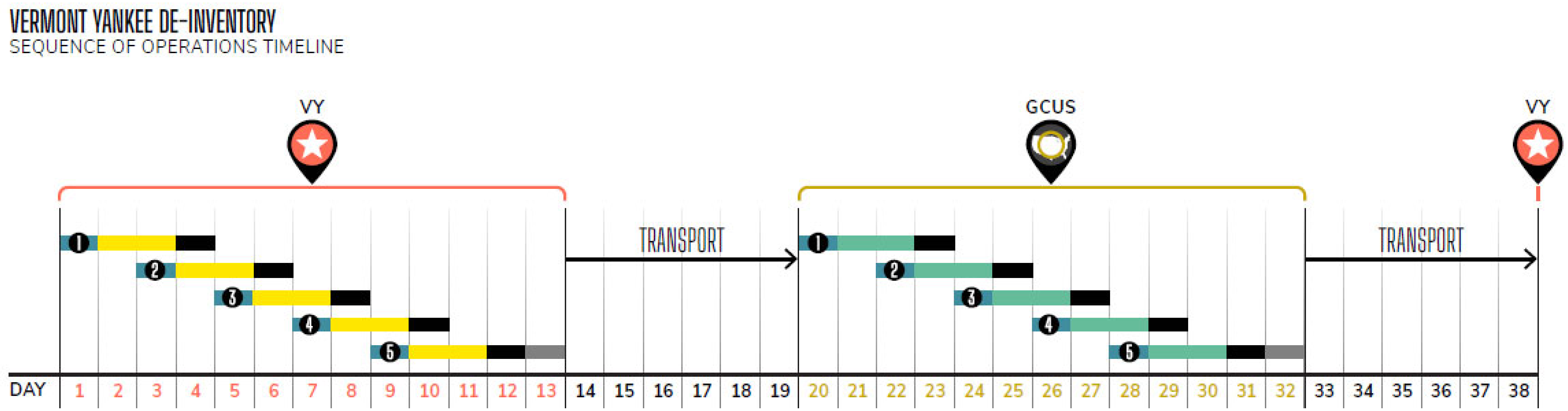
The sequence of operation timeline, **Figure 6-1**, outlines the operations associated with loading, shipping, and return of the trains removing the VY canisters from the ISFSI. The cask loading operations include transferring MPCs from the HI-STORM 100S storage casks to the HI-STAR 100MB transport casks, preparing the casks for transport (e.g., evacuation, helium back-fill, leakage testing), securing the cask/intermodal transport intermodal skids, placement and securement of the cask/skid assemblies onto the railcars, and preparing the railcars for shipment. This evolution is estimated to take approximately 2x 8-hour days per overpack. Estimated transfer of the MPC into the transportation overpack and subsequence loading of the HI-STAR 100MB overpack onto the railcar would take 3 days per overpack.; a full train consist of five canisters will take approximately fifteen days with a single crew or twelve days with two crews performing some activities in parallel.

The transit times listed in **Figure 6-1** are provisional and may change as route details and operations are better defined. This schedule is based on 2 crews working in parallel at both the VY site as well as at the GCUS site. The total round-trip transit time, from the initial transfer of a canister from a storage cask to the return of the empty transportation casks is approximately 38 days.

For a campaign where one train consist is available, containing five transportation casks, the timeline for complete removal of all 59 canisters would require eleven round trip shipments of five HI-STAR 100MB packages per shipment and a final round trip shipment with four HI-STAR 100MB packages over a period of 65 weeks. It is worth noting that no margin, or contingency, has been added to this schedule.

Table 6-6 estimates the resource requirements needed to support this de-inventory campaign. An additional eight to nine weeks of planning and preparation is added before the start of the first campaign. The level of detail is the week.

Figure 6-1: Sequence of Operations



LEGEND

- # Cask number

Crew 1 operations

- Receive cask
- Secure cask
- Prepare train

Crew 2 operations

- Load and stage cask
- Unload cask

ASSUMPTIONS

1. One train is used consisting of five cask railcars
2. Starting condition is five empty transportation casks at VY secured to railcars
3. Operations occur 8 hours per day, 7 days per week
4. Two operation crews working in parallel at both VY and GCUS
5. Three days to receive (empty), inspect, prepare, load, and stage the loaded transportation cask
6. One day to load and secure a single transportation cask onto cask railcar
7. One day to prepare the train for transport
8. Six days to travel between VY and GCUS
9. One day to remove a single transportation cask from a cask railcar
10. Three days to receive (loaded), inspect, prepare, unload, and stage the empty transportation cask
11. One day to load and secure a single transportation cask onto cask railcar
12. One day to prepare the train for transport
13. Six days to travel between GCUS and VY
14. No margin is added in the above durations

Table 6-6: Operations Timeline with Required Resources

	Major steps for a 59 MPC campaign	Resources required [in full-time equivalent]*											Estimated Duration
		OM	COSS	TS	PW	RP	TC	CO	RM	EO	QS	SP	
1	Detailed operations planning, campaign preparation, equipment mobilization, procedure preparation and approval, training program, pre-loading review(s) and dry run(s)	1	2	1	2	2	1	2	6	2	1	3	9 weeks prior to 1st campaign
2	On-site transfer of the SNF and GTCC LLW canisters and preparation of 5 packages	1	2	1	1	2	1	2	6	2	1	3	13 days per 5-cask campaign
3	Shipment to destination by rail	0.5			1		2						6 days per 5-cask campaign
4	Unloading	0.5	2		1		1		6	2	1		13 days per 5-cask campaign
5	Return transport of empty casks	0.5			1		2						6 days per 5-cask campaign

***Key:**

OM: Operations Manager	**TC**: Transport and Waste Management Coordinator
COSS: Cask Operations Shift Supervisor	**RM**: Rigger/Cask Operations Technician/Mechanic
TS: Training Specialist	**EO**: Tractor/JCB Driver and Equipment Operator
PW: Procedure Writer	**QS**: QA/QC Specialist
RP: Radiation Protection	**SP**: Security Personnel
CO: Crane Operator	

6.5 As Low As Reasonably Achievable (ALARA) Planning

Specific requirements are provided in 10 CFR 72.126 "Criteria for radiological protection" that address radiological control measure for work with dry cask storage of SNF. Infrastructure requirements that would be required for transitioning from essentially a static, monitoring condition of the storage of SNF to an active worksite that involves handling and loading operations would be considerable. Stranded sites that are no longer staffed with trained and qualified health physics personnel would be dependent upon either loaned labor from the utility, if those resources are still available, and/or contract health physics staff. In addition, portable survey instruments, portable Continuous Air Monitors, and area radiation monitors must be provided along with the means to maintain them, calibrate, and response check for usage. Infrastructure must also be provided to facilitate safe operations at the site. Temporary offices, electric power for lights, equipment and instrumentation, potable water, and limited decontamination facilities must be in place prior to start of operations at the ISFSI. Considerations must be made to provide for the following:

- Effluent monitoring and control;
- Airborne and direct radiation monitoring capabilities;
- Personnel and equipment access control;
- Radioactive material control;
- Decontamination capabilities for personnel and equipment; and
- ALARA equipment such as temporary shielding for low exposure waiting areas, video surveillance equipment, and other remote or robotic equipment may be appropriate.

In accordance with the requirements stated in 10 CFR 20 and 10 CFR 72, sufficient controls must be in place to protect the workers and the public from radiation. Therefore, at a minimum, the following requirements must be satisfied prior to commencement of radiological work activities at the site:

- Approved radiological control procedures in place;
- A sufficient number of trained and qualified RCTs are mobilized and ready to support operations at the pad (estimated at one supervisor and three RCTs per shift);
- Sufficient quantity of radiation control equipment and consumable supplies on hand to support the planned work activities (PPE, signage for posting, radioactive waste controls, etc.);
- Qualified RP/ALARA supervision assigned for oversight of radiological work activities;
- Personnel dosimetry for monitoring worker doses including Thermoluminescent Dosimeters and electronic dosimeters available for issue;
- A bioassay program in place for worker monitoring (in vivo and in vitro as necessary);
- Health Physics instrumentation calibrated and suited for the types of surveys and measurements required in place;
- Detailed work plans developed that would be used for RWP preparation and ALARA evaluation; and
- In addition to the RCTs, workers that are supporting operation have been trained and qualified to the applicable Rad Worker Program requirements.

6.6 Quality Assurance Requirements

All quality-affecting activities associated with cask handling operations including transportation would be controlled under an NRC-approved Quality Assurance Plan (QAP) meeting the requirements of 10 CFR Part 50, Appendix B (within owner-controlled area); 10 CFR Part 71, Subpart H (as related to transportation); and 10 CFR Part 72, Subpart G (within the ISFSI site), as applicable to the scope of work. The licensee's QAP is to be used to control activities related to use of a packaging for the shipment of licensed material performed by the licensee (qualified cask user/operator) in accordance with 10 CFR Part 71.

A QAP would be applied to the design, analysis, fabrication, and testing of the HI-STAR 100MB components that are important to safety and the support equipment that is either important to safety or safety-related. Additionally, the licensee's QAP would be used to control transportation activities per the licensee's QAP and applicable 10 CFR Part 71 requirements.

Fabrication of important safety components and support equipment for the HI-STAR 100MB systems would be controlled under the licensee's QAP or by a qualified supplier's QAP that has been approved for this scope of work. Component classification guidance is taken from Regulatory Guide 7.10 [35] and NUREG/CR-6407 [36] to establish a graded approach to QA. These QAPs are used to establish the quality category of components, subassemblies, and piece parts according to each item's relative importance to safety.

7.0 BUDGET AND SPENDING PLAN

The total estimated budget for the whole VY campaign organized over 81 calendar weeks is $18.5M. This amount is based on the assumptions and estimates listed below. The estimates provided here are centerline estimates based on the current knowledge of the sites and of the operations needed. They are based on operations being performed on the current date (2024). This section provides a breakdown of the estimated campaign costs of de-inventorying the VY site, by activity, and to the extent cost information is currently available. This report does not specify the party or parties responsible for the costs estimated herein.

The following assumptions were made to assess the costs in this report:

- One set of 5 transport casks, 5 pairs of impact limiters, 5 personnel barriers, 5 transport cradles for loading and unloading a canister into the cask, etc. are provided by the cask vendor. Ancillary equipment to prepare the transport cask for transportation (e.g., tooling, lifting yoke, spreader bar, leak test equipment, VDS, etc.) will be supplied by the cask vendor. No estimate is provided here for this equipment.
- The cask railcar, escort car, buffer cars, locomotives, etc. are provided by DOE. No estimate is provided here.
- The site-specific physical road survey and the complete de-inventory study which includes communication with the site and official stakeholders are not included here.
- It is assumed that no covered building would be used at the designed transload location. No cost for a new building construction or pad is considered here.
- Only the train transport to the selected short line to Class I transfer location is considered. Train delivery to the final destination and return shipment of the empties by train are not included. For scheduling purposes, the destination is considered to be GCUS. Only the cost of the loaded cask transports from the origin site to the Class I railroad is included.
- Assumptions are made based on the current status of the origin site and current understanding of the operation. Some pieces of equipment are not yet designed, and no reasonable assumptions are made at this point.
- No additional onsite fencing and lighting is considered.
- A total of 12 iterations of approximately 6 working weeks each will be necessary to complete the de-inventory. In addition, another iteration of 9 weeks is added and will happen before the first shipment for campaign readiness, procedure writing, dry run, testing and training purpose. 1 week of contingency per iteration is included in the 6 weeks duration.
- Pre-loading canisters inspection activities are not included in the cost estimates.
- Does not account for potential impact of additional specific local regulatory requirements, if applicable, and assumed labor performed by vendor-approved specialists.

7.1 Fees and Permits

No truck permit is expected to be necessary for these moves other than the one that may be required for the mobilization of the transfer equipment (that are already included in the mobilization cost) as there is no highway transport of the casks.

No physical road survey would be expected.

An estimated amount of $50,000 for the NRC route approval processing, preparation of the security plan, route survey and the clearance are to be expected. In addition to these costs, states may require the payment of fees for the transport of SNF or HLW through the States. These costs are currently unknown.

7.2 Campaign Operation Management

The Campaign Operation Management would require a crew to be dedicated to the preparation, planning, and supervision of the operation, as described in **Section 6.0**. The Operation Management Team would be composed of a Project Manager, Plant Manager/Coordinator supported by a Scheduler and some engineering staff.

The estimated cost for the Management crew for the 81-week campaign is $2.4 million. In addition to the physical road survey, the management crew would also oversee the planning phase leading to a complete de-inventory study including communication with the site and official stakeholders. This is not included here.

7.3 Equipment for the Loading Operations

The estimated costs for the mobilization of the equipment on site, the lease of one 375-ton crane, a 150-ton crane, and operators for 81 weeks at the shipper site and one large forklift, two-man baskets, three welding machines, miscellaneous supplies, a telescopic handler and the mobilization/demobilization of the equipment would be approximately $1.8 million for the duration of the VY campaign.

Additional equipment is also necessary for the transfer of the Holtec system, including the MPC canister lifting, HI-STORM module lifting and handling system, and transfer trailer. The equipment will be provided by the dry storage system vendor. Lease cost, the mobilization and demobilization costs of this equipment are not provided here.

No cost for a new building or infrastructure is considered here.

7.4 Site modifications

No significant modification of the site is required to support the operation as described in **Section 6.0**.

7.5 In-Transit Security

The security at the shipping site and at the receiving site would be ensured by the crew already in place at the site and is therefore not included in this estimate. The security in-transit on the train to the final destination is not included in this cost estimate.

The in-transit security composed of the security crew is estimated $250,000 for the movement to the Class I railroad for the campaign. These costs will be included in the overall security costs for the entire movement to the final destination as it is reasonable to assume the same security crew will be responsible for the security over the entire shipment.

7.6 Cask Transportation Services at Transshipment Site

The Cask Transportation Services team would consist of a Transport Coordinator located on site who would coordinate the transport operations with truck drivers, support the shipper in the preparation of shipping documentation, and marking, labeling, and placarding. The Transport Coordinator will also notify the required regulatory body in accordance with the applicable regulation. The Transport Coordinator will be supported by a Transport Analyst. They will consolidate the communication between the shipper site, consignee site, truck drivers, and different stakeholders involved during the transportation phases. The team will also oversee the coordination for the return of the empty casks (detailed in **Section 6.0**).

The transportation costs include the rail transport of the casks loaded on railcars from the origin site to the location where the short line meets the class I railroad.

The estimated costs for the cask transportation services are $5 million for the entire campaign.

7.7 On-site Operations

The shipping site operations would be composed of the crew listed in **Section 6.4**. The estimate for the whole crew for the onsite operation is $6.6 million for the entire campaign.

7.8 Breakdown of the Costs by Activity

This section provides a breakdown of the estimated $18.5 million cost of de-inventorying the VY site, by activity, and to the extent cost information is currently available.

- Equipment (e.g., transportation casks, railcars, cranes, movers, etc.): >$4.48 million (cost of casks and railcars is currently unknown)
- Transportation services and security: $5 million
- Management and labor: $9 million
- Infrastructure: $0

7.9 Additional Cost Estimates to Support De-Inventory Activities

Additional costs estimated in this section that are associated with some of the activities involving the shipment of the casks from the transload site to GCUS include: cask consist transportation services (loaded and unloaded) costs; emergency response center operation costs; railcar maintenance services costs; and transportation cask maintenance and compliance costs. Estimates for these costs are provided in the following sub-sections; however, these costs have several significant conditions associated with them including:

- The shipment of the consist occurs in the current quarter of the calendar year (4th quarter of 2024), as rates are temporal.

- The transportation casks meet the 10 CFR Part 71 regulatory limits (e.g., thermal, structural, and radiological) at the time of shipment.
- The maintenance and compliance activities assumed in the cost estimate for the transportation casks are representative of the yet to be built casks systems utilized in this report (i.e., the HI-STAR 100) and are similar to one another.
- The maintenance activities projected for the railcars are representative of DOE's railcar design of the Atlas cask car and will be built to ship the transportation casks identified in this report.
- The transportation cask systems and railcars are assumed to be leased to DOE and maintained at vendor operated facilities.
- The emergency response center is assumed to have been designed for the handling of multiple near-simultaneous rail shipments of SNF and estimated costs are for personal assigned full time to the monitoring of shipments only from the VY ISFSI and the portion of the facility and communication equipment needed to support the shipments from the VY ISFSI.

Due to the potential significant impact of these stated conditions on the following identified costs, the values are presented in ranges that provide a rough order of magnitude for the associated costs. Development of more precise values requires resolution to the above conditions, consideration of economies of scale and synergies associated with the de-inventory of multiple sites at the same or nearly same time, understanding of ownership of equipment (e.g., railcars and casks), and a comprehensive breakdown of activities.

7.9.1 Estimate of Transportation Costs

For the CSX movement of a single rail consist from Palmer, MA interchange to the GCUS site, which is a point-to-point distance of approximately 1,113 railroad miles, costs were developed to be comparable to current market rates for radioactive materials rail shipments and include:

- Total Estimated Costs: $600,000 to $1,000,000/consist (per round trip)
- Therefore, the average freight costs of shipping the consist, which is assumed to be made up of 5 cask cars loaded with transportation casks either containing SNF or empty, 2 buffer cars[8], and an escort car, is approximately $800,000 (2024). This value includes the shipment of the consist from Palmer, MA interchange to GCUS and the return trip of the empty transportation casks on a dedicated train for the loaded movement and merchandise train for the empty return and includes the use of two locomotives in both directions. For clarification, the transport costs from VY to the Palmer, MA interchange are included in section 7.6.

[8] Two buffer cars are assumed to be a satisfactory number. However, more buffer cars may be required or conservatively added based on route clearances, axle loads, and results from testing of full consists (part of DOE's current Atlas railcar program).

7.9.2 Estimate of Emergency Response Center Operation Costs

The estimated operating costs for an Emergency Response Center are based on the following additional assumptions:

- A team of 5 transport analysts to ensure a 24/7 on-duty presence and to allow an individual to attend the required periodic training.
- One manager with the dual role of resource manager and technical expert on emergency response.
- The crew will support the emergency response and will provide the resources to support the day-to-day transport operations with the support of a transport coordinator located on site.
- The crew will be in charge of the coordination and necessary notifications. They will coordinate with the transport vendors (rail carriers, trucking companies, etc.), DOE, and the shipping and receiving sites. They will also act as the interface with the first responders and their contact information will be indicated on the shipping documentation.
- The entire crew will be trained to the DOT, NRC, DOE, and shipper's requirements. The crew will have the necessary DOE clearances, access to the safeguard's information, and appropriate training. Additional emergency training such as FEMA training would also be useful.

The estimated cost for a crew satisfying these assumptions is between $2 and $2.7 million (2024) per year. This number is considered independent of the number of shipments and includes the costs for an office and associated communication equipment.

7.9.3 Estimate of Railcar Maintenance Services Costs

To develop an estimate for railcar maintenance services costs, a combination of experience from an existing fleet of railcars used to ship low level waste in the U.S. and activities involving the design and potential building of AAR S-2043 compliant cask and buffer railcars for SNF shipment was utilized. For the purpose of estimating these costs, they are assumed for a single consist, made up of the aforementioned two buffer cars, five cask cars, and one escort car and dedicated to the de-inventory of the VY ISFSI, as opposed to costs associated with maintaining a fleet of railcars for the de-inventory of multiple sites. No maintenance costs associated with locomotives are included in this assessment. In addition:

- Routine railcar maintenance is assumed provided by the handling rail carriers and depending on the costs, will be invoiced to the car owner (major and emergency maintenance) or covered by the shipping rate (minor/regular maintenance).
- Buffer car (4 axles) maintenance costs are estimated to be approximately $100/month/car.
- Cask car (12 axles) maintenance costs are estimated to be approximately $200/month/car.
- Escort car (4 axles) maintenance costs are estimated to be approximately $250/month/car.
- Costs associated with administering a fleet maintenance program are not included.
- The period of performance is assumed to be 19 months for the 81-week estimated schedule.

The above costs associated with the maintenance of a fleet of railcars encompass activities associated with the physical inspection, periodic regular servicing, and minor routine maintenance and repair activities. In addition, administrative costs for maintaining the program and covering taxes and insurance are included in the above costs. However, these costs are estimated to only cover the cars in use for the de-inventory of the VY ISFSI, rather than the costs associated with establishing and maintaining a facility and fleet for the larger inventory of railcars needed for a national campaign. A separate assessment would need to be performed to establish if it is more prudent to lease the needed support services from an existing qualified supplier rather than establishing a dedicated facility to service, maintain, and store this fleet of railcars considering:

- Administrative costs are estimated to range from $40,000 to $100,000 per year for such a support facility.
- Taxes can vary significantly by site for such a support facility, which could be placed in a large number of jurisdictions due to the number of potential de-inventory sites.
- Similarly, construction and maintenance costs for such a facility can vary widely depending on the suitable site selected.
- Staffing costs for such a facility would also vary by site selected.

As noted above, routine maintenance activities for railcars are generally provided by the rail carrier and a portion is covered in freight rates. Maintenance work beyond routine serving of the cars is estimated to be in the range of $5,000 to $25,000 (2024) per major inspection period for the five cask cars and between $2,000 and $10,000 (2024) for the two buffer cars. This cost estimate covers a single maintenance occurrence, when the car is inspected, and major maintenance is performed. Typically, major maintenance can occur every 100,000 miles, annually, or at a five-year routine inspection, whichever comes first. Due to the sensitive nature of the composition of the escort car, details on the cost for maintenance services are not readily available, but for estimating purposes a range of $10,000 to $50,000 (2024) per major inspection period should be assumed for an escort car. This cost includes maintenance activities involving the rail portion/undercarriage of this car (e.g., trucks, axles, etc.), but does not include any repairs or upgrades to the electronics/instruments located on the escort car.

Using this data, a range of $17,000 to $85,000 (2024) per major inspection period would cover the maintenance costs for the consist to be used to de-inventory the VY ISFSI; however, the more probable cost is approximately $19,000 (2024) per major inspection period.

7.9.4 Estimate of Transportation Cask Maintenance and Compliance Costs

To estimate the costs associated with the maintenance of a transportation cask, the following additional assumptions were made:

- One single shop is assumed to be used to perform the maintenance for all the transport casks (including those from different cask vendors if applicable).
- Costs associated with the transport to or from this shop are not included, as its location has not yet been established (although an economic argument could be made to locate this facility near the receiver site to minimize the transport costs).
- The shop where maintenance activities are to take place must have approval from the State to perform radiological work and dispose of the radioactive wastes potentially

generated by the maintenance activities, noting the shop will need to open potentially contaminated transportation casks that may result in the release of some contamination.

- The shop must provide facilities for the storage of transportation casks, potentially for long periods of time.
- The shop must also allow for the training of personnel on cask maintenance operations.
- The shop must provide a covered building to allow maintenance operations to occur under any weather conditions and at any time of the year.
- The shop must be able to receive and store railcars (preferred) and/or HHT and ideally be connected by a rail spur to a major railroad.
- The shop must be equipped with a crane capable of lifting a transportation cask and the associated cradle/skid from a railcar or HHT:
    - Conservatively, the lifting capacity of this crane would need to be approximately 375 tons, although the transportation casks brought to this facility will be empty (i.e., will not include a canister with SNF).
    - From a nuclear safety standpoint, no critical load lift is necessary and hence, the crane does not need to be designed as single failure-proof.
    - The crane hook and height of the crane must be compatible with the lifting of yokes and associated rigging supplied by cask vendors.

- Some details of the transportation cask maintenance program will be different between cask vendors, however the bulk of the maintenance costs are assumed to involve the following larger scale common activities:
    - External decontamination of the casks
    - Internal decontamination of the casks
    - Replacement of sealing gaskets
    - Periodic maintenance and leak testing of the containment boundary
    - Load tests
    - Maintenance of spare parts
    - Maintenance of the leak testing tools
    - Maintenance of cask leak testing equipment
    - Maintenance of the vacuum drying systems
    - Maintenance of lifting and support equipment (yokes, trunnions, skids, etc.)
- Leak testing will be performed according to ANSI N14.5-2014, unless specified otherwise in a Safety Analysis Report, by an American Society for Nondestructive Testing (ASNT) Level II cask operator.
- The maintenance program will be approved by an ASNT Level III reviewer and performed in accordance to the specifications identified in each transportation cask's Safety Analysis Report.

- The single shop will require a radiation protection plan that will be implemented and maintained.
- The size of the facility and the staff are assumed to limit maintenance to only one cask at a time.
- The staff at this single shop will be composed of 2 trained operators, some engineering support, a ½ time ASNT Level II cask operator, and a part time ASNT level III procedure writer/reviewer.

Given these assumptions, the estimated annual transportation cask maintenance costs will range from \$2.1 to \$2.9 million (2024) per facility, which is assumed to handle only one cask at a time.

8.0 SECURITY PLAN AND PROCEDURES

A Security Plan would encompass strategies and procedures in compliance with 49 CFR Part 172 to ensure the safety and the security of the material, employees, and the public during loading, transloading activities, and movement associated with the transportation of the SNF and GTCC LLW from the VY ISFSI to the final destination.

The transportation activities covered by the plan would include all aspects of the shipment from loading the transportation casks at the VY ISFSI, preparing them for movement on the transport trailer to the on-site rail transload track, to the train movement to the hypothetical destination of the GCUS.

Multiple entities have jurisdiction over commercial shipments of SNF in the U.S. including the NRC, USCG, and the DOT. The DOT's PHMSA issues the Hazardous Materials Regulations in 49 CFR Parts 171-180 and represents the DOT in international organizations. The relevant regulations addressing the security of SNF during transportation include 49 CFR Parts 172-177 (DOT regulations for shipping hazardous materials); 10 CFR 71.97 (advance notification); 10 CFR 73.20 (general performance requirements), 73.37 (requirements for irradiated reactor fuel in transit) and 73.72 (advance notification); and 49 CFR Part 172, Subpart I.

The basic statute regulating HAZMAT transportation in commerce in the U.S. is 49 U.S. Code 5101 et seq., which identifies "hazardous materials" by commodity, or a group of commodities. It identifies regulations for the safe movement of HAZMAT, including safety and security for movements within the U.S. Several agencies have jurisdiction over different aspects of commercial transportation of HAZMAT depending on the mode of transport and other circumstances of the shipment. These agencies include the PHMSA, Federal Motor Carrier Safety Administration, FRA, Federal Aviation Administration, and USCG. Together these entities cover all aspects of commercial transportation of HAZMAT, which includes the movement of SNF, by road, rail, air, or water with an emphasis on safely moving this material.

Given the geographic proximity of both the ISFSI and transload site to navigable waters, the Maritime Transportation Security Act (MTSA) is assumed to govern the Vermont Yankee water-served site, even though the recommended mode of transportation is direct rail or HHT. Any site, whether private or public, that is on or adjacent to water and handling or storing HAZMAT will be governed by the USCG regulations, and it is assumed that MTSA provisions apply to both the ISFSI and transload site. As such, additional security precautions should be implemented, including development, in consultation with the USCG, of an MTSA security plan, if one does not already exist for the site. Likewise, when movement of SNF is occurring on-site, the USCG should be notified to monitor and patrol the navigable waters adjacent to the facility to provide a secure maritime area and limit access to the site by water. The Captain of the Port (COTP) has the authority to establish the area as either a Safety Zone or Security Zone during loading operations.

In addition to the maritime security measures for the rail-served transload site, the rail carrier would be notified the site is being declared a "rail secure area" (due to the transload operation) and maintained and protected with physical security measures to prevent unauthorized access, in accordance with 49 CFR 1580.107. This means all provisions of the Security Plan would be adhered to and enforced and, effectively, a layered security approach would be established to govern the site for ISFSI transload operation, the HHT-to-rail movement, and the rail transload operations.

While maintaining security protocols relevant to the control of sensitive information regarding the movement of the SNF and its associated procedures, all relevant parties to the transportation activity will receive a copy of the Security Plan, and complete applicable training. All personnel will be required to return a signed copy of the Security Plan review signature sheet to the designated site administrator as part of documentation control.

8.1 Security Plan Requirements

Security plans for the transportation of hazardous materials in commerce are addressed in 49 CFR Part 172, Subpart I, which mandates a security plan must be in writing and contain an assessment of security risks for transportation of hazardous materials identified in 49 CFR 172.800, which includes HRCQ of radioactive materials. The plan must address the identified risks including security, while the material is in-route. The Security Plan must also provide protection of the ISFSI facility and transload activities incidental to the transportation, including loading and unloading operations. This document assumes the provisions of the MTSA of 2002 are applicable. No formal determination has yet been made by the USCG or the NRC as to its applicability.

As delineated in 49 CFR 172.802, a Security Plan must also include the following elements addressing:

- Personnel security: Measures to confirm information provided by job applicants hired for positions that involve access to, and handling of, the HAZMAT covered by the Security Plan;
- Unauthorized access: Measures to address the assessed risk that unauthorized persons may gain access to the HAZMAT or transport conveyances being prepared for transportation of the HAZMAT;
- En-route security: Measures to address the assessed security risks of shipments of HAZMAT covered by the Security Plan in-route from origin to destination, including shipments stored incidental to movement;
- Security Plan Owner: Identification, by job title, of the senior management official responsible for overall development and implementation of the Security Plan;
- Security duties: Duties and responsibilities for each position or department tasked with implementing any portion of the plan and the process of notifying employees when specific elements must be implemented;
- Training: Description of the training required by HAZMAT employees in accordance with 49 CFR 172.704 (a)(4) and (a)(5); and
- Risk Assessment: An assessment of the following:
  - Transportation security risks for shipments of the specific HAZMAT listed in 49 CFR 172.800 (includes radioactive materials).
  - Site-specific or location-specific risks associated with facilities at which the HAZMAT is prepared for transportation, stored, or unloaded incidental to movement (e.g., rail transload facility).
  - Appropriate measures to address the assessed risks.

The Security Plan, including the transportation security risk assessment, must be in writing and retained for as long as it remains in effect. It must be reviewed, at a minimum, on an annual basis and updated as necessary to reflect changing circumstances. Each person required to develop or implement a portion of the Security Plan must maintain a copy of the plan (written or electronic) that is accessible at their principal place of business and must make the plan available upon request, at a reasonable time and location, to an authorized official of the DOT or the Department of Homeland Security (DHS). The most recent version of the Security Plan, or portions thereof, must be available to the employees who are responsible for implementing it, consistent with personnel security clearance, or background investigation restrictions and a demonstrated need to know. When the Security Plan is updated or revised, all employees responsible for implementing it must be notified and all copies of the plan must be maintained as of the date of the most recent revision.

8.2 Scope

Key transportation, security, and Federal and State agency officials involved in the transport will need to be identified. The truck and rail transfer sites where the SNF will be loaded or unloaded will also need to be identified. Security professionals will conduct security and risk analyses from point of origin (Vermont Yankee) to the final destination. In addition, a physical route analysis will be conducted to determine any potential logistical issues that may exist or that could pose a risk to security during all phases of the operation. Security professionals involved will identify requirements for compliance as part of the action plan and define and establish procedures for the operation, including contingency plans.

8.3 Identifying and Selecting the Principal Parties (Administrative Team)

The following should be considered for the identification and selection of the principal parties involved in the development of the Security Plan:

- The Security Contractor would chair the Administrative Team for the entire process or until an alternate is determined;
- Once the requirements of each transload site and the destination of the SNF and GTCC LLW is determined, contact should be made with all parties involved in the operation, including the rail and truck operators that will be involved with the transfer;
- Per 10 CFR 73.37 (b)(1)(viii), the initial contact with logistical partners should be made at a high level of the organizations in order to ensure the protection of Safeguards Information;
- Initial meetings should bring together the licensee, security, and risk assessment contractor or designee, high level logistical partners in truck, rail, and other vendors (e.g., crane and rigging companies and monitoring partners), DHS, DOT, USCG, NRC, and other Federal and State officials, as needed;
- The meeting should address the concerns of each representative group, identify any groups that may not be present or need to be included, and come away with a framework for managing the project and how communications will be handled at all phases of the operation; and

- The purpose of this meeting is to establish the Administrative Team as a partnership dedicated to working together to ensure the safety and security of the SNF and GTCC LLW in transportation and identify any areas of concern.

8.4 Selecting the Rail/Truck Transload Site to be Used

The following should be considered when selecting and/or using a secure, existing transload site:

- If an existing transload site is identified, it is preferred that it be a fully enclosed and secure commercial installation or that it can be easily secured. If the site must be established, these measures must be considered to enclose the site to create a secure perimeter around the loading location. This will include fencing and lighting around the perimeter of the property, installing security cameras and limiting egress and ingress to secure gates with locks at both the rail and truck entrances;
- Establish direct contacts at the site(s) for logistics and security;
- Ensure that all persons on site with direct knowledge or access to the transfer location have background checks. Security clearances may also be considered but are not required; and
- Assuming MTSA jurisdiction over the site and transload locations, TWIC identification cards would be mandatory for workers. TWIC cards are issued by TSA and involve background and fingerprint checks.

8.5 Identifying and Selecting the Risk and Security Assessment Team

Identification and selection of the Risk and Security Assessment Team (RSAT) should consider the following:

- Once the routes are proposed and agreed to by the Administrative Team, a RSAT shall be formed to conduct a security risk assessment of the routes and transfer sites;
- The RSAT will be selected and approved by the Administrative Team; and
- The RSAT will be comprised of security and risk professionals from licensees, security contractors, and any Federal and State agency that wishes to participate.

The RSAT will perform the security risk assessment of the surrounding transportation infrastructure. This includes, but is not limited to, bridges, tunnels, overpasses, proximity to population centers or landmarks, direct route access to the installation, identification of potential bottlenecks, narrow roads, interstate highways, proximity to hospitals, schools, civic centers, shipping channels, and highly populated areas. The assessment should include a 10-mile area on either side of the center of the proposed transportation route. Contingency routes should be identified and assessed throughout the transportation route.

Each step in the proposed route should be geographically divided and the results submitted to the Administrative Team for evaluation. If the RSAT uncovers any major concerns during the Security Risk Assessment, the next portion of the route geographically should be placed on hold until the issue is resolved in the event the transportation route must be changed. If no major concerns are uncovered, the RSAT can continue with the next geographical portion of the trip. During the assessment, agreements need to be made with all state agencies in the state(s) that is included in the assessment before finalizing the assessment.

8.6 Evaluating the Security and Risk Assessment

Upon completion of each geographical portion of the risk assessment, the assessment will be submitted to the Administrative Team for review, evaluation, and approval. All identified risks will be evaluated and resolved, or a contingency developed prior to approval of that portion of the transportation route.

8.7 Developing a Hazardous Materials Security Plan

The following should be considered while developing a HAZMAT Security Plan:

- Existing Security Plans for the site, rail carriers, trucking companies and transload sites, should be incorporated into the overall plan, especially to develop a concise hand-off of security responsibilities at each transfer;
- The Security Plan hand-off of responsibility at each site will be reviewed by the RSAT and evaluated and approved by the Administrative Team, DHS, DOT, USCG, the licensee, and each individual state authority for each state that will be crossed;
- Strict chain-of-custody protocols will be established, and all physical transfers will be "manned" and documented [28]; and
- Any additional Security Plan that will be needed at the rail/truck transfer sites will be developed using the "Risk Management Framework for Hazardous Materials Transportation" [29] and the "Enhancing Security of Hazardous Materials Shipments Against Acts of Terrorism or Sabotage" [28].

8.8 Developing Security and Communication Protocols

Security and communication protocols will be developed as follows by the Administrative Team:

- All personnel identified above will have background checks completed prior to being included in any communications;
- The level of security required for operations personnel such as railroad personnel, truck drivers, riggers, flag men, security personnel, and others once the project is operational must be identified and classified;
- What type of communications can/ cannot be used during the entire project;
- What level of distribution will be allowed and how that will be administered and monitored; and
- Develop and approve all distribution lists and approved contacts.

8.9 Developing a Security Plan and Protocols for Marine Facilities

The following will be considered in the development of a Security Plan and associated protocols for a marine facility site (VY and on-site transload track).

When a site handling hazardous materials, including SNF, is located near or on the water, additional maritime security precautions should be considered. While no determination has been made on its applicability, the MTSA describes prudent security measures for maritime facilities.

A Facility Security Plan (FSP) should be developed that identifies procedures and processes for transportation activities on site. The FSP is implemented by a Facility Security Officer (FSO) and submitted to the COTP for the Sector in which the site is located. The RSAT will conduct a security assessment up to the entrance of the marine facility. A review of the FSP in effect inside the marine facility will be conducted with the permission of the USCG COTP.

An Area Maritime Security Plan should be developed that identifies procedures for handling the maritime domain surrounding the facility during a transportation activity. Included in the Area Maritime Security Plan would be buffer zones (per 33 CFR 165.2 and 165.5) where commercial or pleasure vessels would not be permitted during a transportation activity at the site. If vessels are to be used to transport SNF, the vessels would need a Vessel Security Plan (VSP). The VSP outlines vessel security and identifies the Vessel Security Officer, who would be delegated the responsibility of implementing the VSP and coordinating with the USCG and the FSO during a transportation activity. This plan should be created in coordination with the COTP.

8.10 Railroad Security Requirements

The following are railroad security-related requirements:

- The TSA published rules regarding the rail transportation of certain HAZMAT, which became effective on December 26, 2008 [30]. The materials subject to these rules include explosive, toxic inhalation hazards (TIH), poisonous inhalation hazard (PIH), and HRCQ. TSA refers to these commodities collectively as Rail Security-Sensitive Materials (RSSM). As a result of these rules, the carrier will only be able to accept or deliver RSSM from Rail Secure Areas;
- There are additional requirements for delivery/acceptance of RSSM in designated High Threat Urban Areas (HTUA), but none of the geographical locations involved in this assessment fall into designated HTUA;
- Shipments of RSSM will be subject to chain-of-custody requirements which apply:
    - To all shippers of these materials and
    - To receivers only located in HTUA;
- Personnel must be physically present for attended hand-offs of the railcars to document the transfer by recording the following information:
    - Each railcar's initial and number,
    - The individual attending the transfer,
    - The location of the transfer, and
    - The date and time of the transfer;
- Additionally, for any location in a HTUA that receives RSSM by rail, security personnel must be present 24 hours a day, 7 days per week. For any location that has notified the rail carrier that an RSSM railcar is available for shipment (released);
- Security personnel must be present 24 hours a day, 7 days per week from the time notification was provided to the rail carrier until the transfer has been completed and appropriately documented by both the shipper and rail carrier;

- A facility that is directly served by a railroad will be required to provide the following information to the carrier:
    - Acknowledgement that the facility has an appropriately designated Rail Secure Area,
    - The facility has designed and implemented procedures to ensure compliance with TSA chain-of-custody requirements effective as of February 15, 2009 [30] (the requirements remain the same for rail-served sites handling HAZMAT),
    - If the facility has not established a Rail Secure Area or put chain-of-custody procedures in place, declare when it expects to complete these requirements and what interim measures are in place to ensure compliance in the meantime,
    - Without compliance with these measures, the rail carrier may refuse to perform switching services at the facility until the requirements are met, and
    - Proper and current contact information must be supplied, including company name, street address, phone number, and primary point of contact.
- There is no requirement to submit the Security Plan to the rail carrier for review or approval, but the shipper must inform the serving rail carrier that the plan exists; and
- All of the above will apply to the SNF rail transload facility.

8.11 Provisions for Protection of In-Transit Road Shipments

Specific provisions for protection of in-transit road shipments of SNF are found in 10 CFR 73.37(c):

- The transportation vehicle is:
    - Occupied by at least two individuals, one of whom serves as an armed escort, and escorted by an armed member of the local law enforcement agency in a mobile unit of such agency; or
    - Led by a separate vehicle occupied by at least one armed escort, and trailed by a third vehicle occupied by at least one armed escort.
- As permitted by law, all armed escorts are equipped with a minimum of two weapons. This requirement does not apply to LLEA personnel who are performing escort duties.
- Transport and escort vehicles are equipped with redundant communication abilities that provide 2-way communications between the transport vehicle, the escort vehicle(s), the Movement Control Center (MCC), LLEA, and one another. To ensure that 2-way communication is possible at all times, alternate communications should not be subject to the same failure modes as the primary communication.
- The transport vehicle must be equipped with NRC-approved features that permit immobilization of the cab or cargo-carrying portion of the vehicle with the purpose being to render the vehicle inoperable or incapable of movement under its own power. It must take at least 30 minutes to reverse the immobility once engaged.

- The transport vehicle driver must be trained with, and capable of implementing, the transport vehicle immobilization, communications, and other security procedures.

Shipments must be continuously and actively monitored by a telemetric position monitoring system or an alternate tracking system reporting to an MCC. The MCC shall:

- Provide positive confirmation of the location, status, and control over the shipment,
- Implement preplanned procedures in response to deviations from the authorized routes, or
- Notification of actual, attempted, or suspicious activities related to the theft loss or diversion of a shipment.

These procedures must include contact information for the appropriate LLEA along the shipment route.

8.12 Provisions for Protection of In-Transit Rail Shipments

The following provisions are required for protection of in-transit rail shipments in accordance with 10 CFR 73.37(d):

- Loaded cars must be accompanied by two armed escorts.
- At least one escort is stationed on the train, permitting observation of the shipment car while in motion (generally, in an escort or security car).
- As permitted by law, all armed escorts are equipped with a minimum of two weapons. This requirement does not apply to LLEA personnel who are performing escort duties.
- The train operator(s) and each escort are equipped with redundant communication capabilities that provide 2-way communications between the transport, the escort vehicle(s), the MCC, local law enforcement agencies, and one another.
- To ensure that 2-way communication is possible at all times, alternate communications should not be subject to the same failure modes as the primary communication device.
- Rail shipments must be monitored by a telemetric position monitoring system or an alternate tracking system reporting to the licensee, third-party, or rail carrier MCC.
- The MCC shall provide positive confirmation of the location of the shipment and its status.
- The MCC shall implement preplanned procedures in response to deviations from the authorized route or to a notification of actual, attempted, or suspicious activities related to the theft, diversion, or radiological sabotage of a shipment.
- These procedures shall include, but not be limited to, the identification of and contact information for the appropriate LLEA along the shipment route.

8.13 Provisions for Protection of In-Transit Barge Shipments

Specific provisions for protection of in-transit barge shipments are found in 10 CFR 73.37(e) and include:

- A shipment vessel while docked at a U.S. port is protected by:

    - Two armed escorts stationed on board the shipment vessel, or stationed on the dock at a location that will permit observation of the shipment vessel; or
    - A member of a LLEA, equipped with normal local law enforcement agency radio communications, who is stationed on board the shipment vessel, or on the dock at a location that will permit observation of the shipment vessel.
- As permitted by law, all armed escorts are equipped with a minimum of two weapons. This requirement does not apply to LLEA personnel who are performing escort duties.
- A shipment vessel, while within U.S. territorial waters, shall be accompanied by an individual, who may be an officer of the shipment vessel's crew, who will assure that the shipment is unloaded only as authorized by the licensee.
- Each armed escort is equipped with redundant communication abilities that provide 2-way communications between the vessel, the movement control center, local law enforcement agencies, and one another. To ensure that 2-way communication is possible at all times, alternate communications should not be subject to the same failure modes as the primary communication.

Because the on-site loading facility from the VY ISFSI to HHT is located adjacent to the waters of the U.S. waterway, the following will apply, even though no transportation on the waterways is expected to occur:

- U.S. waters extend to 3 nautical miles from the U.S. land territory, except for small offshore islands;
- Security between 3 and 12 nautical miles from the coast falls under the responsibility of the USCG;
- If a U.S. port is used for transport, the licensee shall coordinate with both the USCG and local port authorities during a transport (or transload) operation to ensure that all parties are appropriately informed and to ensure the physical protection thereof [31]; and
- If an established port facility is used, protocols of that MTSA plan will be enforced to protect the shipment from any threat presented from the rail transfer site being located on water or adjacent to the water and provide protection against theft, diversion, or radiologic sabotage while located adjacent or next to the water.

Items requiring action for protection of transload sites (HHT to rail) near navigable waterways include:

- MTSA plan to be developed and implemented on the rail transfer site or amended to include the transfer if already in place,
- Property to be fenced,
- Property to be lighted,
- Perimeter and fence line to be surveilled by a closed-circuit camera system,
- All personnel on a water-served site must obtain a TWIC,

- All personnel who are on duty will have the capability to delay or impede such acts as listed for the Security Plan and can request assistance promptly from LLEA responses forces and USCG, and
- All provisions applicable to U.S. ports may apply to a private water-served site, including coordinating with USCG and local port authorities.

9.0 EMERGENCY RESPONSE PLAN AND PREPAREDNESS

The purpose of the Emergency Response Plan (ERP) is to establish notification protocols and provide response guidance in the event of a reportable incident involving a HHT, rail, or barge shipment transporting HAZMAT. The ERP includes all pertinent contact and contingency information including specific contact names and phone numbers, as well as procedures in the event of an incident. These procedures encompass the requirements for providing and maintaining emergency information during transportation and at facilities where HAZMAT is loaded, stored, or otherwise handled during every phase of transportation [32][39].

Emergency response information is required to be immediately available for use at all times when HAZMAT is present. It is also required to be immediately available to any Federal, State, or local government agency representative who responds to an incident or is investigating an incident (per 49 CFR 172.600(c)(1)&(2)) [33].

9.1 General Guidance for an Emergency Response Plan

As required by 49 CFR 172.602, emergency response information must be provided that can be used in the mitigation of an incident involving hazardous materials and, as a minimum, must contain the following information:

- The basic description and technical name of the hazardous material;
- Immediate hazards to health;
- Risks of fire or explosion;
- Immediate precautions to be taken in the event of an accident or incident;
- Immediate methods for handling fires;
- Initial methods for handling spills or leaks in the absence of fire; and
- Preliminary first aid measures.

This information must be written in English and available for use apart from the package and provided in an approved format such as shipping papers or a document containing all the relevant information that will be found in shipping papers [32].

This emergency response information is usually incorporated into an ERP. The ERP will include the emergency contact telephone number (per 49 CFR 172.604) and this number:

- Must be monitored at all times the HAZMAT is in transportation, including storage incidental to transportation;
- Must be monitored by a “person who is either knowledgeable of the hazardous material being shipped and has comprehensive emergency response and incident mitigation information for that material or has immediate access to a person who possesses such knowledge and information;”
- Must be entered on the shipping paper(s) immediately following the description of the hazardous material;

- Must be entered on the shipping paper(s) in a prominent, readily identifiable, and clearly visible manner; and
- Must be the number of the person offering the hazardous material for transportation when that person is also the emergency response information provider, or the number of an agency or organization capable of, and accepting responsibility for, providing the detailed information.

All HAZMAT rail shippers are registered with CHEMTREC, or a similar company, to provide the above requirements. Shippers must make sure to provide CHEMTREC with current information on the material before it is offered for transportation.

As stated above, the purpose of the ERP is to establish notification and response guidance in the event of a reportable transportation incident involving a HHT or rail shipment that is transporting hazardous material. The plan would include information in compliance with 49 CFR 172.600 to 172.606 (i.e., Subpart G) and other federal, state, and local requirements and regulations and is intended to provide direction by identifying immediate measures to contain the situation and ensure safety and security until the LLEA and emergency response professionals arrive on the scene.

The emergency response procedures apply to persons who offer, accept, transfer, or otherwise handle HAZMAT during transportation. In this case, the procedures will apply to site operations at VY, on-site HHT transport beginning with all transfer operations conducted at VY to transfer the overpacks from the ISFSI to the transfer trailer for the on-site transport to the on-site rail siding (existing lead track). This includes all transload operations to place the overpacks onto the railcars, movement of the dedicated train from the rail transload facility along the entire route from VY to the final destination.

The security personnel accompanying the train will remain with the train for the entire train movement.

Each entity involved in each facet of the transportation operation will develop its own emergency response information and procedures commonly included in an ERP. The plan will be disseminated to the appropriate employees and the information will become part of the overall Security Plan for the licensee. Each entity on the project will have separate and individual procedures respective to its role, but they will be coordinated for the project to delineate hand-off procedures (interfaces) to clearly define responsibilities for each phase and participant. Note that the limitations of information dissemination as identified by 10 CFR 71.11 must be considered before sharing information concerning safety, security, and emergency response.

An example of the index for such a plan and the information to be included is listed below. This example index comes from a proprietary ERP (containing safeguards information) from a trucking company that is actively transporting HAZMAT. It is only intended to be an example of the potential contents of an ERP.

Section 1: Purpose & Scope

Section 2: Commitments, Company procedures, Title 49 CFR related material

Section 3: References – 49 CFR Part 172 (subpart G), Hazardous Material Regulations, First Notifications, Emergency Response Guidebook (latest edition issued by DOT), Condition Reports, Assistance with Radioactive Material Transportation Incidents, Conference of Radiation Control Program Directors, Inc. (CRCPD) "CRCPD Notes," current edition.

Section 4: General - Definitions of relevant terms: Emergency, Hazardous Material, Minor and Major Incident, Reportable Quantity, Responsibilities identified for the following employees: Manager of Compliance, Director of Radiation Safety, Transload Facility Drivers, Driver Incident packet with checklists, schematics, etc.

Section 5: Notifications - Notification of Transportation Incidents, Minor and Reportable Incident Notification - definitions, Emergency Contact Phone Numbers for all Company (transload, etc.) employees including 24/7 contact numbers, Emergency Response Agencies for the jurisdictions in which the SNF is traveling, with requirements for notification and frequency, Emergency Contact Responsibilities

Section 6: Attachments - Incident Log, Checklist of notifications with internal and external notification contacts and contact numbers, Notifications and conditions for contacting the National Response Center and State Agencies, Blank incident logs indicating identifying incidents and resultant injuries, with room for documenting any damage, mode contact information is listed along with vehicle details and road location (for road), and any resulting drug tests.

9.2 VY Site-Specific Considerations for the Emergency Response Plan

The MUA identified the highest ranked route for transporting the SNF and GTCC LLW from VY to be a direct rail route, where the transportation casks would be directly loaded onto railcars. Since VY is located on or adjacent to a U.S. waterway (the Connecticut River), it is assumed that MTSA requirements apply, in addition to the Rail Secure Area designation. These two sources of provisions would present a layered security approach for the operations involved in the loading campaign. As a result, some additional fencing would be required to enclose the rail transload area (the portion of the track where the train would be loaded).

The USCG is responsible for reviewing and approving the MTSA plan for operations conducted on any water-served site, including activities at the ISFSI and rail transload site, as it pertains to safety and security of the sites from the coastline. The respective COTPs from the Ninth USCG District would be involved in the assessment of the plan. This may include a request from the site for the USCG to establish a barrier or security zone around the site while the on-site truck transport and rail transloading operations are conducted. The required notification would be given in writing to the serving rail carrier, NECR, stating that the area meets the requirements of a "rail secure area" and contact information will be supplied to the rail carrier. There is no requirement, as stated earlier, for the rail carrier to approve the Security Plan.

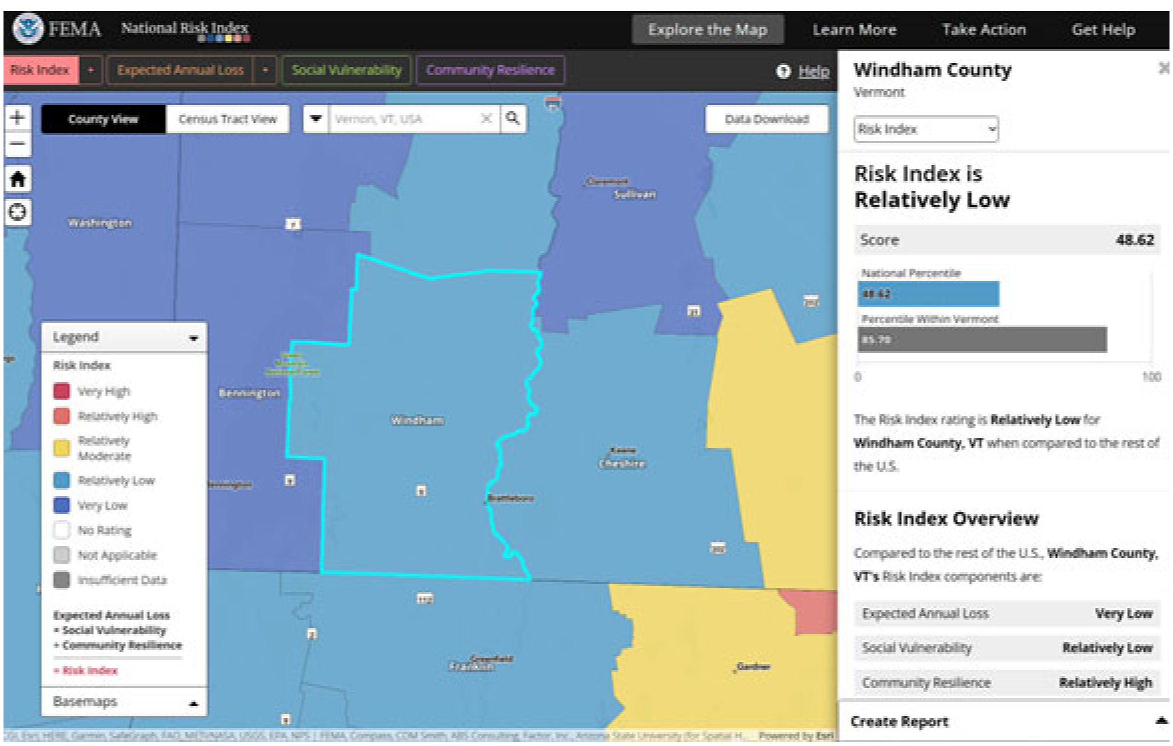
At this time, no formal determination has been made as to the applicability/jurisdiction of MTSA on the VY site. Compliance with MTSA is recommended as a conservative approach to implementing a multi-tiered security plan.

The site Security Plan for VY, as required by 10 CFR Part 73, is comprehensive and encompasses various protection measures for the vital areas of the site, including the ISFSI. This plan will include compliance with 10 CFR 73.55(e)(10)(ii), which requires the licensee to identify areas from which a waterborne vehicle must be restricted and in coordination with local, State, and federal agencies having jurisdiction over waterway approaches, provide periodic surveillance and observation of waterway approaches and adjacent areas. Hence, any MTSA requirements for the site are presumed to become part of the overall Security Plan for the site.

Additional considerations should include natural disaster planning and contingency plans for anticipated events. There are several resources available through the U.S. Army Core of Engineers (USACE) for assistance with emergency planning including the Flood Handbook. The National Oceanic and Atmospheric Administration (NOAA) provides forecasting data to help determine if, and when a flood is predicted for specific geographical areas. Some of the flood related data available includes flow and stage exceedance, historic and recent crests, as well as historical information and predictive information including "chances of exceeding river flow at specific mileposts." Other useful resources for monitoring and predicting weather related events and natural disasters are available from the FEMA Natural Hazards Assessment interactive map for Vernon, VT, the site address, and for Windham County: https://hazards.fema.gov/nri/map.

Figure 9-1 was generated from the National Risk Index, which is a dataset and online tool to help illustrate those communities most at risk for 18 natural hazards: avalanche, coastal flooding, cold wave, drought, earthquake, hail, heat wave, hurricane, ice storm, landslide, lightning, riverine flooding, strong wind, tornado, tsunami, volcanic activity, wildfire, and winter weather. It is intended as a guidance tool to fill gaps in available data and analyses to better inform federal, state, local, Tribal, and territorial decision makers as they develop risk reduction strategies. An example of one of the results for Windham County, VT is reflected in **Figure 9-1**. This figure identifies the overall risk index for Windham County, VT as being "Relatively Low" when compared to the rest of the United States.

Figure 9-1: Risk Index for Windham County, VT



In July 2023, New England and specifically Vermont experienced record flooding. The damage in Vermont is being called "historic and catastrophic" by Governor Phil Scott and the worst since tropical storm Irene in 2011. Much of the historic flooding has occurred in the capital, Montpelier, as a result of steady and stalled storms which affected the Winstook and Lemoille Rivers. Neither the Bellows Falls Dam nor the Vernon Dam have exceeded their capacities and there have not been floods at the VY site, but the flooding in cities close to Vernon has been devastating according to local newscasts. The VY site is located only 6.3 miles from Brattleboro, which experienced some flooding damage and 133 miles from Montpelier which took the brunt of these storms.

Other emergency management and planning information for Vermont can be found at https://anr.vermont.gov/ , https://waterdata.usgs.gov/nwis, and https://vem.vermont.gov/.

10.0 RECOMMENDED NEXT STEPS

Based on the results of this study, the following recommendations are provided to support implementation of a future de-inventory program. These recommendations are listed in approximate order of when to be addressed (earliest to latest):

1. Examine the on-site path from the ISFSI to each loading area and evaluate the need for improvements to ensure acceptable conditions of transport exist.
2. The MPCs will need to be evaluated prior to transport to ensure 10 CFR Part 71 requirements are met. At a minimum, this will need to involve a comparison of the fabrication records against the CoC and verification that the canister integrity has been maintained. It is recommended to allocate two to three years for this activity, which could involve licensing actions. In general, a complete transportability study consisting of a comparison of each transport cask and its contents in a transport configuration to the 10 CFR Part 71 CoC at the time the transport will be performed by the NRC licensee with the support of the transport cask certificate holders prior to transportation of each canister to be offered for transport.
3. The transportation cask for use needs to be finalized on. While this report recommends using the HI-STAR 100MB for all the MPCs on-site, there are other options that may want to be evaluated, such as the HI-STAR 100 and the HI-STAR 190.
4. Establish location of transfer pad needed to perform the following:
    a. Transfer the MPC-68 from the HI-STORM 100S storage cask to the HI-TRAC 100, if not to be performed on existing ISFSI pad.
    b. Transfer the MPC-68 from the HI-TRAC 100 to the HI-STAR 100MB transport overpack.
    c. Ensure the space is clear of structures, the location is suitably located near the on-site transporter or the off-site HHT loading location, the location has sufficient space to perform the stack-up operations including with the required ancillary equipment, and the terrain and soil can accommodate the necessary concrete pad.
    d. Ensure fencing is extended to encompass this pad as necessary.
5. Establish planned shipment date from the VY ISFSI and verify:
    a. The CoC for the transportation package is valid,
    b. The contents, as loaded in the MPC canisters are compliant to the applicable CoC requirements (e.g., dose and thermal transport limits are satisfied), and
    c. Ability for permitting the transportation activities along the selected route(s).
6. Establish equipment needs for transportation:
    a. Procurement of the necessary transfer station, transfer cask, transfer cask mating device, storage cask air pad system, and transfer cask lift yoke, and
    b. Procurement of the necessary transportation casks, up-/down-ending device, associated impact limiters, transport cradles, personnel barriers, and vertical lifting yoke and horizontal lift beam. As discussed in **Section 2.3**, any road or barge

transportation activities may not require the complete cradle assembly necessary for rail transportation.

7. Establish electrical power requirements for performing operations and verify availability at VY ISFSI.
8. Due to the potential significant impacts of the conditions and assumptions identified in **Section 7.9** for the estimated costs associated with activities involving the rail shipment of transportation casks from the transload site to the GCUS site (i.e., cask consist transportation services costs, emergency response center operation costs, railcar maintenance services freight costs, and transportation cask maintenance and compliance costs), the development of more precise costs requires resolution to, or clarification of, the identified conditions and assumptions in Section 7.9, as well as consideration of economies of scale and synergies associated with the de-inventory of multiple sites at the same or nearly same time, understanding of equipment (e.g., railcars and casks) ownership impact, and the need for a comprehensive breakdown of activities involved in these costs.
9. Prepare site for rail loading through:
    a. Extending security fences to encompass the railcar loading location, such as recommended in **Figure 3-4**.
    b. Install gate so HHT/rail can exit controlled area between ISFSI and the on-site rail transload area.

11.0 REFERENCES

[1] Abkowitz, M., "Stakeholder Tool for Assessing Radioactive Transportation (START): Version 3.2.1 User Manual," FCRD-NST-2014-000092, Rev. 8, Prepared for the U.S. DOE Nuclear Fuels Storage and Transportation Planning Project, September 2020.

[2] Google (2023) Windham County, Vermont, USA and surrounding area. http://maps.google.com, Accessed: 19 May 2023.

[3] ESRI Community Maps Contributors (2023) Windham County, Vermont, USA Parcel Map. https://maps.vcgi.vermont.gov/parcelviewer/, Accessed: 19 May 2023.

[4] Reid, Jr. Billy E. Defueled Safety Analysis Report: Vermont Yankee Nuclear Power Station, Rev 2. Northstar Nuclear Decommissioning Co., LLC. September 2020.

[5] Vermont Yankee, International Atomic Energy Agency Power Reactor Information System (IAEA PRIS). May 2023.

[6] Steven J. Maheras, Lauren S. Rodman, Ralph E. Best, Adam Levin, Steven B. Ross, Lawrence M. Massaro, and Philip J. Jensen, "Nuclear Power Plant Infrastructure Evaluations for Removal of Spent Nuclear Fuel," PNNL-30429, April 30, 2021.

[7] Final Safety Analysis Report on the HI-STAR 100 MPC Storage System, Rev 6 (Non-proprietary). HI-2012610. Holtec International, March 2022.

[8] Safety Analysis Report on the HI-STAR 100MB Package, Rev 5 (Non-proprietary). HI-2188080, ML21120A135. Holtec International.

[9] Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, Rev 23 (Non-proprietary). HI-2002444. Holtec International, April 2022.

[10] Safety Analysis Report on the HI-STAR 100 Cask System, Rev 20 (Non-proprietary). HI-951251, ML19184A208. Holtec International.

[11] Leshinkie, Anthony R., Certification of Permanent Cessation of Power Operations, Entergy Nuclear Operations, Inc. January 2015.

[12] Chappell, Coley C., Vermont Yankee Registration of Spent Fuel Cask Use and Notification of Permanent Removal of All Spent Fuel Assemblies, Collected and Compiled by M. Morrow, Entergy Nuclear Vermont Yankee, LLC. May 2009 – August 2018.

[13] AREVA Federal Services LLC, Initial Site-Specific De-Inventory Report for Trojan, RPT-3016128-002, March 21, 2017.

[14] NUREG-0561, Revision 2, Physical Protection of Shipments of Irradiated Reactor Fuel: Final Report.

[15] Memorandum of Understanding, Transportation of Radioactive Materials, 44 Fed. Reg. 38690 (July 2, 1979).

[16] AREVA Federal Services LLC Report RPT-3016127-002, March 21, 2017, Initial Site-Specific De-Inventory Report for Maine Yankee.

[17] AREVA Federal Services LLC Report RPT-3014538-002, May 5, 2017, Initial Site-Specific De-Inventory Report for Connecticut Yankee.

[18] AREVA Federal Services LLC Report RPT-3014537-002, May 10, 2017, Initial Site-Specific De-Inventory Report for Big Rock Point.

[19] AREVA Federal Services LLC Report RPT-3015142-004, June 2, 2017, Initial Site-Specific De-Inventory Report for Humboldt Bay.

[20] AREVA Federal Services LLC Report RPT-3019262-000, August 31, 2017, Initial Site-Specific De-Inventory Report for Kewaunee.

[21] Orano Federal Services LLC Report RPT-3022488-001, January 15, 2023, Initial Site-Specific De-Inventory Report for Crystal River.

[22] Orano Federal Services LLC Report RPT-3022581-001, January 15, 2023, Initial Site-Specific De-Inventory Report for Rancho Seco.

[23] Orano Federal Services LLC Report RPT-3022657-001, January 15, 2023, Initial Site-Specific De-Inventory Report for La Crosse.

[24] Orano Federal Services LLC Report RPT-3022663-001, January 16, 2023, Initial Site-Specific De-Inventory Report for Yankee Rowe.

[25] Orano Federal Services LLC Report RPT-3022658-001, January 17, 2023, Initial Site-Specific De-Inventory Report for Zion.

[26] Hardin, Ernest, "Deep Borehole Field Test Specifications," FCRD-UFD-2015-000132 Rev. 1, Sandia National Laboratory, September 2015.

[27] Merkhofer MW, Keeney RL., "A multi-attribute utility analysis of alternative sites for the disposal of nuclear waste," Risk Anal. 1987 Jun;7(2):173-94.

[28] U.S. Department of Transportation, Research and Special Programs Administration, "Enhancing Security of Hazardous Materials Shipments Against Acts of Terrorism or Sabotage Using RSPA's Risk Management Self-Evaluation Framework (RMSEF), Revision 1", January 2002.

[29] ICF Consulting, U.S. Department of Transportation, Research and Special Programs Administration, "Risk Management Framework for Hazardous Materials Transportation", November 1, 2000.

[30] National Archives and Records Administration, Office of Federal Register, "Code of Federal Regulations 73FR 72173", Title 49 CFR 1580, Title 49 – Transportation, Subtitle B – Other Regulations Relating to Transportation, Chapter X – Surface Transportation Board, Department of Transportation, Subchapter B – Security Rules for All Modes of Transportation, Part 49 CFR 1580 – Rail Transportation Security, November 26, 2008.

[31] Title 10, Code of Federal Regulations Part 73.37, "Requirements for physical protection of irradiated reactor fuel in transit", December 31, 2015.

[32] Title 49, Code of Federal Regulations Part 172, Subpart G, Section 172.602, "Emergency response information" June 2, 2016.

[33] Title 49, Code of Federal Regulations Part 172, Subpart G, Section 172.600, "Emergency response information: Applicability and general requirements" June 2, 2016.

[34] Association of American Railroads, "AAR Open Top Loading Rules Manual," Effective 8/11/17.

[35] U.S. NRC, Regulatory Guide 7.10 "Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material," Rev. 2, March 2005.

[36] J. W. McConnell, Jr., A. L. Ayers, Jr., M. J. Tyacke, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," NUREG/CCR-6407, February 1996.

[37] U.S. DOE Office of Civilian Radioactive Waste Management, "A Multi-attribute Utility Analysis of Sites Nominated for Characterization for the First Radioactive Waste Repository - A Decision Aiding Methodology," DOE/RW-0074, May 1986.

[38] Davis, F., et. al., "A Multi-Attribute Utility Decision Analysis for Treatment Alternatives for the DOE/SR Aluminum-Based Spent Nuclear Fuel." Sandia National Laboratories. SAND98-2146. October 1998.

[39] Department of Energy, "Departmental Materials Transportation and Packaging Management," DOE Order 460.2B, June 2022.

[40] AREVA Federal Services LLC Report DE-NE0008390, October 28, 2016, Atlas Railcar Phase 1 Final Report.

[41] Association of American Railroads, AAR Circular OT-55-O (CPC-1312), "Recommended Railroad Operating Practices for Transportation of Hazardous Materials", January 27, 2015.

[42] Holtec International, Forced Helium Dehydrator, https://holtecinternational.com/products-and-services/innovative-technologies/forced-helium-dehydrator/, Accessed: 24 July 2023.

[43] Holtec International, Variable Elevation Cask Pedestal, https://holtecinternational.com/products-and-services/innovative-technologies/variable-elevation-cask-pedestal-vecasp/, Accessed: 24 July 2023.

[44] Google Maps Bellows Falls Tunnel, by Gary Davidson Runs, Accessed: 24 July 2023.

[45] Vermonter Coming Through Bellows Falls Tunnel, by Anthony Kretowicz, Accessed 24 July 2023.

[46] https://www.engineersconstruction.com/projects/bellows-falls-tunnel-clearance-improvements/, Accessed: 24 July 2023.

[47] Kathy Langan, Langan & Associates Consulting LTD.

[48] www.greatriverhydro.com/facilities, Accessed: 24 July 2023.

[49] U.S. NRC, Certificate of Compliance for Radioactive Material Packages, Certificate Number 9261, HI-STAR 100 System, August 28, 2019 (ML19239A190).

[50] U.S. NRC, Certificate of Compliance for Radioactive Material Packages, Certificate Number 9378, HI-STAR 100MB Package, May 20, 2021 (ML2113A271).

Attachment A: Full Pairwise Comparison for the Tangible Metrics

	Please Place a Single x per line/row where you believe the importance of metric in column 1 falls against the metric in column 2							
Column 1 Metrics	**Column 1 Strongly Favorable**	**Column 1 More Favorable**	**Column 1 Mildly Favorable**	**Neither Favorable (Neutral)**	**Column 2 Mildly Favorable**	**Column 2 More Favorable**	**Column 2 Strongly Favorable**	**Column 2 Metrics**
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Labor and Permitting Costs
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Public Acceptability of Route
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Ease of Permit Procurement
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Number of Permits
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Cumulative Worker Exposure (α handling time & # of workers)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Cumulative Population Dose along Route (α population density)
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Risks Associated with Number of Lifting Activities
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Average Accident Frequency on Route
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Transit Duration per Conveyance and Consist
ISFSI Rental Equipment Costs (e.g., mobile cranes)								Size of conveyance (# of casks per shipment)
Labor and Permitting Costs								Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Labor and Permitting Costs								Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)
Labor and Permitting Costs								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Labor and Permitting Costs								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Labor and Permitting Costs								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Labor and Permitting Costs								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Labor and Permitting Costs								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Labor and Permitting Costs								Public Acceptability of Route
Labor and Permitting Costs								Ease of Permit Procurement
Labor and Permitting Costs								Number of Permits
Labor and Permitting Costs								Cumulative Worker Exposure (α handling time & # of workers)
Labor and Permitting Costs								Cumulative Population Dose along Route (α population density)
Labor and Permitting Costs								Risks Associated with Number of Lifting Activities
Labor and Permitting Costs								Average Accident Frequency on Route
Labor and Permitting Costs								Transit Duration per Conveyance and Consist
Labor and Permitting Costs								Size of conveyance (# of casks per shipment)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Public Acceptability of Route
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Ease of Permit Procurement
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Permits
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cumulative Worker Exposure (α handling time & # of workers)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cumulative Population Dose along Route (α population density)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Risks Associated with Number of Lifting Activities
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Average Accident Frequency on Route
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Transit Duration per Conveyance and Consist
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Size of conveyance (# of casks per shipment)

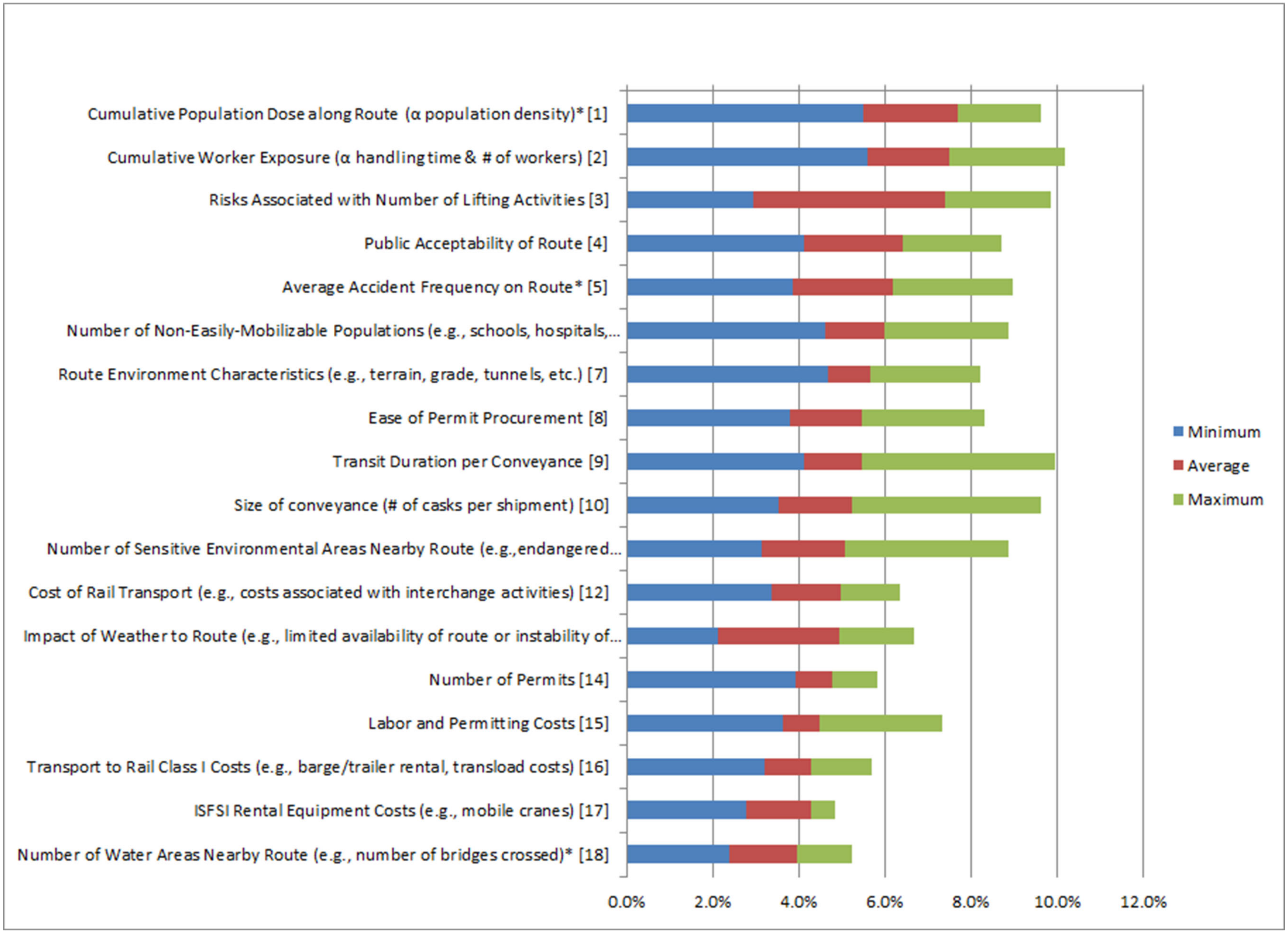
	Please Place a Single x per line/row where you believe the importance of metric in column 1 falls against the metric in column 2							
Column 1 Metrics	**Column 1 Strongly Favorable**	**Column 1 More Favorable**	**Column 1 Mildly Favorable**	**Neither Favorable (Neutral)**	**Column 2 Mildly Favorable**	**Column 2 More Favorable**	**Column 2 Strongly Favorable**	**Column 2 Metrics**
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Public Acceptability of Route
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Ease of Permit Procurement
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Number of Permits
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Cumulative Worker Exposure (α handling time & # of workers)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Cumulative Population Dose along Route (α population density)
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Risks Associated with Number of Lifting Activities
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Average Accident Frequency on Route
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Transit Duration per Conveyance and Consist
Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)								Size of conveyance (# of casks per shipment)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Public Acceptability of Route
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Ease of Permit Procurement
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Number of Permits
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Cumulative Worker Exposure (α handling time & # of workers)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Cumulative Population Dose along Route (α population density)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Risks Associated with Number of Lifting Activities
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Average Accident Frequency on Route
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Transit Duration per Conveyance and Consist
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)								Size of conveyance (# of casks per shipment)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Public Acceptability of Route
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Ease of Permit Procurement
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Permits
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Cumulative Worker Exposure (α handling time & # of workers)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Cumulative Population Dose along Route (α population density)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Risks Associated with Number of Lifting Activities
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Average Accident Frequency on Route
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Transit Duration per Conveyance and Consist
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Size of conveyance (# of casks per shipment)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Public Acceptability of Route
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Ease of Permit Procurement
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Permits
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Cumulative Worker Exposure (α handling time & # of workers)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Cumulative Population Dose along Route (α population density)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Risks Associated with Number of Lifting Activities
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Average Accident Frequency on Route
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Transit Duration per Conveyance and Consist
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Size of conveyance (# of casks per shipment)

	Please Place a Single x per line/row where you believe the importance of metric in column 1 falls against the metric in column 2							
Column 1 Metrics	**Column 1 Strongly Favorable**	**Column 1 More Favorable**	**Column 1 Mildly Favorable**	**Neither Favorable (Neutral)**	**Column 2 Mildly Favorable**	**Column 2 More Favorable**	**Column 2 Strongly Favorable**	**Column 2 Metrics**
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Public Acceptability of Route
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Ease of Permit Procurement
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Number of Permits
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Cumulative Worker Exposure (α handling time & # of workers)
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Cumulative Population Dose along Route (α population density)
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Risks Associated with Number of Lifting Activities
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Average Accident Frequency on Route
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Transit Duration per Conveyance and Consist
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)								Size of conveyance (# of casks per shipment)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Public Acceptability of Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Ease of Permit Procurement
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Number of Permits
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Cumulative Worker Exposure (α handling time & # of workers)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Cumulative Population Dose along Route (α population density)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Risks Associated with Number of Lifting Activities
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Average Accident Frequency on Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Transit Duration per Conveyance and Consist
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Size of conveyance (# of casks per shipment)
Public Acceptability of Route								Ease of Permit Procurement
Public Acceptability of Route								Number of Permits
Public Acceptability of Route								Cumulative Worker Exposure (α handling time & # of workers)
Public Acceptability of Route								Cumulative Population Dose along Route (α population density)
Public Acceptability of Route								Risks Associated with Number of Lifting Activities
Public Acceptability of Route								Average Accident Frequency on Route
Public Acceptability of Route								Transit Duration per Conveyance and Consist
Public Acceptability of Route								Size of conveyance (# of casks per shipment)
Ease of Permit Procurement								Number of Permits
Ease of Permit Procurement								Cumulative Worker Exposure (α handling time & # of workers)
Ease of Permit Procurement								Cumulative Population Dose along Route (α population density)
Ease of Permit Procurement								Risks Associated with Number of Lifting Activities
Ease of Permit Procurement								Average Accident Frequency on Route
Ease of Permit Procurement								Transit Duration per Conveyance and Consist
Ease of Permit Procurement								Size of conveyance (# of casks per shipment)
Number of Permits								Cumulative Worker Exposure (α handling time & # of workers)
Number of Permits								Cumulative Population Dose along Route (α population density)
Number of Permits								Risks Associated with Number of Lifting Activities
Number of Permits								Average Accident Frequency on Route
Number of Permits								Transit Duration per Conveyance and Consist
Number of Permits								Size of conveyance (# of casks per shipment)
Cumulative Worker Exposure (α handling time & # of workers)								Cumulative Population Dose along Route (α population density)
Cumulative Worker Exposure (α handling time & # of workers)								Risks Associated with Number of Lifting Activities
Cumulative Worker Exposure (α handling time & # of workers)								Average Accident Frequency on Route
Cumulative Worker Exposure (α handling time & # of workers)								Transit Duration per Conveyance and Consist
Cumulative Worker Exposure (α handling time & # of workers)								Size of conveyance (# of casks per shipment)
Cumulative Population Dose along Route (α population density)								Risks Associated with Number of Lifting Activities
Cumulative Population Dose along Route (α population density)								Average Accident Frequency on Route
Cumulative Population Dose along Route (α population density)								Transit Duration per Conveyance and Consist
Cumulative Population Dose along Route (α population density)								Size of conveyance (# of casks per shipment)
Risks Associated with Number of Lifting Activities								Average Accident Frequency on Route
Risks Associated with Number of Lifting Activities								Transit Duration per Conveyance and Consist
Risks Associated with Number of Lifting Activities								Size of conveyance (# of casks per shipment)
Average Accident Frequency on Route								Transit Duration per Conveyance and Consist
Average Accident Frequency on Route								Size of conveyance (# of casks per shipment)
Transit Duration per Conveyance and Consist								Size of conveyance (# of casks per shipment)

Attachment B: Results from the Eleven Individual's Pairwise Comparison for the Tangible Metrics

Metric	Rater 1 %	Rater 1 Ranking	Rater 2 %	Rater 2 Ranking	Rater 3 %	Rater 3 Ranking	Rater 4 %	Rater 4 Ranking	Rater 5 %	Rater 5 Ranking	Rater 6 %	Rater 6 Ranking	Rater 7 %	Rater 7 Ranking	Rater 8 %	Rater 8 Ranking	Rater 9 %	Rater 9 Ranking	Rater 10 %	Rater 10 Ranking	Rater 11 %	Rater 11 Ranking	Average %	Average Ranking	Average Average	Metric
ISFSI Rental Equipment Costs (e.g., mobile cranes)	4.85%	14	2.78%	18	4.63%	12	4.63%	10	4.63%	12	4.47%	13	3.59%	18	4.63%	12	4.41%	11	4.74%	15	3.70%	17	4.3%	17	13.8	ISFSI Rental Equipment Costs (e.g., mobile cranes)
Labor and Permitting Costs	5.07%	12	4.85%	13	3.65%	18	3.98%	13	3.65%	18	4.79%	12	3.65%	17	3.65%	18	7.35%	6	4.79%	13	4.03%	15	4.5%	15	14.1	Labor and Permitting Costs
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	5.72%	6	4.58%	14	3.76%	17	3.21%	17	3.76%	17	3.70%	15	4.74%	12	3.76%	17	4.79%	9	5.72%	7	3.54%	18	4.3%	16	13.5	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Cost of Rail Transport (e.g., costs associated with interchange activities)	5.07%	12	5.61%	9	5.17%	8	3.38%	16	5.17%	8	6.37%	6	5.07%	10	5.17%	8	4.68%	10	5.28%	12	3.98%	16	5.0%	12	10.5	Cost of Rail Transport (e.g., costs associated with interchange activities)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)	5.45%	10	5.12%	12	4.68%	11	6.15%	6	4.68%	11	7.46%	4	5.56%	8	4.68%	11	8.22%	5	5.50%	9	4.85%	9	5.7%	7	8.7	Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)	6.70%	3	5.94%	6	4.03%	16	6.05%	7	4.03%	16	6.05%	7	5.39%	9	4.03%	16	2.12%	18	5.50%	9	4.74%	10	5.0%	13	10.6	Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)*	3.76%	18	5.23%	11	4.25%	15	3.00%	18	4.25%	15	2.72%	18	4.25%	16	4.25%	15	2.40%	17	4.79%	13	4.68%	12	4.0%	18	15.3	Number of Water Areas Nearby Route (e.g., number of bridges crossed)*
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)*	3.98%	17	5.83%	7	4.58%	13	5.94%	8	4.58%	13	3.16%	17	4.41%	14	4.58%	13	8.88%	2	5.45%	11	4.63%	13	5.1%	11	11.6	Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)*
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)*	5.99%	5	7.08%	2	5.23%	6	7.84%	5	5.23%	6	5.45%	9	4.63%	13	5.23%	6	8.88%	2	5.61%	8	4.96%	8	6.0%	6	6.4	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)*
Public Acceptability of Route	7.35%	2	5.50%	10	8.71%	2	5.50%	9	8.71%	2	7.57%	3	4.41%	14	8.71%	2	4.14%	12	4.19%	17	5.99%	5	6.4%	4	7.1	Public Acceptability of Route
Ease of Permit Procurement	5.72%	6	6.59%	4	5.12%	9	3.81%	14	5.12%	9	5.23%	10	5.88%	4	5.12%	9	8.33%	4	4.19%	17	5.23%	7	5.5%	8	8.5	Ease of Permit Procurement
Number of Permits	5.34%	11	5.83%	7	4.36%	14	4.19%	12	4.36%	14	3.92%	14	5.77%	5	4.36%	14	4.14%	12	4.68%	16	5.72%	6	4.8%	14	11.4	Number of Permits
Cumulative Worker Exposure (α handling time & # of workers)	8.12%	1	6.10%	5	7.90%	4	8.88%	2	7.90%	4	6.81%	5	5.61%	7	7.90%	4	5.66%	7	7.35%	1	10.19%	1	7.5%	2	3.7	Cumulative Worker Exposure (α handling time & # of workers)
Cumulative Population Dose along Route (α population density)*	6.32%	4	6.86%	3	8.66%	3	8.28%	3	8.66%	3	5.50%	8	5.66%	6	8.66%	3	9.53%	1	7.03%	2	9.64%	2	7.7%	1	3.5	Cumulative Population Dose along Route (α population density)*
Risks Associated with Number of Lifting Activities	5.66%	9	4.47%	15	9.37%	1	9.04%	1	9.37%	1	9.86%	1	6.92%	3	9.37%	1	2.94%	16	6.86%	3	7.79%	3	7.4%	3	4.9	Risks Associated with Number of Lifting Activities
Average Accident Frequency on Route*	5.72%	6	8.99%	1	5.01%	10	8.12%	4	5.01%	10	8.22%	2	4.85%	11	5.01%	10	3.87%	15	6.05%	5	7.14%	4	6.2%	5	7.1	Average Accident Frequency on Route*
Transit Duration per Conveyance	4.58%	16	4.25%	17	5.66%	5	4.30%	11	5.66%	5	5.17%	11	9.97%	1	5.66%	5	4.14%	12	6.05%	5	4.74%	10	5.5%	9	8.9	Transit Duration per Conveyance
Size of conveyance (# of casks per shipment)	4.63%	15	4.41%	16	5.23%	6	3.70%	15	5.23%	6	3.54%	16	9.64%	2	5.23%	6	5.50%	8	6.21%	4	4.47%	14	5.3%	10	9.8	Size of conveyance (# of casks per shipment)

Lowest Rated (purple)
Highest Rated (red)


Cumulative Population Dose along Route (α population density)* [1]
Cumulative Worker Exposure (α handling time & # of workers) [2]
Risks Associated with Number of Lifting Activities [3]
Public Acceptability of Route [4]
Average Accident Frequency on Route* [5]
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals,...
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.) [7]
Ease of Permit Procurement [8]
Transit Duration per Conveyance [9]
Size of conveyance (# of casks per shipment) [10]
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered...
Cost of Rail Transport (e.g., costs associated with interchange activities) [12]
Impact of Weather to Route (e.g., limited availability of route or instability of...
Number of Permits [14]
Labor and Permitting Costs [15]
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs) [16]
ISFSI Rental Equipment Costs (e.g., mobile cranes) [17]
Number of Water Areas Nearby Route (e.g., number of bridges crossed)* [18]
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%
Minimum
Average
Maximum

Attachment C: Full Pairwise Comparison for the Routes

Place a single "X" per line where you believe the importance of the metric for the route in column A falls against the same metric for the route in column B.

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
ISFSI Rental Equipment Costs (e.g., mobile cranes)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time			x					D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time			x					E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance			x					D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance			x					E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer			x					D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Labor and Permitting Costs	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time					x			C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance					x			C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time	x							D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time	x							E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance	x							D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer	x							D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer	x							E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center			x					E. HHT & Rail from Green Mnt Rail Yard
Cost of Rail Transport (e.g., costs associated with interchange activities)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time						x		C. Rail via Palmer
	A. Rail-min. travel time					x			D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time						x		E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance						x		C. Rail via Palmer
	B. Rail-min. distance					x			D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance						x		E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer			x					D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center					x			E. HHT & Rail from Green Mnt Rail Yard

Place a single "X" per line where you believe the importance of the metric for the route in column A falls against the same metric for the route in column B.

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Impact of Weather to Route (e.g., limited availability of route or instability of weather)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center					x			E. HHT & Rail from Green Mnt Rail Yard
Number of Water Areas Nearby Route (e.g., number of bridges crossed)*	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time			x					C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance			x					C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)*	A. Rail-min. travel time			x					B. Rail-min. distance
	A. Rail-min. travel time			x					C. Rail via Palmer
	A. Rail-min. travel time			x					D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time			x					E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance			x					C. Rail via Palmer
	B. Rail-min. distance			x					D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance			x					E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer				x				D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer				x				E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard

Place a single "X" per line where you believe the importance of the metric for the route in column A falls against the same metric for the route in column B.

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)*	A. Rail-min. travel time					x			B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance			x					C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Public Acceptability of Route	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time	x							E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer	x							E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center			x					E. HHT & Rail from Green Mnt Rail Yard
Ease of Permit Procurement	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time	x							E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer	x							E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Number of Permits	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard

Place a single "X" per line where you believe the importance of the metric for the route in column A falls against the same metric for the route in column B.

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Worker Exposure (α handling time & # of workers)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time			x					D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time			x					E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance			x					D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance			x					E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer			x					D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Cumulative Population Dose along Route (α population density)*	A. Rail-min. travel time						x		B. Rail-min. distance
	A. Rail-min. travel time			x					C. Rail via Palmer
	A. Rail-min. travel time			x					D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance		x						C. Rail via Palmer
	B. Rail-min. distance	x							D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center			x					E. HHT & Rail from Green Mnt Rail Yard
Risks Associated with Number of Lifting Activities	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time		x						D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time		x						E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance		x						D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance		x						E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer		x						E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard
Average Accident Frequency on Route*	A. Rail-min. travel time		x						B. Rail-min. distance
	A. Rail-min. travel time					x			C. Rail via Palmer
	A. Rail-min. travel time						x		D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time						x		E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance							x	C. Rail via Palmer
	B. Rail-min. distance							x	D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance							x	E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer					x			D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer					x			E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard

Place a single "X" per line where you believe the importance of the metric for the route in column A falls against the same metric for the route in column B.

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Transit Duration per Conveyance	A. Rail-min. travel time			x					B. Rail-min. distance
	A. Rail-min. travel time						x		C. Rail via Palmer
	A. Rail-min. travel time					x			D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time						x		E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance						x		C. Rail via Palmer
	B. Rail-min. distance					x			D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance						x		E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer		x						D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer			x					E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center					x			E. HHT & Rail from Green Mnt Rail Yard
Size of conveyance (# of casks per shipment)	A. Rail-min. travel time				x				B. Rail-min. distance
	A. Rail-min. travel time				x				C. Rail via Palmer
	A. Rail-min. travel time	x							D. HHT & Rail from Riverside Transload Center
	A. Rail-min. travel time	x							E. HHT & Rail from Green Mnt Rail Yard
	B. Rail-min. distance				x				C. Rail via Palmer
	B. Rail-min. distance	x							D. HHT & Rail from Riverside Transload Center
	B. Rail-min. distance	x							E. HHT & Rail from Green Mnt Rail Yard
	C. Rail via Palmer	x							D. HHT & Rail from Riverside Transload Center
	C. Rail via Palmer	x							E. HHT & Rail from Green Mnt Rail Yard
	D. HHT & Rail from Riverside Transload Center				x				E. HHT & Rail from Green Mnt Rail Yard

Attachment D: Route Information from START for Vermont Yankee

Route	HHT Distance (mi.)	Barge Distance (mi.)	Rail Distance (mi.)
A. Rail-min. travel time	0	0	1,147
B. Rail-min. distance	0	0	1,145
C. Rail via Palmer	0	0	1,164
D. HHT & Rail from Riverside Transload Center	34	0	1,195
E. HHT & Rail from Green Mnt. Rail Yard	31	0	1,193

Metric are within 800 m. buffer for entire route, unless stated otherwise.	A. Rail-min. travel time	B. Rail-min. distance	C. R-Palmer route VY to Palmer, MA Leg 1 of 2	C. R-Palmer route Palmer, MA to GCUS Leg 2 of 2	C. TOTAL	D. HHT - Riverside Transload Center - 1 of 3 VY to 46 Steamtown Road, Bellows Falls, VT	D. Rail 2 of 3 46 Steamtown Road, Bellows Falls, VT to Palmer, MA.	D. Rail 3 of 3 Palmer, MA. to GCUS "C. Palmer, MA to GCUS,R, min time LEG 2 OF 2"	D. TOTAL	E. HHT 1 of 3 VY to 54 Depot Street, Bellows Falls, VT	E. Rail 2 of 3 54 Depot Street, Bellows Falls, VT to Palmer, MA.	E. Rail 3 of 3 Palmer, MA. to GCUS "C. Palmer, MA to GCUS,R, min time LEG 2 OF 2"	E. TOTAL
Total Distance (mi)	1,147	1,145	51	1,113	1,164	34	82	1,113	1,229	31	80	1,113	1,224
Travel Time (hr/min)	33/1,993	35/2,122	2/ 104	31/ 1,853	33/ 1,946	3/ 171	3/ 175	31/ 1,853	37/ 2,188	3/ 186	3/ 169	31/ 1,853	37/ 2,197
Accident Likelihood (per mi)	0.001518656	0.001784097		0.001376454	0.001376454	0.000012726	0.000217906	0.001376454	0.001261427	0.000011723	0.000210118	0.001376454	0.001265659
ratio of accident likelihoods	1.203918669	1.414347743			1.091187647				1.000000000				1.003354312
Water Crossings	185	188	10	185	195	6	17	185	208	6	17	185	208
Average Track Class	3.5	3.5	n/a	3.60	n/a	n/a	2.60	3.60		n/a	2.60	3.60	
Average Rail Traffic Density	4.6	4.5	n/a	4.70	n/a	n/a	1.90	4.70		n/a	1.90	4.70	
Total Population	945,467	891,676	26,220	940,761	966,981	13,180	41,751	940,761	995,692	16,513	40,860	940,761	998,134
Population Density (per mil^2)	826.56	780.38	504.65	847.67	832.64	385.92	508.54	847.67	812.27	522.74	510.63	847.67	817.41
Mass Gathering Places	964	885	17	956	973	20	32	956	1008	23	32	956	1011
Tribal Lands (per mi^2)	1.59	1.59	0.00	1.59	1.59	0.00	0.00	1.59	1.59	0.00	0.00	1.59	1.59
Water Areas (per mi^2)	22.45	22.56	2.37	19.48	21.85	3.36	6.31	19.48	29.15	3.39	5.88	19.48	28.75
Protected Areas (per mi^2)	155.61	155.80	60.50	115.12	176	36.92	93.62	115.12	246	33.71	91.41	115.12	240.24
Sensitive Environmental Area (per mi^2)	10.42	10.65	0.13	11.10	11	0.04	0.13	11.10	11	0.04	0.13	11.10	11.27
Correctional Facilities	42	39	0	40	40	0	0	40	40	0	0	40	40
Tunnels	2 or 6	2 or 6	0	2 or 6	2 or 6	0	0 or 1	2 or 6	2 or 7	0	0	2 or 6	2 or 6
Emergency Response Capability	0.33 per mile	0.33 per mile	14	0.34 per mile		0.15	0.28	0.34 per mile		0.22	0.25	0.34 per mile	
Fire Stations	0.18 per mile	0.18 per mile	7	0.18 per mile		0.06	0.14	0.18 per mile		0.10	0.14	0.18 per mile	
Local Law Enforcement	0.13 per mile	0.13 per mile	6	0.14 per mile		0.06	0.11	0.14 per mile		0.10	0.09	0.14 per mile	
Hospitals	0.02 per mile	0.02	1	0.02 per mile		0.03	0.02	0.02 per mile		0.03	0.02	0.02 per mile	
Educational Institutions	347	332	14	331	345	15	25	331	371	19	25	331	375
Grammar Schools	329	314	13	311	324	15	24	311	350	19	24	311	354
Higher Education	18	18	1	20	21	0	1	20	21	0	1	20	21
Special Populations	484	462	11	470	481	21	31	470	522	27	31	470	528
Child Care	371	355	9	358	367	19	26	358	403	23	26	358	407
Nursing Homes	113	107	2	112	114	2	5	112	119	4	5	112	121
Railroad Crossings (at grade)	1,643	1,610	96	1,625	1,721	3	130	1,625	1,758	3	126	1,625	1,754
Signs	0	0	0	0	0	0	0	0	0	0	0	0	0
Signals	0	0	0	0	0	0	0	0	0	0	0	0	0
No signs or signals	0	0	0	0	0	0	0	0	0	0	0	0	0
Both signs and signals	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown signs/signals	1,643	1,610	96	1,625	1,721	3	130	1,625	1,758	3	126	1,625	1,754