U.S. Department of Energy

INITIAL SITE-SPECIFIC DE-INVENTORY REPORT FOR YANKEE ROWE

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

April 2024

Cover photo courtesy of the Yankee Rowe Site.

Initial Site-Specific De-Inventory Report for Yankee Rowe

RPT- 3022663-001

Prepared by: Orano Federal Services LLC

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
000	11/15/2019	N/A	Initial Issue
001	5/12/2023	Disclaimer	Updated disclaimer per DOE GC recommendations
		Acronyms	Added two new railroads to the list of acronyms and Atomic Energy Act
		Executive Summary	• Deleted first paragraph • Clarified some text • Corrected campaign duration and cost with data from Section 7

Rev.	Date	Affected Pages	Revision Description
			• Updated here and throughout the report to "Security Plan" • Updated here and throughout the report to "Emergency Response Plan" • Updated year from 2019 to 2022 as the cost values between the two years will not have changed significantly
		Section 1	• Editorial changes made to clarify text • Added "Possible" to Figure 1-2 caption • Change from transportation cask to dry shielded canister
		Section 2	• Updated NAC MPC CoC amendment information and identified current NRC review activity • Included information on a recent road evaluation • Added footnote for goldhofer • Replaced Figure 2-10 • Figure 2-8 and 2-10 moved into landscape • Added new Figure 2-10a • Removed redundant text to Section 6 • Minor clarifications and updated reference • Added paragraph on China experience with transportation cask • Table 2-11 corrected leak test port plug torque value • Added clarification on transportability of the NAC STC transport cask • Updated NAC-STC operational description • Added further GTCC LLW information
		Section 3	• Added some a challenge to the first track location • Provided updated information on nearby railroads in Table 3-3
		Section 4	• New introductory text has been added to identify the temporal nature of the information in this chapter • Two new paragraphs provided by the Department of Energy's General Counsel have been added • Clarified entities and persons in bulleted list • Updated names for various positions

Rev.	Date	Affected Pages	Revision Description
		Section 5	Minor grammatical updates
		Section 6	• Clarified areas involved with this activity • Minor grammatical updates • Added new footnote to clarify NRC route approval is not typically required for DOE shipments • Table 6-4 clarified crane sizes • Corrected port plug torque value • Updated the timing of some of the cask loading operations • Updated Figure 6-1 with new timing information • Deleted text related to the superseded DOE Manual 460.2 • Deleted paragraph related to NRC oversight • Deleted material in section 6.6 related to the QAP
		Section 7	• Updated dates, removed non-applicable text, and made some grammatical corrections • Revised section 7.6 title
		Section 8	• Revised section title (removed “”Safety”) • Clarifications made to the text • Clarified protection of Safeguards Information • Renamed sections 8.4, 8.11, 8.12, 8.13 • Deleted text related to the superseded DOE Manual 460.2 and associated bullets in Sections 8.11, 8.12 & 8.13 • Added new bullets to Sections 8.11, 8.12 & 8.13 covering in-transit protection
		Section 9	• Modified section and sub-section titles • Minor grammatical updates made • Section 9.1 revised to reflect requirements associated with emergency response information that is commonly incorporated into an Emergency Response Plan • Updated information required for an emergency contact telephone number • Provided some clarifying remarks on the example index of an ERP and corrected some items in the index

Rev.	Date	Affected Pages	Revision Description
		Section 10	Clarified the first and third recommendations
		Section 11	Updated references and added a new reference

DISCLAIMER

TABLE OF CONTENTS

Executive Summary xi
1.0 Introduction 1-1
2.0 Pertinent Site Information 2-1
2.1. Description of Site/Characteristics 2-1
2.2. Characteristics of SNF and GTCC LLW to be Shipped 2-24
2.3. Description of Canisters/Overpacks to be Shipped 2-29
3.0 Transportation Route Analysis 3-1
3.1. Heavy Haul Trucking Routes 3-1
3.2. Rail Access Locations 3-10
3.2.1. Rail Infrasctructure *3-10*
3.2.2. Transload Sites *3-14*
3.2.3. Exploring The Hoosac Tunnel Loading Options *3-21*
3.3. Barge Loading Locations 3-26
3.4. Barge Unloading Locations 3-26
3.5. Down-Selected Transportation Routes 3-26
4.0 Participating Entities 4-1
5.0 Multi-Attribute Utility Analysis 5-1
5.1. Description of MUA Applied to the YR ISFSI 5-1
5.2. Description of Evaluated Routes 5-3
5.3. Evaluation of Routes 5-5
5.3.1. Identification of Attributes and Metrics *5-5*
5.3.2. Evaluation of Individual Metrics *5-9*
5.3.3. Route Assessments *5-14*
5.4. Route Recommendations 5-19
5.5. Additional Sensitivity Analyses 5-35
5.5.1. Suppression of Evaluation Span for Select Metrics *5-35*
5.5.2. Details of Select Sensitivity Results *5-39*
6.0 Concept of Operations for Recommended Approach 6-1
6.1. Considerations regarding the transportation package selection 6-1
6.1.1. Package Permits / Requirements *6-3*
6.1.2. Operational Readiness *6-5*
6.1.3. Site Operations *6-8*
6.1.4. Transport Operations *6-17*
6.1.5. Demobilization *6-27*
6.2. Resource Requirements / Staffing 6-28
6.3. List of Ancillary Equipment 6-28
6.4. Sequence of Operations / Schedule 6-31
6.5 As Low As Reasonably Achievable (ALARA) Planning 6-34
6.6 Quality Assurance Requirements 6-36
7.0 Budget and Spending Plan 7-1
7.1. Fees and Permits 7-2
7.2. Campaign Operation Management 7-2
7.3. Equipment for the Loading Operations 7-2
7.4. Site modifications 7-3
7.5. In-Transit Security 7-3
7.6. Cask Transportation Services at Transshipment Site 7-3
7.7. Onsite Operations 7-3
7.8. Breakdown of the Costs by Activity 7-3
7.9. Additional Cost Estimates to Support De-Inventory Activities 7-4

7.9.1. Estimate of Transportation Costs ... 7-4
7.9.2. Estimate of Emergency Response Center Operation Costs ... 7-5
7.9.3 Estimate of Railcar Maintenance Services Costs ... 7-5
7.9.4 Estimate of Transportation Cask Maintenance and Compliance Costs ... 7-6
8.0 Security Plan and Procedures ... 8-1
8.1. Security Plan Requirements ... 8-2
8.2. Scope ... 8-3
8.3. Identifying and Selecting the Principal Parties (Administrative Team) ... 8-4
8.4. Select the Rail/Truck Transload Site to be Used ... 8-4
8.5. Identifying and Selecting the Risk and Security Assessment Team ... 8-5
8.6. Evaluating the Security and Risk Assessment ... 8-5
8.7. Developing a Hazardous Materials Security Plan ... 8-5
8.8. Develop Security and Communication Protocols ... 8-6
8.9. Railroad Security Requirements ... 8-6
8.10. Provisions for Protection of In-Transit Road Shipments ... 8-7
8.11. Provisions for Protection of In-Transit Rail Shipments ... 8-8
9.0 Emergency Response Plan and Preparedness ... 9-1
9.1. General Guidance for an Emergency Response Plan ... 9-1
9.2. YR Site-Specific Considerations for the Emergency Response Plan ... 9-3
10.0 Recommended Next Steps ... 10-1
11.0 References ... 11-1
Attachment A: Full Pairwise Comparison for the Tangible Metrics ... A-1
Attachment B: Results from the Twelve Individual's Pairwise Comparison for the Tangible Metrics ... B-1
Attachment C: Full Pairwise Comparison for the Routes ... C-1
Attachment D: Route Information from START for YR NPS ... D-1

LIST OF FIGURES

Figure 1-1: Potential Flow Of Operations Assessed For Loading A Consist Per Mode Of Transport From YR ISFSI 1-2
Figure 1-2: Possible Routes Evaluated By The MUA For Shipment Of SNF And GTCC LLW From YR ISFSI........ 1-3
Figure 2-1: YR Site Location[6]........ 2-2
Figure 2-2: Yankee Atomic Electric Company Owner-Controlled Area[7]........ 2-3
Figure 2-3: YR Site[6]........ 2-4
Figure 2-4: YR ISFSI Location[6]........ 2-5
Figure 2-5: YR ISFSI[6]........ 2-7
Figure 2-6: YR VCC[2]........ 2-8
Figure 2-7: YR ISFSI Layout[11] 2-9
Figure 2-8: Aerial View of YR Site (2017)[5] 2-10
Figure 2-9: Spillway Bridge on Sherman Dam (1997)[5] 2-11
Figure 2-10: Proposed HHT Vehicle Path from ISFSI to Offsite Readsboro Road[6]........ 2-12
Figure 2-11: On-Site Yankee Road........ 2-13
Figure 2-12: YR-MPC Transportable Storage Canister Assembly[8]........ 2-19
Figure 2-13: YR-MPC TSC Fuel Basket Assemblies (36-Assembly Configuration)[20] 2-19
Figure 2-14: YR-MPC Storage System - VCC[9]........ 2-21
Figure 2-15: YR-MPC On-Site TFR With Transfer Adapter[9] 2-23
Figure 2-16: GTCC Canister Identification 2-27
Figure 2-17: NAC-STC On Transport Frame Mounted On Railcar 2-37
Figure 2-18: NAC-STC Package Ready for Transport........ 2-38
Figure 2-19: NAC-STC Section Views[19] 2-40
Figure 2-20: NAC-STC Containment Boundary[19]........ 2-41
Figure 2-21: YR-MPC VCC Unloading Transfer Operation with TSC Partially Removed[19]........ 2-42
Figure 2-22: NAC-STC Transfer Operation with YR-MPC TSC Partially Inserted[19]........ 2-44
Figure 2-23: YR-MPC TFR Adapter Plate[9] 2-45
Figure 2-24: NAC YR-MPC Heavy-Haul Trailer System[9]........ 2-51
Figure 2-25: Loaded VCC on HHT 2-58
Figure 2-26: VCC Lid Installation on VCC Positioned on HHT........ 2-59
Figure 2-27: NAC YR-MPC Air Pad System[9]........ 2-59
Figure 2-28: YR-TSC Insertion into VCC with YR-TFR Restraints Installed........ 2-60

Figure 2-29: NAC VCC Movement from HHT to ISFSI Pad on Air Pads and Engaged to JCB Telescopic Handler 2-60
Figure 2-30: NAC VCC Movement to/from ISFSI Pad on Air Pads 2-61
Figure 3-1: Path from the ISFSI Across the Site to the Nearest Public Roads 3-2
Figure 3-2: HHT Route from YR to Transload Site at Westfield, MA[6] 3-5
Figure 3-3: HHT Route from YR to Transload Site at Deerfield, MA[6] 3-6
Figure 3-4: HHT Route from YR to Transload Site at Bellows Falls, VT[6] 3-7
Figure 3-5: HHT Route from YR to Transload Site at Bennington, VT[6] 3-8
Figure 3-6: HHT Route from YR to Transload Site at Shelbourne Falls, MA[6] 3-9
Figure 3-7: HHT Route from YR to Transload Site at North Adams, MA[6] 3-10
Figure 3-8: YR Site Rail Access Through Hoosac Tunnel 3-12
Figure 3-9: Westfield, MA Transload Site 3-14
Figure 3-10: Deerfield, MA Transload Site 3-15
Figure 3-11: Bellows Falls, VT Transload Site 3-15
Figure 3-12: North Bennington, VT Transload Site 3-16
Figure 3-13: Shelburne Falls, MA Transload Site 3-17
Figure 3-14: North Adams, MA (Hoosac Tunnel West) Transload Site 3-17
Figure 3-15: Removal of YR Pressure Vessel 3-18
Figure 3-16: Track across bridge to the East of Hoosac Tunnel[51] 3-19
Figure 3-17: Overhead Obstacles Affecting Approach to Hoosac Tunnel 3-19
Figure 3-18: Hoosac Tunnel Trespassers 3-20
Figure 3-19: Overview of Track Configuration and Layout from Transload Site to Rail Secure Area[6] 3-21
Figure 3-20: Representation of the Security Perimeter around the Rail Secure Area[6] 3-22
Figure 3-21: Area to be Leased at the Mouth of Hoosac Tunnel 3-23
Figure 3-22: HHT Positioning Path[6] 3-24
Figure 3-23: HHT to 100 Springdale Road, Westfield, MA then Transload to Rail 3-34
Figure 3-24: HHT to East Deerfield Yard in Deerfield, MA then Transload to Rail 3-34
Figure 3-25: HHT to 46 Steamtown Road, Bellows Falls, then Transload to Rail 3-35
Figure 3-26: HHT to 206 Harwood Hill Road, Bennington, VT then Transload to Rail 3-35
Figure 3-27: HHT to 14 Depot Street, Shelburne Falls, MA then Transload to Rail 3-36
Figure 3-28: HHT to Hoosac Tunnel (West Portal) via North Adams, MA then Transload to Rail 3-36
Figure 5-1: Overview of MUA Applied to YR ISFSI 5-3
Figure 5-2: Weighting of the Tangible Metrics Based on Pairwise Comparisons 5-13
Figure 5-3: Example of a Portion of a Pairwise Comparison for Routes Assessment 5-21

Figure 5-4: Resulting List of Prioritized Routes From YR ISFSI Site 5-22
Figure 5-5: Impact of Each Tangible Metric on Each Route's "Score" 5-25
Figure 5-6: Minimum, Average, and Maximum Results from Sensitivity Analysis for Minimization of Each Metric 5-33
Figure 5-7: Minimum, Average, and Maximum Results from Sensitivity Analysis for Maximization of Each Metric 5-34
Figure 5-8: Example of Suppression of Span for Cumulative Population Dose Along Each Route 5-36
Figure 5-9: Resulting List of Prioritized Routes from the YR ISFSI for the Suppression of Span for Safety Metrics 5-37
Figure 5-10: Impact of Each Tangible Metric on Each Route's Scoring for the Suppression of Span for Safety Metrics 5-38
Figure 5-11: Impact of Removing the Safety Metrics 5-40
Figure 5-12: Impact of Removing the Public Acceptability Metric 5-41
Figure 5-13: Impact of Removing Public Acceptability and Safety Metrics 5-42
Figure 6-1: Sequence of Operations 6-33

LIST OF TABLES

Table 2-1: SNF and GTCC TSC Inventory Summary for YR Site[8] 2-6
Table 2-2: YR-MPC TSC[50] 2-17
Table 2-3: YR-MPC VCC[50] 2-20
Table 2-4: YR TFR[50] 2-22
Table 2-5: YR Fuel Design Information[8] 2-24
Table 2-6: YR Fuel Discharge Data[5] 2-25
Table 2-7: YR Fuel Burnup Data[5] 2-26
Table 2-8: YR ISFSI Contents[8] 2-27
Table 2-9: Description Of Authorized YR-MPC TSC Contents For NAC-STC Transport[21] 2-29
Table 2-10: NAC YR-MPC Storage and NAC-STC Transport Cask Weights[45] 2-31
Table 2-11: NAC-STC Transport Cask Design Characteristics and Component Dimensions[19] 2-32
Table 3-1: Nearest Rail Tracks to the YR Site 3-4
Table 3-2: Class I Railroads in the Region Closest to YR 3-13
Table 3-3: Class II , Class III and Switching Railroads Near YR 3-13
Table 3-4: Comparison of the East Portal Hoosac Tunnel and Westfield Transload Sites 3-25
Table 3-5: Routes Versus Screening Criteria 3-29
Table 4-1: Participating Entity Functional Identification 4-2
Table 5-1: Attributes and Associated Metrics 5-6
Table 5-2: Example of a Portion of a Pairwise Comparison for Metrics Assessment 5-12
Table 5-3: Weighting of Tangible Metrics 5-13
Table 5-4: Route Averaged Population Density Along Each Route 5-17
Table 5-5: Average Accident Frequency Over Each Route[1] 5-18
Table 5-6: Route Transit Durations[1] 5-18
Table 5-7: Prioritized List of Routes from YR ISFSI 5-24
Table 5-8: Weighting of Routes 5-26
Table 5-9: Weighting of Routes at Minimum Metric Value (Part 1 of 3) 5-27
Table 5-10: Weighting of Routes at Minimum Metric Value (Part 2 of 3) 5-28
Table 5-11: Weighting of Routes at Minimum Metric Value (Part 3 of 3) 5-29
Table 5-12: Weighting of Routes at Maximized Metric Value (Part 1 of 3) 5-30
Table 5-13: Weighting of Routes at Maximized Metric Value (Part 2 of 3) 5-31
Table 5-14: Weighting of Routes at Maximized Metric Value (Part 3 of 3) 5-32
Table 5-15: Comparison of Original MUA Results to the Suppressed Span MUA Results 5-38
Table 5-16: Results from the Deletion of the Safety Metrics 5-40

Table 5-17: Results from the Deletion of the Public Acceptability Metric 5-41
Table 5-18: Results from the Deleteion of the Public Acceptability and Safety Metrics 5-42
Table 6-1: Activities to Prepare for and Remove SNF and GTCC LLW from YR ISFSI....6-3
Table 6-2: Maintenance Program Schedule 6-10
Table 6-3: Transport Related Activities to Prepare and Remove SNF and GTCC LLW from YR ISFSI...6-19
Table 6-4: Additional Equipment for YR Site Transfer....6-29
Table 6-5: Off-Site HHT Transport 6-30
Table 6-6: Equipment for the Transload Facility 6-30
Table 6-7: Rail Equipment (per Consist) 6-31
Table 6-8: Operations Timeline with Required Resources 6-34

LIST OF ACRONYMS

AAR	Association of American Railroads
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
B&E	Berkshire & Eastern Railroad
BWR	Boiling Water Reactor
CE	Combustion Engineering
CFR	Code of Federal Regulations
CHF	Canister Handling Facility
CoC	Certificate of Compliance
COSS	Cask Operations Shift Supervisor
COTP	Captain of the Port
CRCPD	Conference of Radiation Control Program Directors, Inc.
DFC	Damaged Fuel Can
DHS	Department of Homeland Security
DOE	Department of Energy
DOT	Department of Transportation
DPC	Dairyland Power Cooperative
ERP	Emergency Response Plan
FL	Florida
FME	Foreign Material Exclusion
FRA	Federal Railroad Administration
FSAR	Final Safety Analysis Report
FSO	Facility Security Officer
FSP	Facility Security Plan
GCUS	Geographical Center of the 48 Contiguous United States
GPS	Global Positioning System
GTCC	Greater Than Class C
G&W	Genessee & Wyoming Inc.
HAZMAT	Hazardous Material
HBU	High Burnup
HHT	Heavy Haul Truck/Trailer
HLW	High-Level Radioactive Waste
HRCQ	Highway Route Controlled Quantity
HTUA	High Threat Urban Areas
IN	Indiana
ISFSI	Independent Spent Fuel Storage Installation
ISR	Independent Safety Review
JCB	Joseph Cyril Bamford Company
LACBWR	LaCrosse Boiling Water Reactor
LLEA	Local Law Enforcement Agency
LLW	Low-Level Radioactive Waste
MA	Massachusetts

MCC	Movement Control Center
MPC	MultiPurpose Canister
MSLD	Mass Spectrometer Leak Detection
MTHM	Metric Tons Heavy Metal
MTSA	Maritime Transportation Security Act
MUA	Multi-Attribute Utility Analysis
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Report
NWPA	Nuclear Waste Policy Act
NY	New York
OH	Ohio
OJT	On-the-Job Training
OM	Operation Manager
OSHA	Occupational Safety and Health Administration
PAR	Pan Am Railways
PAS	Pan Am Southern Railways
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIH	Poisonous Inhalation Hazard
PPE	Personal Protective Equipment
PWR	Pressurized Water Reactor
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
RCT	Radiation Control Technician
RFA	Reconfigured Fuel Assembly
RP	Radiation Protection
RPV	Reactor Pressure Vessel
RSAT	Risk and Security Assessment Team
RSSM	Rail Security Sensitive Materials
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SFP	Spent Fuel Pit
SFA	Spent Fuel Assembly
SME	Subject Matter Expert
SNF	Spent Nuclear Fuel
START	Stakeholder Tool for Assessing Radioactive Transportation
STC	Storable Transport Cask
TFR	Transfer Cask
TIH	Toxic Inhalation Hazards
TN	Tennessee
TPE	Training Program Evaluation
TS	Technical Specification
TSA	Transportation Security Administration
TSC	Transportable Storage Canisters
TWIC	Transportation Worker Identification Credential
U.S.	United States

USCG	U.S. Coast Guard
UT	Utah
VCC	Vertical Concrete Cask
VDS	Vacuum Drying System
VSP	Vessel Security Plan
VT	Vermont
WVDP	West Valley Demonstration Project
YAEC	Yankee Atomic Electric Company
YR	Yankee Rowe Nuclear Power Station

EXECUTIVE SUMMARY

The purpose of this report is to assist the United States (U.S.) Department of Energy (DOE) in laying the groundwork for implementing an integrated nuclear waste management system. This includes preparing for future large-scale transport of Spent Nuclear Fuel (SNF), High-Level Radioactive Waste (HLW), and Greater Than Class C (GTCC) Low-Level Radioactive Waste (LLW). This report addresses the tasks, equipment, and interfaces necessary for the complete de-inventory of the Yankee Rowe Nuclear Power Station (YR) independent spent fuel storage installation (ISFSI) site located in the Berkshire Hills of Franklin County in Rowe, Massachusetts, 0.5 miles south of the Vermont/Massachusetts border. As such, this report is intended to provide information useful for planning options within an integrated nuclear waste management system.

Multiple modes of transport of the existing SNF and GTCC LLW were considered as part of this report (i.e., heavy haul truck (HHT), rail, and barge). However, only HHT-to-rail routes were evaluated as viable modes of transport by this assessment. To assess the identified routes and modes, a Multi-Attribute Utility Analysis (MUA) was performed. In addition to subject matter expert (SME) input, data from the 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 existing SNF and GTCC LLW from YR to a Class I railroad and then to the hypothetical destination near the geographical center of the 48 contiguous United States (GCUS).

The MUA established a ranking of six possible routes from the YR site, listed here in order of decreasing favorability as analyzed by the MUA:

1. HHT from YR ISFSI to Westfield, MA and then by rail to the GCUS.
2. HHT from YR ISFSI to the Hoosac Tunnel West in North Adams, MA and then by rail to the GCUS.
3. HHT from YR ISFSI to Deerfield, MA and then by rail to the GCUS.
4. HHT from YR ISFSI to Shelburne Falls, MA and then by rail to the GCUS.
5. HHT from YR ISFSI to Bennington, VT and then by rail to the GCUS.
6. HHT from YR ISFSI to Bellows Falls, VT and then by rail to the 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 extremely consistent rankings, with the routes maintaining the same ranking for almost every weighting variation analyzed.

Using the primary MUA result, a concept of operations and recommended budget and spending plan are detailed for the removal of existing SNF and GTCC LLW from the YR site using the highest ranked shipment route: by HHT from the YR site for approximately 68 miles to a transload location in Westfield, MA, followed by an approximately 1,084 mile rail route through Buffalo, NY, Cleveland, OH, and Indianapolis, IN to the GCUS. The total estimated budget for the YR campaign organized over 32 calendar weeks is $9.0M (2022), noting this only covers on-site operational activities and not transportation costs, hardware costs, etc. 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, the recommended next steps are identified for the process of initiating the removal of the existing SNF and GTCC LLW from the YR site.

1.0 INTRODUCTION

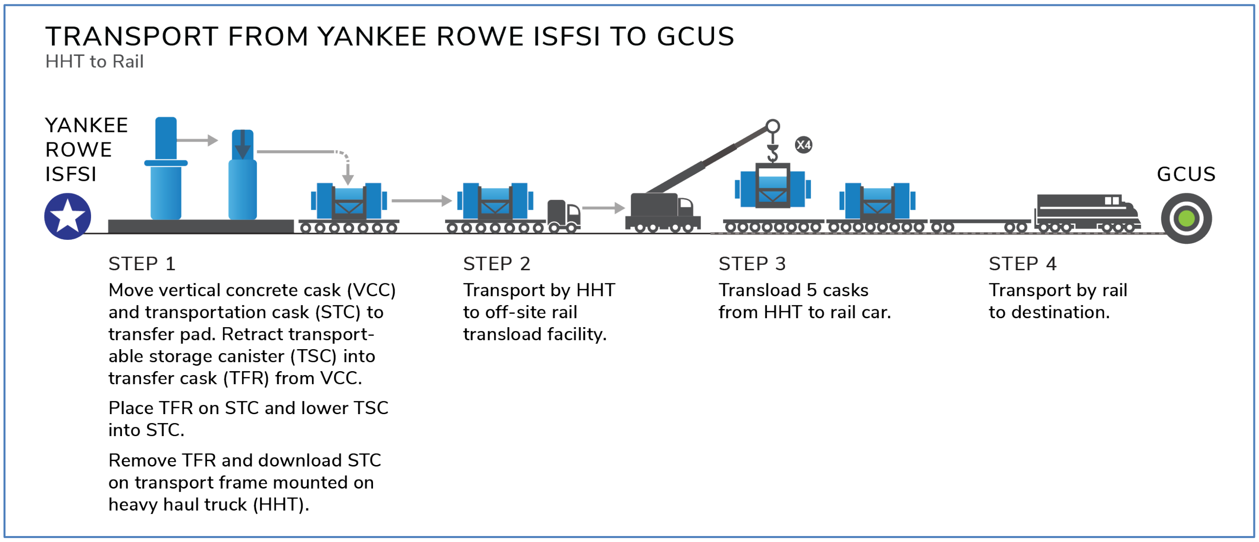
This report provides an assessment of the tasks, equipment, and interfaces that would be necessary to remove the SNF and GTCC LLW from the YR ISFSI located in the Berkshire Hills of Franklin County in Rowe, Massachusetts, 0.5 miles south of the Vermont/Massachusetts border. The objective of this removal activity would be to transport the existing SNF and GTCC LLW to a Class I railroad, where it could then be transported to a future 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 GCUS as a hypothetical destination is not to imply that this location is being considered for a future 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 the laying of groundwork for implementing an integrated nuclear waste management system for the U.S. DOE. This includes preparing for future large-scale transport of SNF, HLW, and GTCC LLW. This assessment specifically examines the removal of the existing SNF and GTCC LLW contained within the YR ISFSI using Orano Federal Services' and our teaming partners' 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 U.S. Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) 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 existing SNF and the GTCC LLW to be shipped from the site, a description of the NAC International Multi-Purpose Canister storage system (NAC-MPC) used to store this material onsite and the associated transportation packaging system, the NAC Storable Transport Cask (NAC-STC) system. The site information is vital to establishing whether sufficient space exists to perform transfer activities and to 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 an intermodal transport cradle/frame) to facilitate the shipment of these NAC-STCs from the YR ISFSI. Although interacting directly with the site is not within the scope of this activity, sufficient sources of information exist to perform an informed assessment of the site. Ultimately, however, a formal inspection would be necessary to verify assumed site criteria. Identification of the characteristics of the existing SNF and the GTCC LLW at the YR ISFSI provide information that will be necessary to verify compliance with the transportation licenses via their NRC Certificates of Compliance (CoCs). Similarly, the description of the NAC-STCs to be shipped from the YR ISFSI will be provided to allow verification of compliance with their CoCs, allowing, if necessary, provisions to be designated to bring them into compliance or identification of exemptions requiring approval from the regulator in the future.

After the pertinent site information was assessed, a transportation route analysis was performed, as described in **Section 3.0**, identifying transportation routes from the YR ISFSI to a Class I railroad, which would then be used for subsequent shipment to a repository or interim storage facility. Multiple modes of transport of the existing SNF and GTCC LLW were considered (i.e., HHT, rail, and barge). From the YR ISFSI site itself, only HHT-to-rail routes were evaluated to be viable options for shipment of the existing SNF and GTCC LLW. **Figure 1-1** depicts the major steps of the potential transfer scenarios considered. The result of the assessment of the transportation routes is a listing of multiple viable routes with various attributes, both positive and negative, that require evaluation to identify the optimal and/or favored route to transport the existing SNF and GTCC LLW from the YR site.

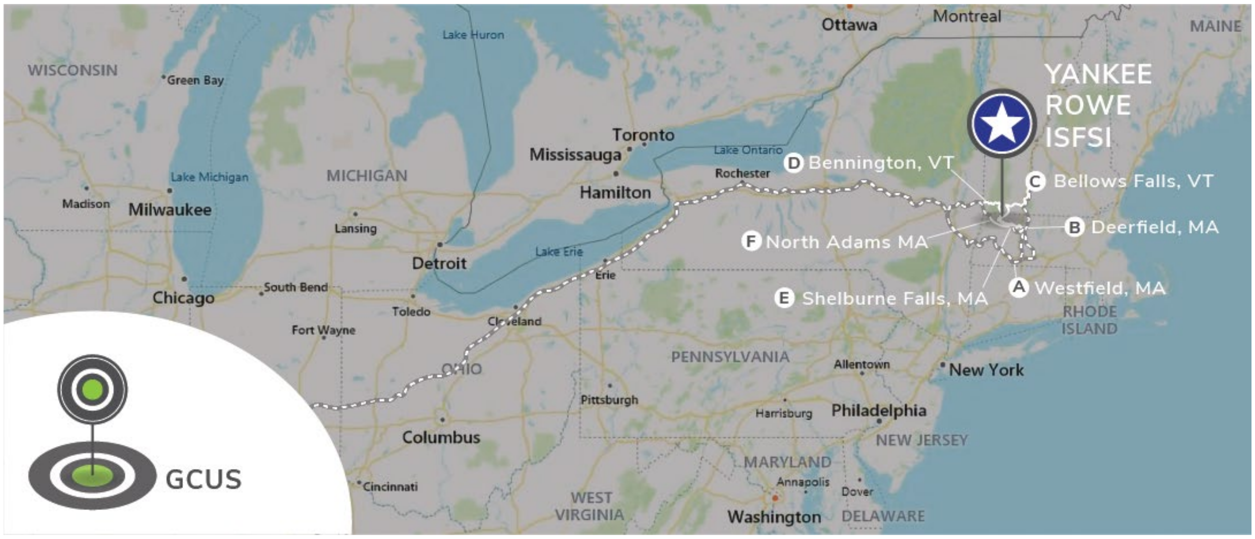
Figure 1-1: Potential Flow Of Operations Assessed For Loading A Consist Per Mode Of Transport From YR ISFSI



An MUA was selected as the means to assess the various routes and modes and identify a ranking of these routes. Due to the large number of routes and associated modes initially identified, performing the MUA for all the potential routes would be burdensome, so initial screening criteria were established to reduce the number of routes considered based on attributes associated with a particular mode of transport. These screening criteria were applied in **Section 3.0** to reduce the number of identified routes from a burdensomely large quantity to a manageable six. After the participating entities were identified in **Section 4.0**, these six routes were evaluated using the MUA to rank the routes for shipping the existing SNF and GTCC LLW from YR 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 **Section 6.0** and **Section 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 existing SNF and GTCC LLW from YR.

Figure 1-2: Possible Routes Evaluated By The MUA For Shipment Of SNF And GTCC LLW From YR ISFSI



The routes are described in further detail in **Section 3.0**. These figures were produced using results from START software[1]. Each route indicated was analyzed through the MUA process.

2.0 PERTINENT SITE INFORMATION

2.1. Description of Site/Characteristics

The YR site, owned by Yankee Atomic Electric Compay (YAEC), is located in the Berkshire Hills of Franklin County in Rowe, Massachusetts, 0.5 miles south of the Vermont, Massachusetts border as shown in **Figure 2-1.**

The 1,800 acre site, as shown in **Figure 2-2** and **Figure 2-3**, is located in a predominately rural area which is heavily forested and lightly populated. The terrain in the vicinity of the site is mountainous with elevations ranging from 800 to 2,500 feet above sea level. The site borders the eastern shore of the Deerfield River and adjacent to the Sherman Dam. The Deerfield River is used extensively for hydroelectric power generation both upstream and downstream of the YR site. The Sherman Dam, immediately adjacent to the site, operates as a hydroelectric generating station. Sherman Pond, the impoundment behind this dam had been used as a source of cooling water for the former power plant. There are numerous grades both uphill and downhill on the routes leading away from the site.

YR was a 185-megawatt (electric) (MWe) Westinghouse design nuclear power plant that achieved criticality in 1960 and began commercial operations in 1961. YAEC is the holder of Yankee Nuclear Power Station Facility Operating License DPR-3 (Docket No. 50-029). YR was shut down October 1, 1991 in response to regulatory uncertainties associated with the integrity of the reactor vessel. During the outage and before February 26, 1992, all fuel assemblies, control rods, and neutron sources were removed from the Reactor Vessel and stored in the Spent Fuel Pit (SFP). On February 27, 1992, YAEC notified the Nuclear Regulatory Commission (NRC) of the company's decision to permanently cease power operations at YR. On August 5, 1992, the NRC issued Amendment No. 142 to the Facility Operating License DPR-3, which changed the facility operating license to a possession only license. The YR License Termination Plan was approved by the NRC in July 2005 and continues to be maintained. The federally licensed site is now reduced to approximately 2 acres surrounding the Independent Spent Fuel Storage Installation (ISFSI) facility[2]. Beginning in June 2002, spent fuel and GTCC waste were transferred to dry casks and placed on the onsite Independent Spent Fuel Storage Installation (ISFSI). The transfer activities were concluded in June 2003. Plant closure activities were completed in December 2006 and the NRC License was reduced to the ISFSI in the summer of 2007. As of August 2007, all plant systems and components were dismantled and disposed of with the exception of those associated with the ISFSI[3] and a partial release for all areas of the YR site except the ISFSI was issued by the NRC[4]. Storage of the SNF and GTCC LLW removed from the reactor is currently controlled under the NRC license SFGL-13 (Docket 72-031). The location of the ISFSI is approximately 500 feet from the former reactor site and is shown in **Figure 2-4**.

There is no barge access or direct rail access at the YR site. YR had direct rail service, but the rail spur to the site was removed in the early 1970s and cannot be reinstalled because the construction of the Cockwell (formerly Bear Swamp) Pumped Storage Plant resulted in submersion of the rail line providing access to Yankee Rowe[5]. Heavy haul truck transport would be required to move transportation casks containing used nuclear fuel and GTCC low-level radioactive waste from this location over a public highway to a railroad siding for loading onto rail.

Figure 2-1: YR Site Location[6]

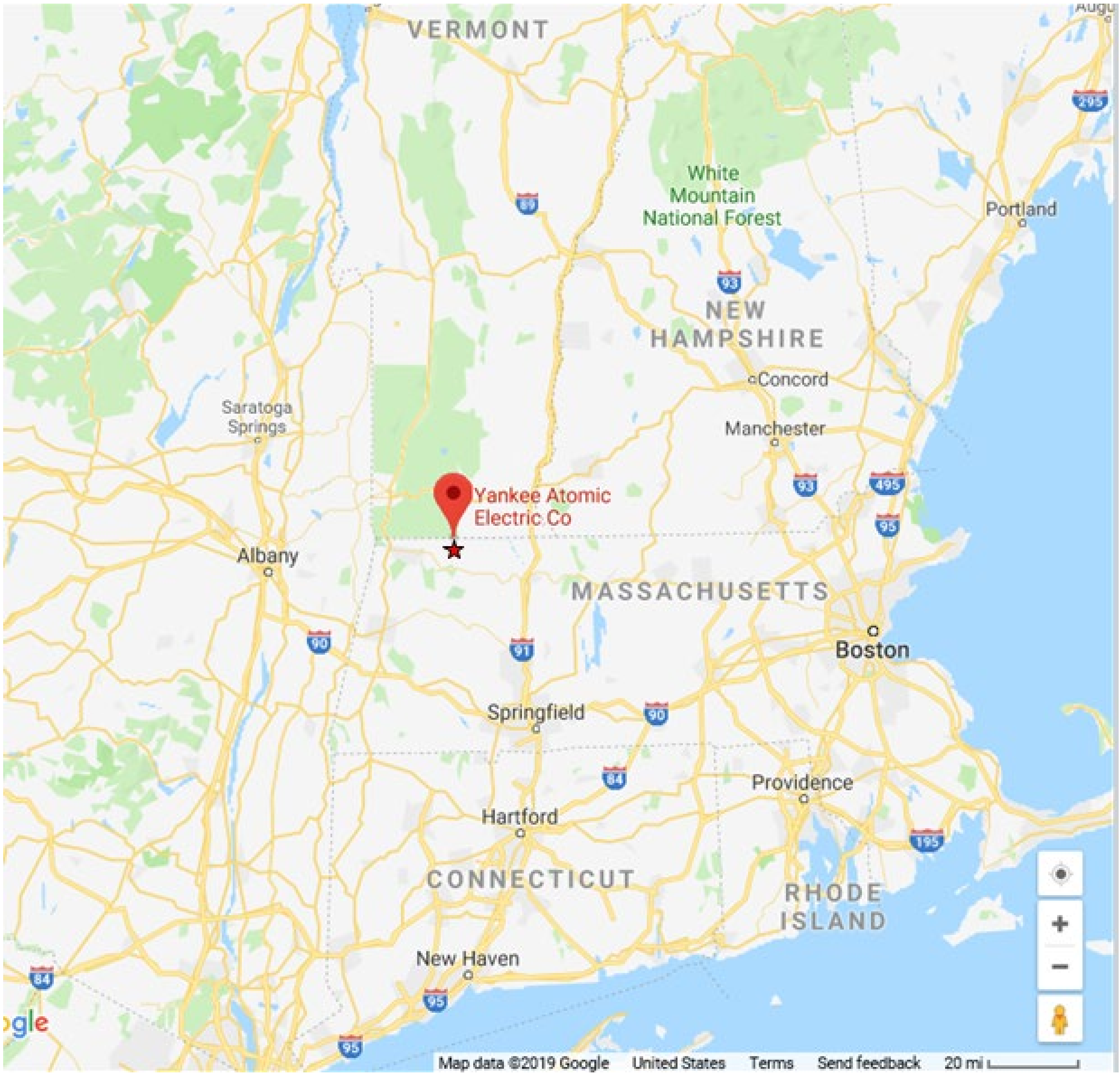


Figure 2-2: Yankee Atomic Electric Company Owner-Controlled Area[7]

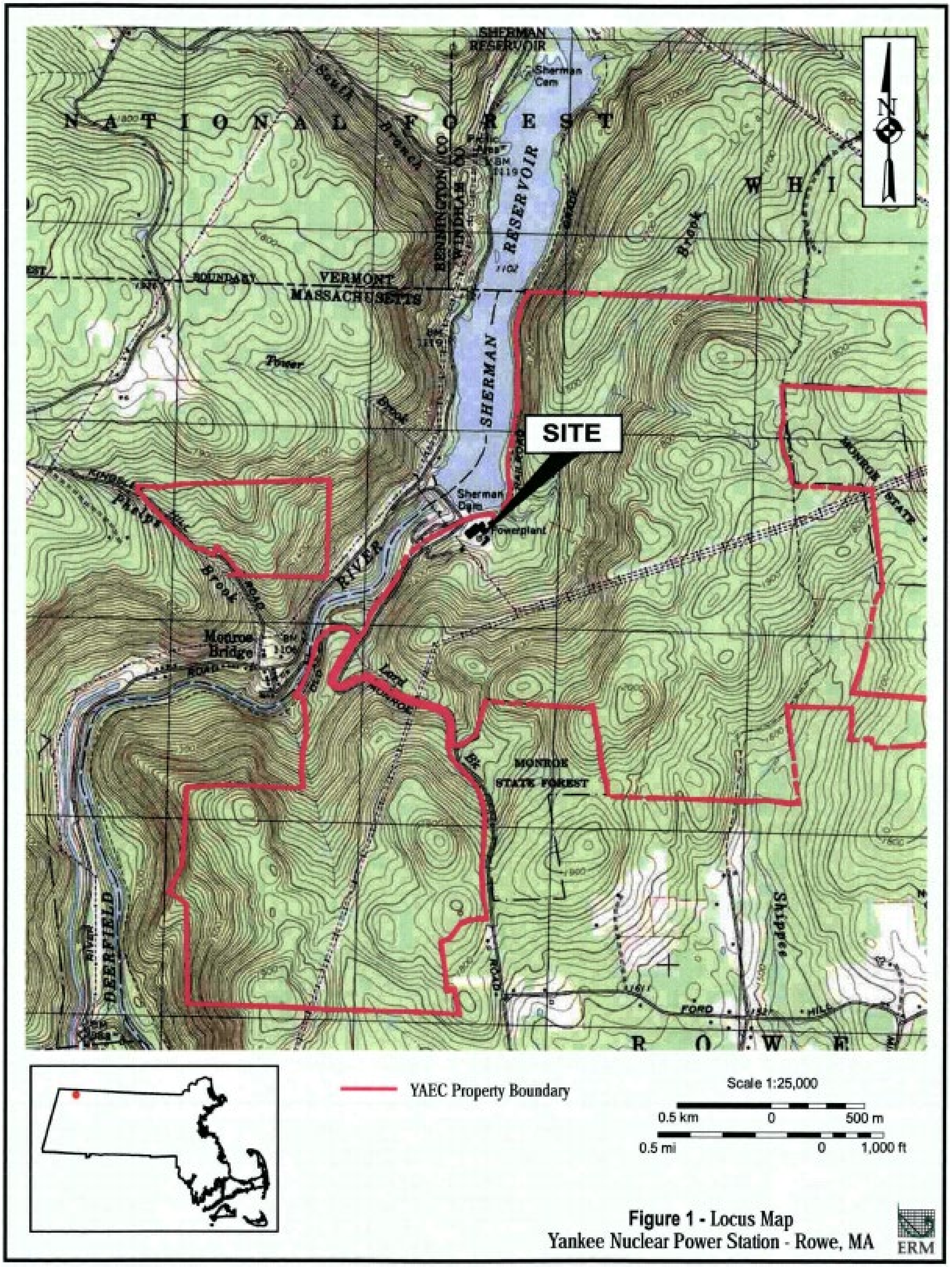


Figure 2-3: YR Site[6]

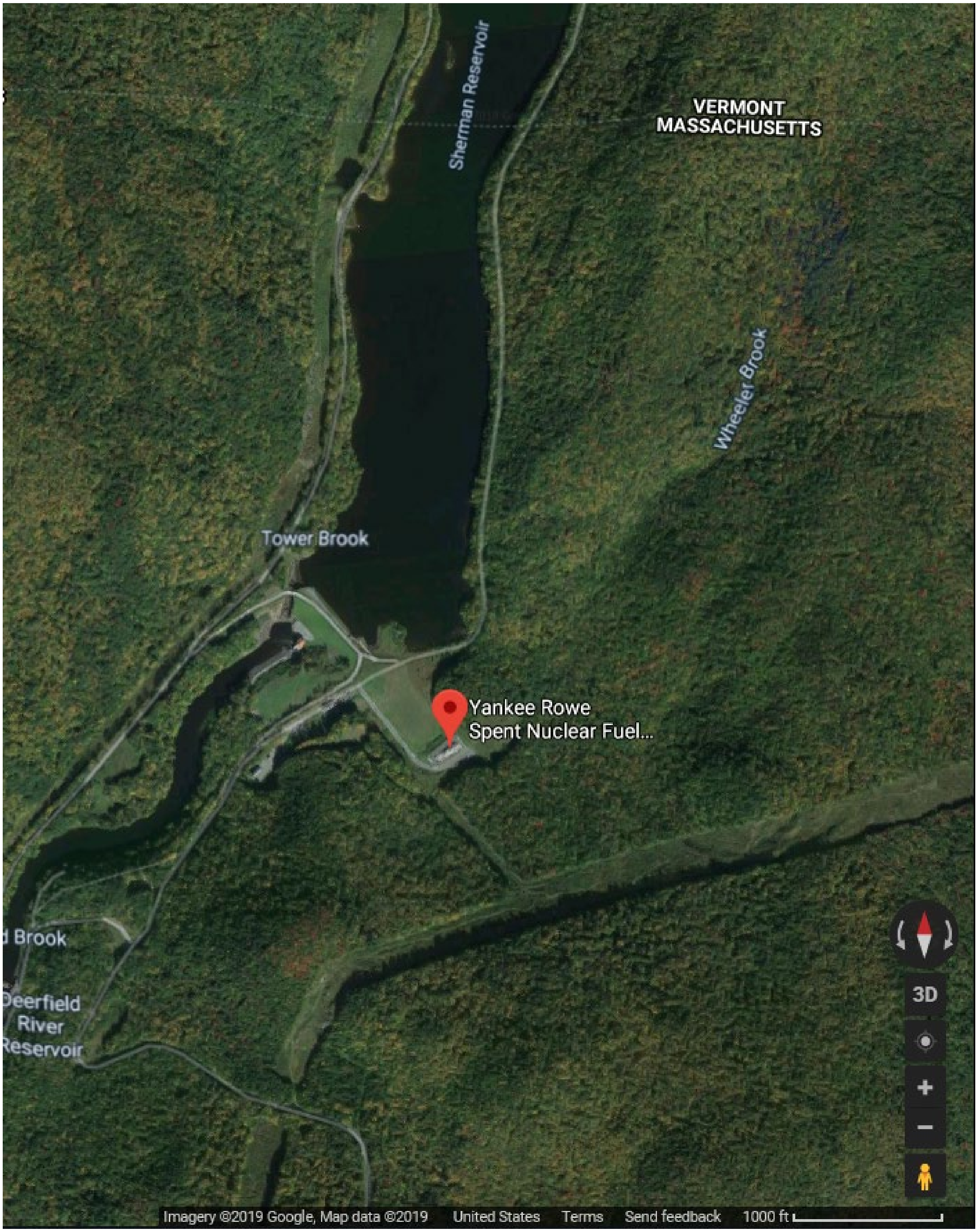
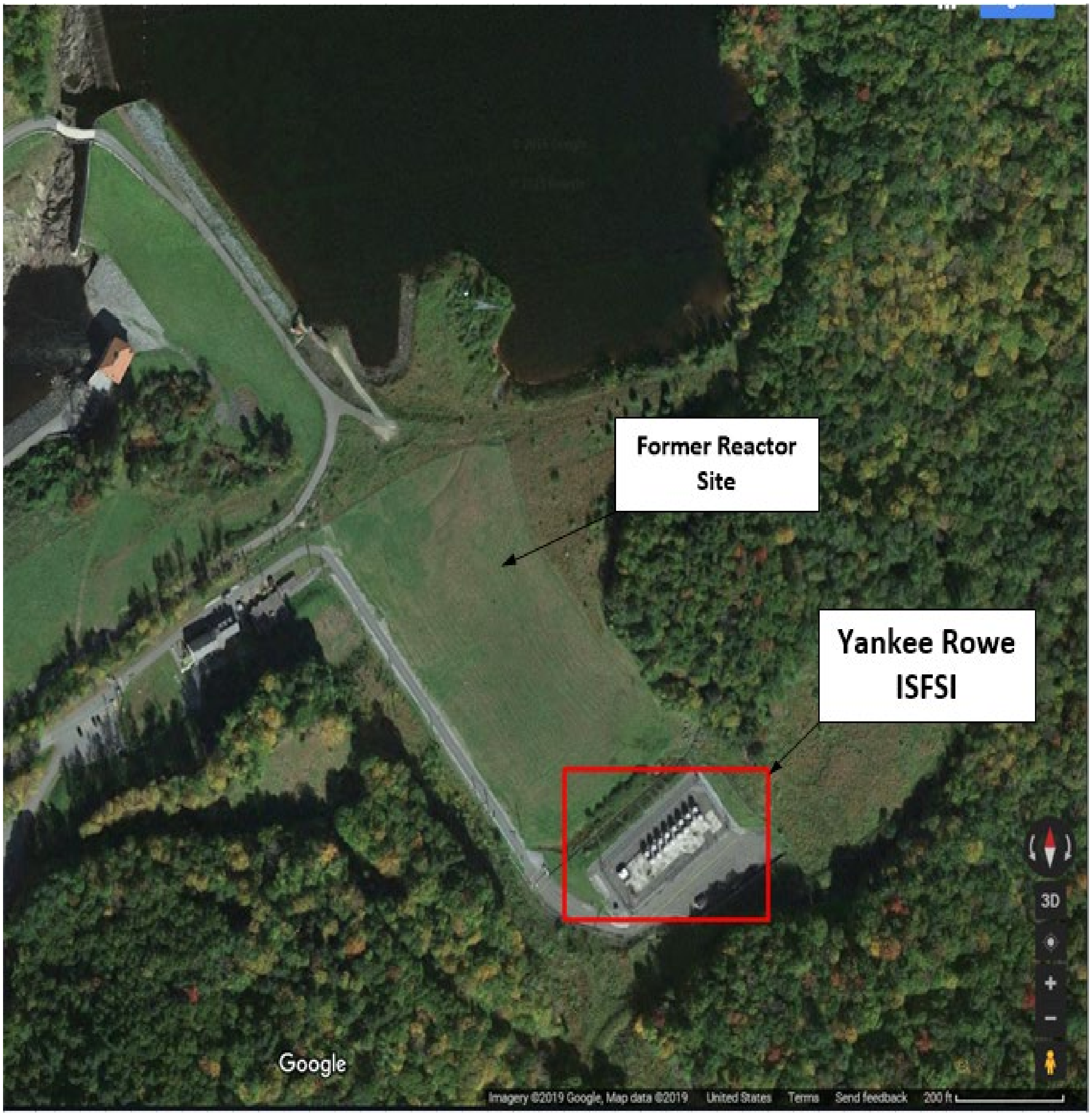


Figure 2-4: YR ISFSI Location[6]



The storage system used at the YR site is the NAC International Multi-Purpose Canister storage system (NAC-MPC) (Docket No. 72-1025), which consists of a transportable storage canister (TSC) with a spent fuel assembly (SFA) fuel basket, a vertical concrete cask (VCC) storage module, and a transfer cask (TFR). The TSCs can be loaded into a NAC Storable Transport Cask (NAC-STC) (Docket No. 71-9235) to enable transporting the contents from the YR site.

As part of the plant decommissioning process, all the SNF and GTCC LLW were removed from the SFP and were then moved to the on-site ISFSI. The final GTCC LLW cask was placed on the ISFSI on June 30, 2003. The intact fuel assemblies were loaded into YR-MPC Transportable

Storage Canisters (TSCs), which were then loaded into concrete storage casks and moved to the ISFSI Storage Pad. Damaged and potentially damaged fuel assemblies, fuel rods, and fuel debris were first loaded into Damaged Fuel Cans (DFCs) or Reconfigured Fuel Assemblies (RFAs) and were loaded into YR-MPC TSCs in fuel basket locations designated for damaged fuel and RFA contents. The GTCC LLW, consisting of irradiated reactor internals and solid, particulate cutting debris (dross) or filter media was loaded into individual GTCC LLW cans, and then loaded into a YR-MPC TSC provided with a GTCC LLW Basket. As with the TSCs containing SNF, the TSC containing the GTCC LLW was dewatered and vacuum dried before being closed. The total inventory of the YR SNF and GTCC LLW stored in YR-MPC Systems is presented in **Table 2-1**.

Table 2-1: SNF and GTCC TSC Inventory Summary for YR Site[8]

YR-MPC Canisters		# SNF Assemblies (PWR) +1 RFA	# Reconfigured Fuel Assemblies (RFAs)	# Damaged Fuel Cans	# Damaged SNF Assemblies
SNF	GTCC LLW				
15	1	534	1	7	7

The 15 NAC-MPC canisters of spent nuclear fuel are currently registered to NAC-MPC CoC No.1025, Amendment 8[45] and NAC-MPC FSAR Revision 12[50]. Amendment 9 to CoC No. 1025 is currently undergoing NRC review and contains revised License Renewal Aging Management Program requirements (equipment inspections), added Time Limited Aging Analysis (TLAAs), and incorporates language from Enforcement Guidance Memo (EGM) for administrative control conditions associated with system loading/unloading/inspection activities as they pertain to weather related phenomena. It is expected that the YR NAC-MPC Systems will be re-registered to CoC No. 1025, Amendment 9 and Final Safety Analysis Report (FSAR) Revision 13[5] following NRC approval in mid-2023. Use of the ISFSI for storage and handling of spent fuel is granted upon compliance with the conditions of the General License issued under 10 CFR Part 72, Subpart K.

Refer to **Section 2.2** and **Section 2.3** below for information regarding the details of the SNF and GTCC to be shipped, and for canister and overpack details.

The ISFSI and VCCs are shown in **Figure 2-5** and **Figure 2-6**. The ISFSI concrete storage pad, constructed in 1999, is located towards the southeast of the site boundary and is approximately 160 ft long x 48 ft wide, and 35 in thick. The ISFSI and VCCs, which are in 2 rows of 8 casks each, are contained within an approximately 2 acre licensed area and all 16 VCCs are loaded. The ISFSI pad includes a gravel path adjacent to the VCCs to allow the movement of a VCC along the full length of the pad. The pad is approximately 2 ft 5 in above ground elevation in the southeast corner near the truck dock paved area to allow VCC movement onto and off of an appropriately positioned HHT and is adjacent to an HHT access road. There is a ramp on the south side going up from the paved ISFSI area onto the ISFSI concrete pad. The ISFSI area is securely fenced and locked inside its own protected area of approximately of approximately 220 ft x 88 ft with limited work space available. Located on the ISFSI pad inside the protected area is an Instrumentation Building. Electrical power is available at the ISFSI[5]. The ISFSI is inaccessible to the public and subject to surveillance 24 hours a day. There is a paved area approximately 140 ft x 60 ft on the called southeast side of the ISFSI[10]. A storage shed and two portable security enclosures are located along a back wall in this area.

Figure 2-5: YR ISFSI[6]

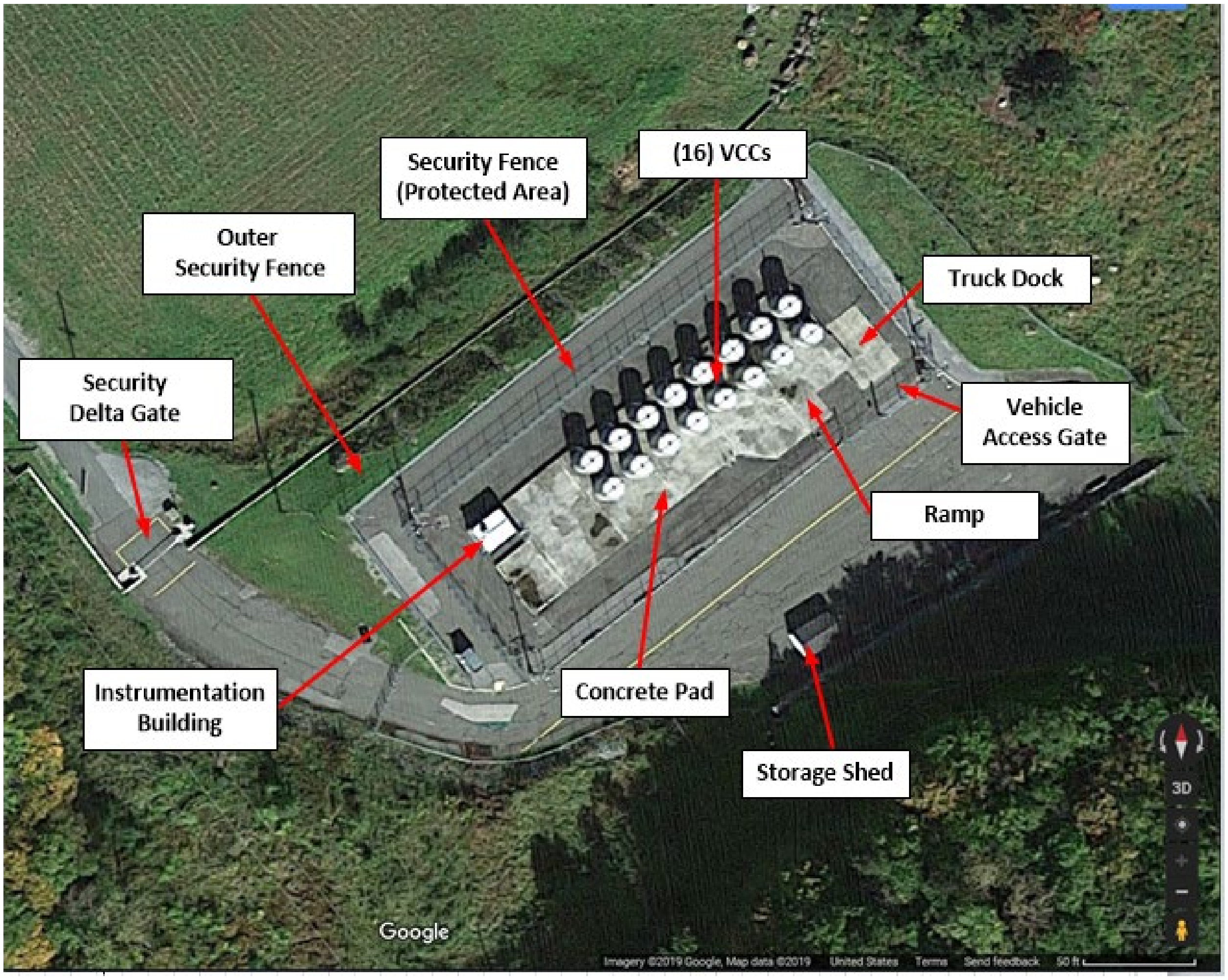
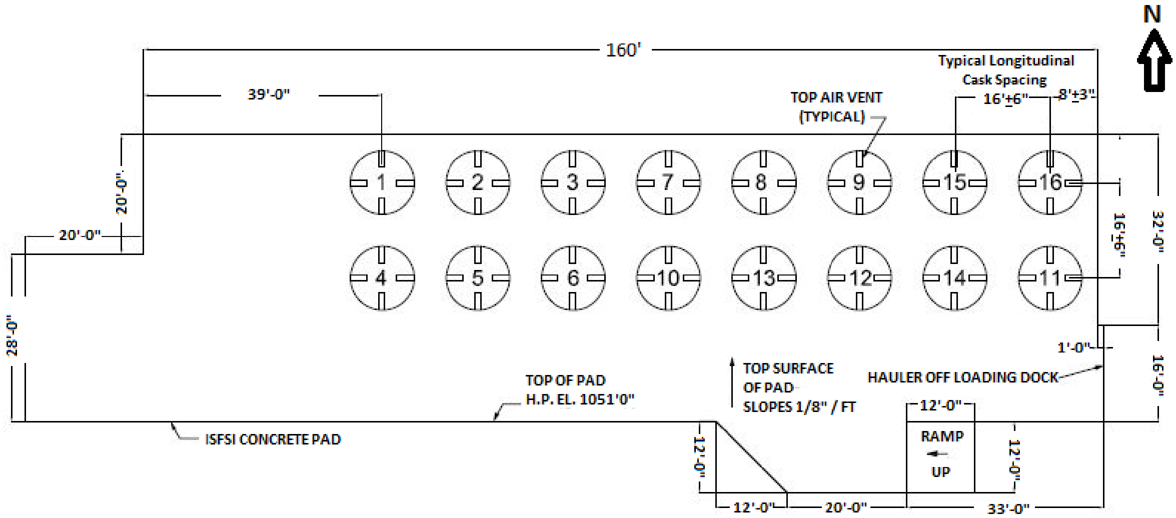


Figure 2-6: YR VCC[2]

Photo courtesy of Yankee Rowe

Figure 2-7 shows a layout of the storage systems at the YR ISFSI. The 16 VCCs are all loaded.

Figure 2-7: YR ISFSI Layout[11]



Site Infrastructure

Figure 2-8 provides an aerial view of the YR site, including the former reactor and associated structures site, ISFSI, Sherman Reservoir and Dam, and Deerfield River. **Figure 2-9** shows the Sherman Dam spillway bridge. There is no barge access as the site is not located on or near a navigable waterway. There is also no direct rail access at the site. Yankee Rowe had direct rail service, but the rail spur to the site was removed in the early 1970s.

Heavy haul transport (HHT) vehicles will be required to move NAC-STC transportation casks containing used nuclear fuel or GTCC low-level radioactive waste from the ISFSI to an off-site rail transload location. An on-site access road, approximately 0.16 mile, from the ISFSI to the Sherman Dam, will need to be constructed and confirmation of engineering stability will be required for authorization for heavy haul vehicles to cross the dam. The Sherman Dam is owned and operated by ArcLight Capital Partners, a private equity firm[5]. The onsite road system has no restrictions or obstacles which would present difficulty for use of trucks or HHT vehicles. However, the spillway bridge at the west end of the Sherman Dam is 11 ft, 3 in wide and according to the utility, has a load limit of 140 tons on the unsupported 50 foot span[12]. These limits would need to be confirmed and considered in selection of a HHT vehicle. The HHT vehicle will leave the ISFSI and travel a total distance of 0.45 miles across the Sherman Dam and exiting the site to the intersection of Readsboro Road. After crossing the spillway bridge at the west end of the Sherman Dam, the road elevation drops approximately 7 ft over an approximate 260 ft distance and then rises approximately 15 ft over an approximately 600 ft distance before reaching Readsboro Road. The intersection between the site access road and turning north onto Readsboro Road is at an angle of approximately 150 degrees and will require careful maneuvering if used. **Figure 2-10** shows a proposed HHT vehicle path from the ISFSI access gate to the off-site Readsboro Road. In 2019, an evaluation was conducted on a deteriorating on-site road (Yankee Road). Several sections of the road have cracked and are displaced as shown in **Figure 2-11**. The road is used for employee access to the site and is not anticipated to be used for heavy haul transport.

Figure 2-8: Aerial View of YR Site (2017)[5]

Figure 2-9: Spillway Bridge on Sherman Dam (1997)[5]

Figure 2-10: Proposed HHT Vehicle Path from ISFSI to Offsite Readsboro Road[6]

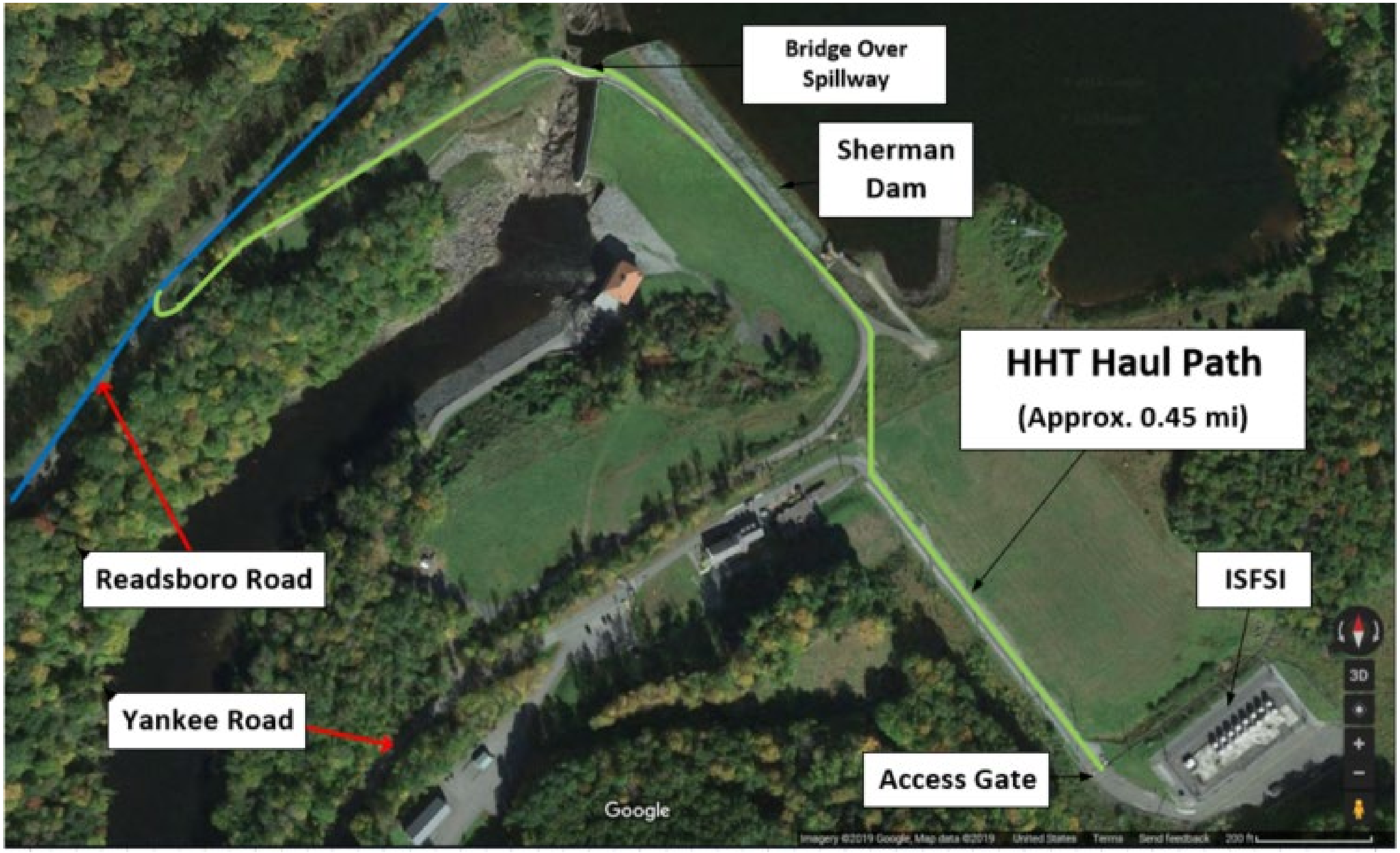


Figure 2-11: On-Site Yankee Road

Photo Courtesy of Yankee Rowe – August 2022

Near-site Transportation Infrastructure

HHT vehicles will be required to move the casks from the ISFSI to an off-site railcar transload location. The HHT vehicle routes to the railcar transload locations range from 18 to 68 miles and begin on Readsboro Road in the north or south direction after leaving the site. The routes consist of local roads which include weight-restricted roads and bridges, hilly terrain with tight curves, uphill and downhill grades, and ice-covered roads at times during the winter with average snowfall of 120" per year in the western Massachusetts area. There is no NRC-approved route for cask shipment from the YR site[12]. A route survey and load evaluation for the HHT route to the off-site railcar transload location will be required. The nearest rail access is at the east end of the Hoosac Tunnel, a distance of about 6.7 miles southwest from the YR site via Readsboro Road. This location was used in the past for transloading from truck to rail. Readsboro Road has a load limit of 140 tons, crosses two bridges, and has been used for heavy haul transportation in the past[13]. However, the rail siding has been removed and there is not enough room to construct a rail siding at the Hoosac Tunnel location to accommodate assembly of the complete consist.

The site is not located on or near a navigable waterway and has no barge access. The closest available barge facility is in Albany, New York, more than 50 miles west of the site[12].

I-90 (the Massachusetts Turnpike), an east-west interstate highway, is located 58 miles south of the site. I-91 is a north-south interstate located 20 miles east of the site. The roads leaving the site and traveling north on Readsboro Road leading to I-91 are narrow and have steep grades through mountains. Additional equipment, i.e. steerable rear end, pusher, etc. may be needed.

Regardless of the final transportation route selected to reach the destination site, the NAC-STC transportation casks will be moved on a goldhofer[1] or suitable HHT vehicle to the rail transfer location. Refer to **Section 6.1.3** for specific details of the canister transfer and cask preparation operations for the NAC-MPC and NAC-STC systems.

NAC-MPC Storage System Details

The SNF and GTCC LLW located at the YR ISFSI were loaded into NAC International's Multi-Purpose Canister (NAC-MPC) Storage Systems. The system is comprised of the following components: a specially designed YR-MPC TSC with a 36-PWR SFA fuel basket assembly (See **Figure 2-12**), a YR-MPC Vertical Concrete Cask (VCC), and a YR Transfer Cask (TFR). The YR-MPC TSCs can be loaded into a NAC Storable Transport Cask (NAC-STC) to enable transporting the contents off of the YR site. The YR-MPC SNF storage systems include 13 YR-MPC TSCs provided with a 36-PWR SNF fuel basket and 2 YR-MPC TSCs provided with a modified shield lid to accommodate up to four (4) DFCs per TSC. The YR GTCC LLW was loaded into one specially designed YR-MPC TSC provided with a 24-cell GTCC LLW basket assembly.

[1] In this report, a goldhofer equates to a heavy-duty, self-propelled trailer/module.

The YR-MPC VCCs, shown in **Figure 2-14**, were fabricated on site and loaded with canisters at an outdoor location adjacent to the fuel building. There are 16 YR-MPC systems at the YR ISFSI, with details as follows:

- The YR-MPC VCCs are 158.4 inches high including the VCC lid with a liner inside diameter of 79.0 inches and an outer diameter of 128.0 inches[14].
- The walls of the YR-MPC VCC are 24.5 inches thick and consist of a 3.5 inch thick inner steel liner surrounded by 21 inches of reinforced concrete[14].
- The approximate weights of the YR-MPC VCC are 151,375 lbs empty and 206,100 lbs loaded for the SNF fuel basket and 204,800 for the YR-MPC GTCC LLW VCC.
- The YR-MPC VCC lid weighs approximately 2,840 lbs and is secured to the cask liner with 6 ½-inch bolts. Three of the lid bolt holes are threaded to provide for attaching swivel hoist rings for lifting[15].
- Installed below the YR-MPC VCC lid is a shield plug that rests on the shield lid support ring and is removed prior to unloading a YR-MPC TSC. The shield plug weighs approximately 5,490 lbs and is held in place by the YR-MPC VCC lid. There are three threaded lifting bosses for attaching swivel hoist rings for lifting the shield plug[16].
- The YR-MPC VCCs can be moved in a vertical orientation through the use of an air pad system. The system includes four air pads that are placed under the VCC base plate by jacking the VCC and installing the air pads between the four ventilation inlets. The air pads are then inflated and the cask can be maneuvered with a modified fork truck, or similar equipment. Once in the designated position on the ISFSI, the air pads are deflated and the jacks are installed in the four air inlets to lift the VCC to allow removal of the air pads. The VCC is then lowered to the ISFSI surface.

The YR-MPC TSCs, used to confine the SNF and shown in **Figure 2-12** are stainless steel and provide confinement of the contents. The YR-MPC GTCC LLW Waste TSCs are essentially identical to the fuel YR-MPC TSC, except a special YR-MPC GTCC LLW basket is installed in place of the SNF fuel basket. Details of the YR-MPC TSCs are as follows:

- The YR-MPC TSCs are 122.5 inches high with an outer diameter of 70.64 inches[17].
- The nominal loaded weights of the YR-MPC SNF TSCs are 54,730 pounds.
- The nominal loaded weight for the YR-MPC GTCC TSC is 53,425 lbs with a total of content weight of 12,340 lbs for the 24 GTCC LLW cans, a GTCC basket weight of 26,475 lbs and a TSC weight of 14,600 lbs.
- The YR-MPC TSC structural lid includes six threaded holes (2-4 ½ UNC-2B) to install swivel hoist rings and redundant sling sets or alternate TSC lifting system, which are used for lifting the loaded YR-MPC TSC[18].

To enable transferring a YR-MPC TSC from a storage cask (i.e., YR-MPC VCC) to a transportation overpack (i.e., NAC-STC), a YR TFR, shown in **Figure 2-15** with the transfer adapter, will be used. Details of the YR TFRs are as follows:

- The YR TFR is 133.38 inches high without retaining ring and 134.15 inches high with retaining ring installed and an outer diameter of 86.5 inches.

- The walls of the YR TFR have neutron and lead shielding encapsulated by carbon steel (CS) inner and outer shells[18].
- The inner annulus of the YR TFR has a nominal diameter of 71.5 inches and a cavity length of 123.5 inches[18].
- The approximate weight of the YR TFR is 80,745 lbs empty and 135,475 lbs loaded with a dry welded YR-MPC TSC[18].
- The top of the YR TFR is provided with a retaining ring which is bolted to the top of the TFR during YR-MPC TSC transfer operations to prevent a YR-MPC TSC from being accidently withdrawn from the TFR cavity[18].
- Attached to the bottom of the YR TFR is a set of hydraulically operated shield doors mounted on door rails to permit passage of a YR-MPC TSC[18].
- The cask includes a set of two lifting trunnions for engagement to the lift yoke.
- There is no YR TFR or lift yoke available at the YR site as the original YR TFR was sold to Dairyland Power Cooperative (DPC) for use on the LaCrosse boiling water reactor (LACBWR) dry storage program utilizing NAC's storage system MPC-LACBWR.

The fuel assemblies from YR were loaded into NAC-MPC system (YR-MPC) and placed on the ISFSI beginning on June 26, 2002 with the final loaded fuel system placed on the ISFSI on May 31, 2003. The GTCC LLW TSC was placed on the ISFSI pad on June 30, 2003.

The YR-MPC TSC (**Table 2-2** and **Figure 2-12**) is used for storing the SNF and GTCC LLW on site and for future transport in the NAC-STC[19]. The YR-MPC TSC consists of a cylindrical SA240 Type 304L stainless steel shell with welded bottom plate, shield lid, structural lid, and a fuel basket.

The bottom is a 1.00-inch thick SA240 Type 304L stainless steel plate. The shell is constructed of 5/8-inch thick rolled steel plate with a nominal outer diameter of 70.64 inches. The shield lid is a 5-inch thick SA240/SA182 Type 304 stainless steel plate/forging and contains drain and fill penetrations for accessing the TSC cavity following shield lid to TSC shell welding. The structural lid is a 3-inch SA240/SA182 Type 304L stainless steel plate/forging. The canister contains a stainless steel and aluminum fuel basket that can accommodate 36 Yankee class Pressurized Water Reactor (PWR) spent fuel assemblies, fuel debris, fuel lattices, and RFAs. Two of the YR-MPC TSC shield lids were modified to allow storage of up to four DFCs containing damaged fuel assemblies and fuel debris. The YR-MPC TSC has a maximum content weight limit of 30,600 lbs.

The YR-MPC TSC and integral fuel basket provides heat transfer paths, criticality control, and structural support. One YR-MPC TSC is loaded per YR-MPC VCC. The YR-MPC TSC is configured to hold 36 Yankee class PWR SNF assemblies. The YR-MPC fuel basket is designed to store up to 36 zirconium alloy-clad assemblies enriched to 4.03 wt % U^{235}, stainless steel clad assemblies enriched up to 4.97 wt % U^{235}, RFAs, or damaged or potentially damaged fuel and fuel debris in DFCs. The YR-MPC fuel basket configuration is shown in **Figure 2-13**.

The following weights are utilized to calculate the total content weights:

- Maximum SFA content weight utilized for design and certification: 950 lbs.

- GTCC LLW Canister (loaded): 514 lbs.

RFAs can accommodate up to 64 fuel rods, as intact or damaged fuel or fuel debris, in an 8x8 array of stainless steel tubes, respectively. Intact and damaged fuel rods, as well as fuel debris, are held in the fuel tubes. The RFAs have the same external dimensions as a standard intact fuel assembly, and are accounted for in the total of SFAs as a standard SFA.

The GTCC basket positions up to 24 waste containers within square sleeves formed by 3/16-inch thick Type 304 stainless steel plates. The GTCC LLW basket is a right-circular cylinder formed by a series of 2.5-inch thick Type 304 stainless steel plates, laterally supported by 8 equally space welded 1.0-inch thick Type 304 stainless steel outer ribs. The GTCC LLW containers accommodate radiation activated and surface contaminated steel, cutting debris (dross) or filter media, and have external dimensions of 7.76 x 7.76 inch.

Table 2-2: YR-MPC TSC[50]

Attribute	YR-MPC, 36 Assy TSC	YR-MPC, 24 GTCC TSC
a. Capacity (intact assemblies)	36 Yankee Class PWR	24 GTCC Cans
b. Maximum Weight (lbs)		
Empty	24,130	41,075
Loaded	54,730	53,425
c. Thermal		
Design Heat Rejection (kilowatt (kW))	12.5 storage/12.5 transportation	2.9 storage/2.9 transportation
Max. Per Assy. Heat Load (kW)	0.347 storage/0.347 transportation	
Maximum Burnup (GWD/Metric Tons Uranium (MTU))	36	
d. Shape	Cylindrical	Cylindrical
e. Dimensions (in.)		
Overall Length	122.5	122.5
Outside Diameter	70.64	70.64
Wall Thickness	0.625	0.625

Attribute	YR-MPC, 36 Assy TSC	YR-MPC, 24 GTCC TSC
Shield Lid Thickness	5	5
Structural Lid Thickness	3	3
Bottom Thickness	1.00	1.00
Basket Length	112.8	112.8
f. Materials of Construction		
Canister Body	Stainless steel (SS)	SS
Basket	SS, Boral, and Al	SS
Port Covers	SS	SS
g. Cavity Atmosphere	He	He
h. Maximum Lid Leak Rate (cm^3/sec, helium)	$\leq 2 \times 10^{-7}$	N/A(1)

(1) GTCC LLW TSCs are not leakage tested as there is no significant gaseous or releasable radioactive contents.

Figure 2-12: YR-MPC Transportable Storage Canister Assembly[8]

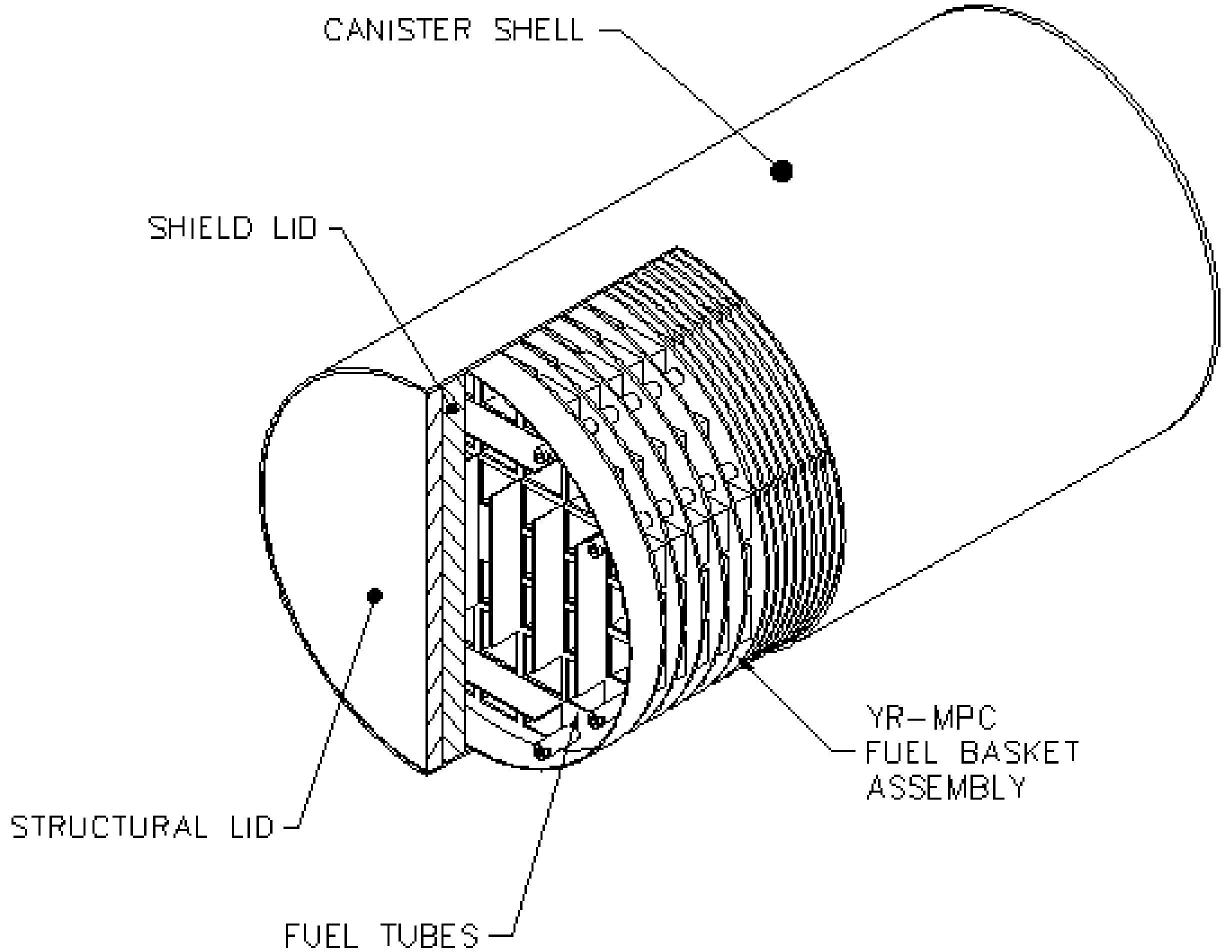
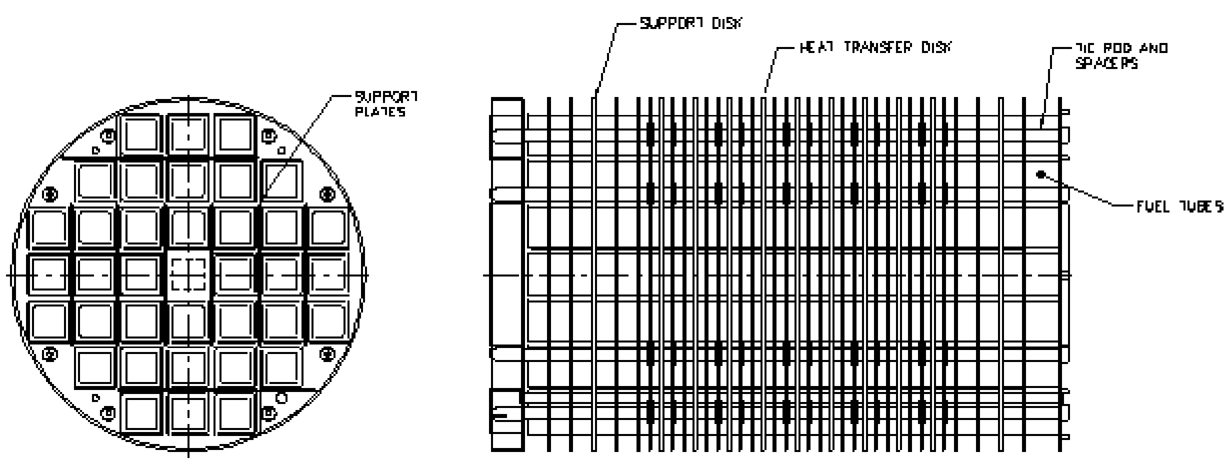


Figure 2-13: YR-MPC TSC Fuel Basket Assemblies (36-Assembly Configuration)[20]



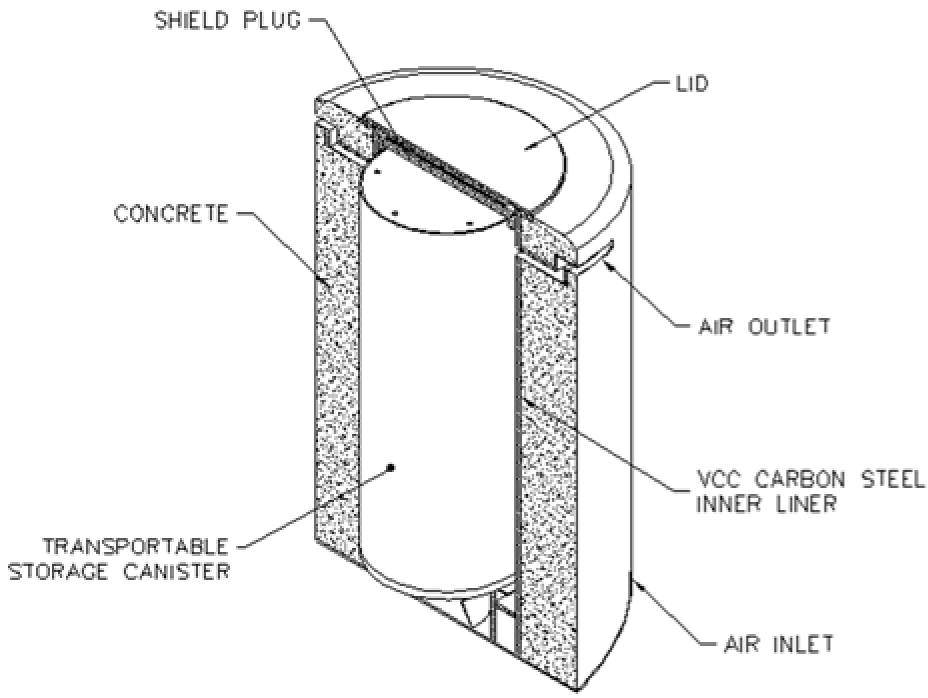
The YR-MPC VCC (**Table 2-3** and **Figure 2-14**) is the storage overpack for the YR-MPC TSC and provides structural support, shielding, protection from environmental and accident conditions, and natural convection cooling of the TSC during storage. The VCC is a reinforced concrete structure with a carbon steel inner liner. It contains an annular air passage with inlet and outlet vents to allow for natural air circulation around the TSCs. The YR-MPC TSC is axially positioned on the VCC base plate and baffle weldment with the YR-MPC TSC baseplate protected by a stainless-steel cover sheet.

Table 2-3: YR-MPC VCC[50]

Attribute	YR-MPC VCC
a. Capacity (TSC)	1
b. Weight (lbs)	
Empty (nominal)	151,375
Loaded	206,100
c. Shape	Cylindrical
d. Dimensions (in.)	
Overall Length	158.4
Outer Diameter	128
VCC Liner Inside Diameter	79
Wall Thickness	24.5 (3.5-in CS and 21-in reinforced concrete)
Shield Plug	6.125
Lid Thickness	1.5
e. Neutron Shield (in.)	
Side Thickness (Concrete)	21
Lid Thickness (NS-4-FR)	1
Bottom Thickness	N/A
f. Materials of Construction	
Cask Body	Concrete (Type II Portland Cement), CS Reinforcing Steel (A615 Grade 60), and CS Liner Assembly (A36)

Attribute	YR-MPC VCC
Neutron Shield, Radial	Concrete
Neutron Shield, Shield Plug	NS-4-FR
g. Outside Surface Dose (mrem/hr)	≤ 50 Side, ≤ 55 Top, 200 ≤ Inlet/Outlet Average

Figure 2-14: YR-MPC Storage System - VCC[9]

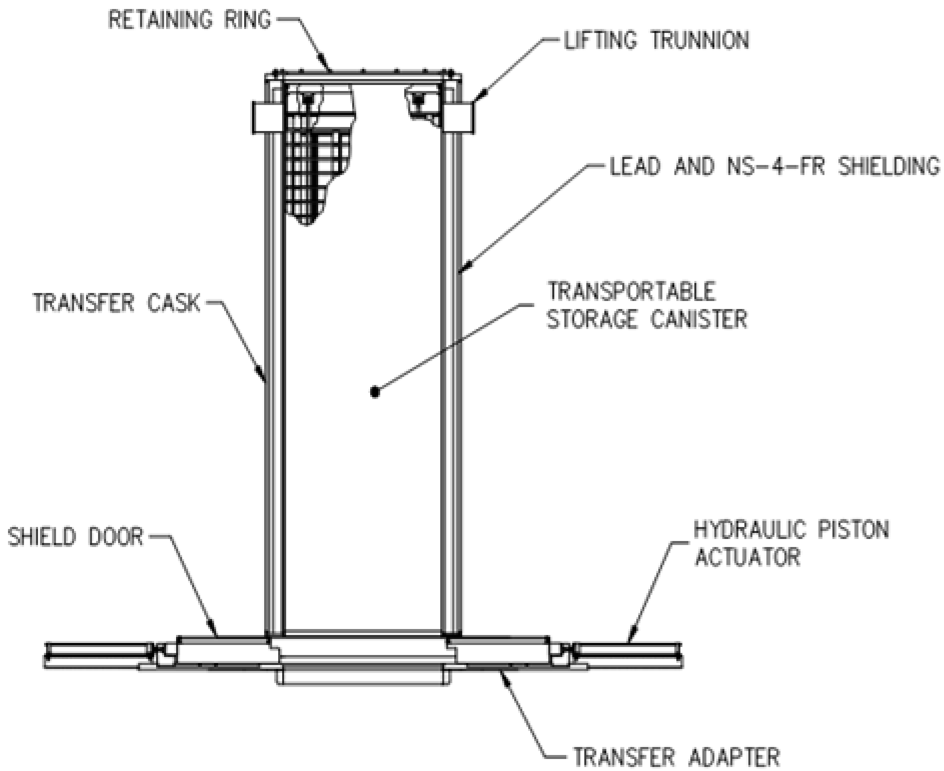


The YR TFR (see **Table 2-4** and **Figure 2-15**) is used for transfer operations on-site. There is no YR TFR on the YR ISFSI site. The YR TFR was sold to DPC for use at LACBWR where new shield doors and retaining ring were procured. The YR TFR is currently in storage at the LACBWR ISFSI. The cylindrical YR TFR has a bolted top retaining ring to prevent a loaded YR-MPC TSC from inadvertently being removed through the top of the TFR and becoming unshielded. The TFR is stacked on top of the VCC. The retractable bottom shield doors are opened during unloading/loading operations using a Transfer Adapter. Then the YR-MPC TSC is retrieved/retracted into the TFR using the appropriate lifting device and crane.

Table 2-4: YR TFR[50]

Attribute	YR-MPC Metal TFR
a. Capacity (TSC)	1
b. Weight (lbs)	
Empty	80,745
Loaded	135,475
c. Shape	Cylindrical
d. Dimensions (in.)	
Overall Length	133.88
Overall Cross Section	86.5
Cavity Length	123.5
Cavity Cross Section	71.5
Wall Thickness CS/Pb/NS-4-FR/CS)	7.5
Retaining Ring Thickness	0.75
Bottom Shield Door Thickness	9.5
e. Neutron Shield (in.)	
Side Thickness	3.5
Lid Thickness	N/A
Bottom Thickness	N/A
f. Materials of Construction	
Cask Body	CS/Pb
Neutron Shield	NS-4-FR
g. Outside Surface Dose (mrem/hr)	≤300 side

Figure 2-15: YR-MPC On-Site TFR With Transfer Adapter[9]



<u>Transport Equipment</u>

At the current time, there may not be enough space on the YR ISFSI pad to perform the set-up and positioning of equipment to perform the YR-MPC TSC transfer operations in a safe and efficient manner. It is recommended that an evaluation of the available pad area for a TSC Transfer Station be conducted within the ISFSI security perimeter. Alternatively, an extension of the pad area to accommodate all equipment requirements within the security perimeter may be a potential solution. It is estimated that a TSC Transfer Station pad of approximately 25 ft x 35 ft elevated above grade to approximately 27 inches will be required to be constructed within the ISFSI site perimeter.

A TSC Transfer Station and seismic support structure in accordance with NAC-MPC CoC Technical Specification (TS) B.3.5, or an acceptable alternative secure lifting/transfer capability will be required for off-loading of the YR-MPC TSC from the VCC into a YR TFR, and subsequent transfer and loading of the YR-MPC TSCs into the NAC-STC. The transfer and loading of the YR-MPC TSCs would be performed in a vertical orientation with the VCC and NAC-STC positioned adjacent to each other at the Transfer Station. As an alternative to the TSC Transfer Station and mobile or fixed crane systems, a seismically qualified gantry system provided with YR TFR lifting slings and an integrated chain hoist system could be used to efficiently transfer and load the YR-MPC TSCs into the NAC-STC casks. This operational alternative is discussed in further detail in **Section 6.0** and **Section 10.0**.

During YR-MPC TSC transfer and loading operations, a loaded VCC can be brought from its storage on the ISFSI pad to the designated transfer/unloading position on the pad using hydraulic jacks, air pads, and appropriate maneuvering equipment. After the VCC is positioned, the off-site HHT (e.g., goldhofer) conveying an empty NAC-STC transport cask is positioned adjacent to the TSC Transfer Station/ISFSI pad and the NAC-STC is prepared for off-loading, the cask body is uprighted, lifted from the HHT, and set down on its bottom end in the uprighted orientation on the TSC Transfer Station/ISFSI pad. If operationally preferred, the NAC-STC on its intermodal transport cradle can be lifted off of the HHT, set on the ground, prepared for removal from its transport cradle, uprighted from the cradle, then placed on the TSC Transfer Station/ISFSI pad as described above. If a single failure proof gantry crane system is utilized to transfer the TSC to the TFR from the VCC and then load the TSC into the NAC-STC cask, it may be possible to leave the VCCs in their current positions during the TSC transfer sequence. Therefore there would be no need to move the VCCs using air pads and maneuvering equipment.

At the completion of the NAC-STC loading with a YR-MPC TSC and preparation of the package for transport, the NAC-STC is downloaded onto the intermodal transport cradle and the off-site HHT transport vehicle for movement to the rail transloading facility. The empty VCC is repositioned on the pad using the appropriate equipment and the hydraulic jacks and air pad systems staged for pickup of the next loaded VCC designated for unloading.

2.2. Characteristics of SNF and GTCC LLW to be Shipped

This section describes the inventory of SNF including intact and damaged fuel, and GTCC LLW for the YR site and summarizes the information contained in the Nuclear Power Plant Infrastructure Evaluations for Removal of Spent Nuclear Fuel[5], the NAC-MPC FSAR[50], and NRC CoC No. 1025[45] including TSs and Approved Contents and Design Features.

The fuel assemblies are either 16 x 16 or 18 x 18 rod arrays as described in **Table 2-5**.

Table 2-5: YR Fuel Design Information[8]

Fuel Supplier / Design	Cladding Material	Enrichment (wt. % ^{U235}) Min./Max.	Maximum Burnup (GWd/MTU)	Assembly Dry Weight (lbs.)	Total No. Loaded in YR-TSCs
Combustion Engineering (CE) 16 x 16 Yankee Class	Zircaloy	3.7 / 3.9	32	805	156
Exxon (EX) 16 x 16 Yankee Class	Zircaloy	3.5 / 4.0	36	826	228
Westinghouse (WE) 18 x 18 Yankee Class	348 Stainless Steel	4.94 / 4.94	32	924	76

Fuel Supplier / Design	Cladding Material	Enrichment (wt. % U235) Min./Max.	Maximum Burnup (GWd/MTU)	Assembly Dry Weight (lbs.)	Total No. Loaded in YR-TSCs
United Nuclear (UN) 16 x 16 Yankee Class	Zircaloy	4.0 / 4.0	36	830	73

Table 2-6 and **Table 2-7** provide data associated with the fuel assemblies loaded in the YR ISFSI. The fuel was discharged from the reactor vessel between 1972 and 1991. The lowest burnup is 4.2 GWd/MTHM and the highest burnup is 36 GWd/MTHM. There is no high burnup SNF (i.e., greater than 45 GWd / MTHM) stored at YR. More details on the SNF are contained within the Nuclear Power Plant Infrastructure Evaluations for Removal of Spent Nuclear Fuel Report[5], the NAC-MPC FSAR[50], and NRC CoC[45]. In addition to the 533 spent fuel assemblies (including seven failed assemblies placed in DFCs) loaded into the 15 NAC-MPC TSCs, the TSCs also contain one (1) RFA for a total of 534 fuel compartments containing SNF materials.

Table 2-6: YR Fuel Discharge Data[5]

Year	No. of Assemblies Discharged
1972	36
1974	37
1975	40
1977	36
1978	40
1981	36
1982	40
1984	36
1985	40
1987	36
1988	40
1990	40
1991	76
Total	533

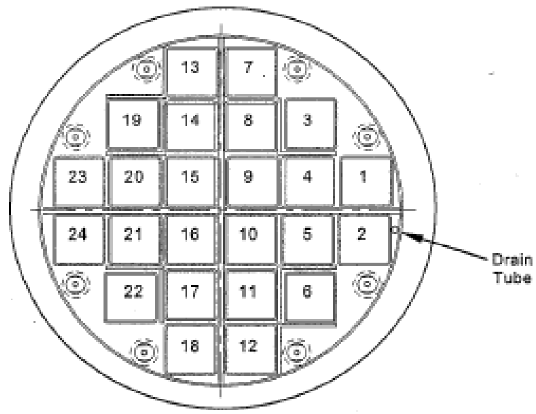
Table 2-7: YR Fuel Burnup Data[5]

Burnup (GWd/MTHM)	Number of Assemblies
0-5	1
5-10	24
10 - 15	20
15 - 20	4
20 - 25	70
25 - 30	251
30 - 35	142
35 - 40	21
Total	**533**

The reactor experienced a number of failed fuel rods. Damaged, potentially damaged, and failed fuel was packaged into RFAs or DFCs, which were then loaded into designated corner locations of the baskets of specific TSCs. The mixture of fuel assemblies and location of damaged fuel and RFAs in specific TSCs is provided in **Table 2-8**.

Solid, irradiated, and contaminated hardware and solid, particulate debris or filter media were placed in GTCC LLW containers and loaded into the GTCC LLW TSC provided with shielded GTCC LLW baskets as shown in **Figure 2-16**. The transport of the GTCC LLW TSCs is exempt from the requirements of 10 CFR Part 71 for fissile material packaging as it meets the requirement of the Code of Federal Regulations (CFR) 10 CFR 71.15. The GTCC TSC and inventory layout[54] is shown below:

Figure 2-16: GTCC Canister Identification



TSC Position Number	GTCC Baffle Canister Identification Number
1	BC-S
2	BC-Z
3	BC-D
4	BC-K
5	BC-F
6	BC-N
7	BC-Q
8	BC-H
9	BC-I
10	+BC-SV
11	BC-M
12	BC-R

TSC Position Number	GTCC Baffle Canister Identification Number
13	BC-V
14	BC-C
15	BC-A
16	BC-E
17	BC-J
18	*
19	BC-O
20	BC-G
21	BC-L
22	BC-B
23	BC-T
24	BC-W

+ Baffle Can SV contents provided on page 3 of 3 of Memorandum FTOD 03-068 Rev.2

*This position contains directly stored fuel cage skeleton pieces consisting of 7 intact spacer grids and 2 spacer grid/lower nozzle assemblies.

The summary of contents for the YR ISFSI is as shown in **Table 2-8.**

Table 2-8: YR ISFSI Contents[8]

Fuel Load Sequence No.	YR-MPC VCC / TSC Serial Number	TSC Contents	Heat Load[1] (kW)	Burnup[2] (MWd/MTU)	Weight of Contents (lbs.)[3]	Date Loaded into ISFSI
1	TSC-001 / YR-VCC-01	36 Intact SNF Assemblies (36 Zr)	8.35	35,755	29,280	6/26/02
2	TSC-002 / YR-VCC-02	36 Intact SNF Assemblies (36 Zr)	8.46	34,856	29,356	7/18/02

Fuel Load Sequence No.	YR-MPC VCC / TSC Serial Number	TSC Contents	Heat Load[1] (kW)	Burnup[2] (MWd/MTU)	Weight of Contents (lbs.)[3]	Date Loaded into ISFSI
3	TSC-003 / YR-VCC-03	36 Intact SNF Assemblies (36 Zr)	8.02	34,259	29,565	7/27/02
4	TSC-004 / YR-VCC-04	36 Intact SNF Assemblies (36 Zr)	6.80	35,999	29,128	8/19/02
5	TSC-005 / YR-VCC-05	36 Intact SNF Assemblies (36 Zr)	7.06	34,899	29,451	8/29/02
6	TSC-006 / YR-VCC-06	36 Intact SNF Assemblies (36 Zr)	7.91	33,496	29,318	9/12/02
7	TSC-007 / YR-VCC-07	36 Intact SNF Assemblies (30 Zr / 6 SS)	5.71	35,154	30,025	11/26/02
8	TSC-008 / YR-VCC-08	36 Intact SNF Assemblies (28 Zr / 8 SS)	7.48	32,578	30,495	12/11/02
9	TSC-009 / YR-VCC-09	36 Intact SNF Assemblies (28 Zr / 8 SS)	7.53	35,041	30,518	12/19/02
10	TSC-010 / YR-VCC-10	36 Intact SNF Assemblies (30 Zr / 6 SS)	7.57	31,755	30,345	1/9/02
11	TSC-011 / YR-VCC-13	36 Intact SNF Assemblies (27 Zr / 9 SS)	7.52	32,929	30,597	1/29/03
12	TSC-012 / YR-VCC-12	36 Intact SNF Assemblies (27 Zr / 9 SS)	7.47	32,206	30,593	2/8/03
13	TSC-015 / YR-VCC-15	36 Intact SNF Assemblies (28 Zr / 8 SS)	7.42	33,755	30,495	2/28/03
14	TSC-013 / YR-VCC-16	30 Intact SNF Assemblies + 4 DFCs + 2 empty tubes (23 Zr / 11 SS)	6.97	32,394	29,160	3/12/03

Fuel Load Sequence No.	YR-MPC VCC / TSC Serial Number	TSC Contents	Heat Load[1] (kW)	Burnup[2] (MWd/MTU)	Weight of Contents (lbs.)[3]	Date Loaded into ISFSI
15	TSC-014 / YR-VCC-14	28 Intact SNF Assemblies + 3 DFCs + 1 RFA + 4 empty tubes (20 Zr / 11 SS)	6.63	35,088	28,408	5/31/03
16	TSC-016 / YR-VCC-11	23 Containers of GTCC LLW + 1 position of directly stored fuel cage skeleton pieces[54]	< 2.9 kW	----	< 11,822	6/30/03

(1) Heat load values are for the entire system based on YR data at start of loading operation 05/01/2002.

(2) Burnup values are for the maximum fuel assembly in the NAC-MPC System YR-MPC TSC.

(3) TSC contents limited to 30,600 lbs. Maximum fuel assembly weight 950 lbs.

2.3. Description of Canisters/Overpacks to be Shipped

The inventory of YR-MPC TSCs at the YR ISFSI to be evaluated for shipment includes the 16 YR-MPC TSCs listed in **Table 2-8**. The YR-MPC TSCs are certified by the NRC for transportation of SNF and GTCC LLW in the NAC-STC under CoC 71-9235, Revision 23, which expires on May 31, 2024[52]. The characteristics of the YR SNF contents authorized in CoC 71-9235, per Paragraph 5.(b)(1)(ii) are provided in **Table 2-9**.

Table 2-9: Description Of Authorized YR-MPC TSC Contents For NAC-STC Transport[21]

Assembly Manufacturer/Type	UN 16×16	CE 1 16×16	West. 18×18	Exxon 2 16×16	Yankee RFA	Yankee DFC
Cladding Material	Zircaloy	Zircaloy	SS	Zircaloy	Zirc/SS	Zirc/SS
Maximum Number of Rods per Assembly	237	231	305	231	64	305
Maximum Initial Uranium Content (kg/assembly)	246	240	287	240	70	287
Maximum Initial Enrichment (wt% ^{235}U)	4.0	3.9	4.94	4.0	4.94	4.97 [3]

Assembly Manufacturer/Type	UN 16×16	CE 1 16×16	West. 18×18	Exxon 2 16×16	Yankee RFA	Yankee DFC
Minimum Initial Enrichment (wt% ^{235}U)	4.0	3.7	4.94	3.5	3.5	3.5 [3]
Maximum Assembly Weight (lbs)	≤ 950	≤ 950	≤ 950	≤ 950	≤ 950	≤ 950
Maximum Burnup (MWD/MTU)	32,000	36,000	32,000	36,000	36,000	36,000
Maximum Decay Heat per Assembly (kW)	0.28	0.347	0.28	0.34	0.11	0.347
Minimum Cool Time (yrs)	11.0	8.1	22.0	10.0	8.0	8.0
Maximum Active Fuel Length (in)	91	91	92	91	92	N/A

Notes:

1. Combustion Engineering (CE) fuel with a maximum burnup of 32,000 MWD/MTU, a minimum enrichment of 3.5 wt. % ^{235}U, a minimum cool time of 8.0 years, and a maximum decay heat per assembly of 0.304 kW is authorized.

2. Exxon assemblies with stainless steel in-core hardware shall be cooled a minimum of 16.0 years with a maximum decay heat per assembly of 0.269 kW.

3. Stated enrichments are nominal values (fabrication tolerances are not included).

The contents and quantity of YR GTCC LLW authorized in the NAC-STC CoC are specified in Paragraphs 5.(b)(1)(iii) and 5.(b)(2)(iv), respectively, and limit total TSC Co^{60} content to ≤ 125,000 curies, total GTCC content weight to ≤ 12,340 pounds, and total decay heat load of ≤ 2.9 kW.

The inventory of YR SNF loaded into 15 YR-MPC TSCs, and GTCC LLW loaded into one YR-MPC GTCC TSC in storage at the YR ISFSI meets all the specified conditions for immediate transport in the NAC-STC CoC 71-9235, Revision 23[52] once a suitable receiving facility is identified.

The NAC-STC is designed to be compatible with all NAC-MPC Storage Systems currently deployed at three ISFSIs in the U.S. including Yankee Rowe (YR-MPC), Connecticut Yankee and DPC's La Crosse Boiling Water Reactor (MPC-LACBWR). In addition, the NAC-STC is also certified for the transport of Vitrified High-Level Waste (HLW) loaded into MPC-WVDP Overpacks, which have the same outer diameter as the other MPC TSCs and are currently in storage at the DOE's West Valley Demonstration Project (WVDP). The NAC-STC is also certified for the direct loading (un-canistered) and transport of undamaged standard and high burnup (HBU) PWR spent fuel assemblies. NRC CoC No. 71-9235 authorizes the transport of undamaged HBU spent fuel assemblies with decay heat loads of up to 1.7 kW/assembly with an increase in total authorized cask decay heat of 24 kW.

The original two NAC-STC casks systems have been transporting bare intact PWR spent fuel assemblies from reactor stations to a centralized reprocessing center in China for the last 20 years.

Ten NAC-STC casks have been supplied to China for the transport of directly loaded intact HBU SNF assemblies and have been in operation for less than five years. An additional four NAC-STC casks will be supplied to China over the next year for the transport of directly loaded intact HBU SNF assemblies. The NAC-STC casks supplied to China include all required package components and auxiliaries including impact limiters, vertical lift yoke, horizontal lift beam, intermodal transport cradle and personnel barrier, vacuum drying and helium leak test system, and cask and auxiliary equipment spare.

The NAC-STC is designed with an inner stainless-steel shell with XM-17 transition sections, a poured-in-place lead gamma shield, a stainless-steel outer shell, and a solid neutron shield encased in a stainless-steel closure with SS/Cu fins. The NAC-STC is the only current transport cask system compatible with the transport of NAC-MPC canister systems and is not dimensionally suitable for the transport of NAC UMS or NAC MAGNASTOR TSCs. However, it is the long-term intent of NAC to recertify the MAGNATRAN Transport Cask (CoC 71-9356) for the transport of all NAC-MPC and NAC-UMS TSCs. The use of the MAGNATRAN transport cask will result in the total off-site HHT loaded weight to be increased from approximately 245,000 lbs to approximately 300,000 lbs. Overall dimensions of the two cask systems are similar (e.g., OD of Impact Limiters of 128 inches), and the use of the MAGNATRAN is not expected to result in any changes to the proposed HHT and railroad transport considerations.

The weights of the YR-MPC system and NAC-STC transport packaging components are shown in **Table 2-10** and the overall characteristics and dimensions are shown in **Table 2-11**.

Table 2-10: NAC YR-MPC Storage and NAC-STC Transport Cask Weights[45]

YR-MPC and NAC-STC Component Description	YR-MPC Fuel TSC and NAC-STC Weights (pounds)	YR-MPC GTCC LLW TSC and NAC-STC Weights (pounds)
YR Maximum Assembly/GTCC Can Weight	950	514[5]
TSC Contents (SNF / RFA / DFC or GTCC LLW)	30,600 (max.)	12,340 (max.)
Loaded/Closed Canister	54,730	53,425
VCC Loaded	206,100	204,800
VCC Shield Plug	5,490	5,490
VCC Lid	2,840	2,840
TFR (empty)	80,745	80,745
TFR w/TSC	135,475	134,170
Transfer Adapter	12,700	12,700
TFR Lift Yoke (nominal estimated weight)	6,500	6,500
TFR Under-the-Hook Weight (1)	141,975	140,660
NAC-STC YR-MPC Content Weight	54,730	53,425
NAC-STC Transport Spacers for YR-MPC	860	860
NAC-STC Top Impact Limiter (Balsa)	5,800	5,800

YR-MPC and NAC-STC Component Description	YR-MPC Fuel TSC and NAC-STC Weights (pounds)	YR-MPC GTCC LLW TSC and NAC-STC Weights (pounds)
NAC-STC Bottom Impact Limiter (Balsa)	5,650	5,650
NAC-STC Inner Lid	10,690	10,690
NAC-STC Outer Lid	8,120	8,120
NAC-STC without Inner and Outer Lids	157,160	157,160
NAC-STC with Inner and Outer Lids	175,970	175,970
NAC-STC with Inner and Outer Lids + Spacers	176,830	176,830
Loaded NAC-STC with YR-MPC Contents	231,560	230,255
NAC-STC Lift Yoke (nominal estimated weight)	7,000	7,000
Loaded NAC-STC Under-the-hook Weight (dry) (2)	258,560	237,255
NAC-STC Package Transport Ready Weight (3)	243,010	241,695
NAC-STC Package Design Transport Weight (4,5)	260,000	260,000
Intermodal Transport Cradle/Personnel Barrier (estimated weight)	32,000	32,000

(1) TFR Under-the-hook weight: YR TFR with loaded YR-MPC TSC and TFR lift yoke.
(2) NAC-STC Under-the hook weight: NAC-STC loaded with YR-MPC TSC contents, inner and outer lids, YR-MPC transport cavity spacer, and NAC-STC lift yoke.
(3) NAC-STC Package – Transport-ready weight: loaded cask w/ YR-MPC TSCs containing SNF or GTCC LLW and balsa impact limiters.
(4) Design Maximum NAC-STC Package Transport Weight based on YR-MPC contents and use of balsa impact limiters.
(5) The NAC-STC is designed to accommodate various contents including YR-MPC PWR SNF and GTCC TSCs, YR-MPC PWR SNF and GTCC TSCs, MPC-LACBWR BWR SNF TSCs, MPC-WVDP Vitrified HLW Overpacks, and undamaged PWR standard and HBU SNF fitting within the cavity length of 165.0 inches.
(6) Total allowable GTCC waste per GTCC LLW TSC is 12,340 lbs and a maximum decay heat of 2.9 kW.

Table 2-11: NAC-STC Transport Cask Design Characteristics and Component Dimensions[19]

Design Characteristic	Value	Material
Maximum Design NAC-STC Package Weight	260,000 lbs.	--
Maximum NAC-STC Package Weight w/YR Contents	243,010 lbs.	--
NAC-STC Overall Length without Impact Limiters	193 in.	--

Design Characteristic	Value	Material
NAC-STC Overall Length with Balsa Impact Limiters	273.3 in.	--
NAC-STC Body Maximum Cross-Section Diameter • Across corners of neutron shield plates • Across flats of neutron shield plates	 99 in. 98.2 in.	-- --
NAC-STC Upper Forging Diameter	85.3 in.	--
NAC-STC Bottom Forging Diameter	82.6 in.	--
Balsa Impact Limiter Diameter	128 in.	--
Balsa Limiter Height	52.2 in.	--
NAC-STC Cavity Length	165.0 in.	--
Cask Cavity Diameter	71.0 in.	--
Cask Capacity (no. of assemblies) • Directly Loaded PWR SNF • YR-MPC TSC SNF • YR-MPC GTCC Cans	 26 36 24	 -- -- --
Inner Shell Thickness • Center Shell Section • Upper and Lower Transition Rings (max.)	 1.5 in. 2.0 in.	 Type 304 Stainless Steel Type XM-19 Stainless Steel
Gamma Shield Thickness • Center Shell Section • Transition Sections (min.)	 3.7 in. 3.2 in.	 Chemical-Copper Lead Chemical-Copper Lead
Outer Shell Thickness	2.65 in.	Type 304 Stainless Steel
Top Forging – Radial Thickness at Cavity Diameter	7.85 in.	Type 304 Stainless Steel

Design Characteristic	Value	Material
Bottom Thickness (total) • Bottom Forging • Bottom Outer Forging (Radial at Bottom N/S) • Bottom Plate/Forging Neutron Shielding (N/S)	13.65 in. 6.2 in. 3.9 in. 5.45 in. 2.0 in.	 Type 304 Stainless Steel Type 304 Stainless Steel Type 304 Stainless Steel NS-4-FR, Solid Synthetic Polymer
Neutron Shield Assembly - Thickness • Neutron Shielding • Outer Shell • Bottom / Top End Plates	5.50 in. 0.25 in. 0.472 in.	NS-4-FR Type 304 Stainless Steel Type 304 Stainless Steel
Lifting Trunnion (Primary and Secondary) • Base Diameter • Shaft Diameter • Lip Diameter	10 in. 5.5 in. 6 in.	Type 17-4 PH Stainless Steel (welded)
Rotation Pocket Thickness (reference)	5.75 in.	Type 17-4 PH Stainless Steel (welded)
NAC-STC Inner Lid • Total Thickness • Lid Rim • Central Sections • Neutron Shield • Neutron Shield Coverplate • Bolts (42) • Torque • O-Rings • Inter-seal Port Plug	9.0 in. 7.12 in. 6.0 in. 2.0 in. 1.0 in. 1-1/2 - 8 UN 2,540 ± 200 ft-lb. 2 1	 Type 304 Stainless Steel Type 304 Stainless Steel NS-4-FR Type 304 Stainless Steel SB-637, GR N07718 Double Metallic (for TSCs) Seal – Metallic /Torque 30 ± 3 ft-lbs.

Design Characteristic	Value	Material
NAC-STC Outer Lid • Lid Rim • Central Sections • Bolts (36) • Torque • O-Ring	2.5 in. 5.25 in. 1 – 8 UN 550 ± 50 ft-lb. 1	SA205, Type 630 Stainless Steel SA564, Type 630, Class A / B Metal (for TSCs)
Inner Lid Vent and Drain Port Coverplates • Body thickness • Bolts (4) • Torque • O-Ring • Leak Test Port Plug	1.0 in. 1/2 - 13 UNC 300 ± 20 in-lbs. 2 1 each	Type 304 Stainless Steel SA-193, GR B6, Type 410 SS Double Metallic (for TSCs) Seal – Metallic / Torque 70 ± 5 in-lbs
Interlid and Pressure Port Covers • Bolt Lip • Total Cover Depth • Bolts (4) • Torque • O-Ring • Leak Test Port Plug	1.0 in. 3.135 in. 3/8 – 16 UN 140 ± 10 in-lbs. 2 1 each	17-4 pH Stainless Steel SA-193, GR B6, Type 410 SS PTFE Seal – Viton / Torque 70 ± 0.5 in-lbs.

Figure 2-17 shows a representation of a NAC-STC cask on an intermodal cradle secured to a 12-axle railcar, where the top and bottom images show the cask with and without the personnel barrier installed. **Figure 2-18** shows a picture of a NAC-STC transport package being placed on a heavy haul trailer (HHT) with personnel barrier that was designed/used for transport in China.

As the impact limiters do not exceed 128 inches in diameter, a railcar loaded with the NAC-STC cask and supporting components is expected to fit within the Association of American Railroads (AAR) Plate C requirements found within the AAR Manual of Standards and Recommended Practices.

The HHT is expected to use the same intermodal transport cradle, and the same connection methods as used for the railcar transport. The overall transport weight and dimensions for each

NAC-STC transport cask load, including margins, is estimated to be: 300,000 pounds, 23 feet long, 11 feet wide, and 11 feet high (measured from base of the cradle). Haul path, roadway, and bridge capacities of 140 tons and bridge clearance width of 11 feet 3 inches represent potential challenges to the safe transport from a site. Engineering surveys of the haul path and roadways to the transload site are necessary to ensure safe transport and the limitations carefully considered and verified in finalizing HHT selection with the transport company. It is important to note that larger heavy loads (365 tons, 35 ft long and 13.5 ft diameter) have previously been successfully removed from the site[5] utilizing the same haul path and similar equipment.

The NAC-STC packages at YR will be loaded with TSCs containing SNF or GTCC LLW. The major components of the NAC-STC package are shown in **Figure 2-19** and include the cask body, primary and secondary lifting trunnions, rear rotation trunnion pockets, cask inner and outer lid, vent and drain ports and coverplates, transport-only pressure and interlid port covers, and a loaded and welded YR-MPC TSC containing SNF or GTCC LLW inserted into the NAC-STC cavity provided with YR-MPC upper and lower transport spacers. The YR-MPC TSC consists of the canister shell, a spent fuel or GTCC LLW basket, a shield lid with vent and drain ports and port covers (not accessible during transfer and loading of the YR-MPC TSC into the NAC-STC), and the exterior structural lid that is designed for the safe handling and transfer of the loaded TSC to and from the VCC, and to the NAC-STC for off-site transport. The YR-MPC TSCs are constructed of stainless steel and after loading, are welded closed, vacuum dried, backfilled with high-purity helium, re-evacuated and refilled with high-purity helium, and the shield lid and port covers are leakage tested (the shield lid, vent and drain port covers provide for the TSC confinement boundary closure) prior to the installation and welding of the structural lid to the TSC shell weldment. During storage operations the TSCs provided for confinement of the radioactive contents.

Figure 2-17: NAC-STC On Transport Frame Mounted On Railcar

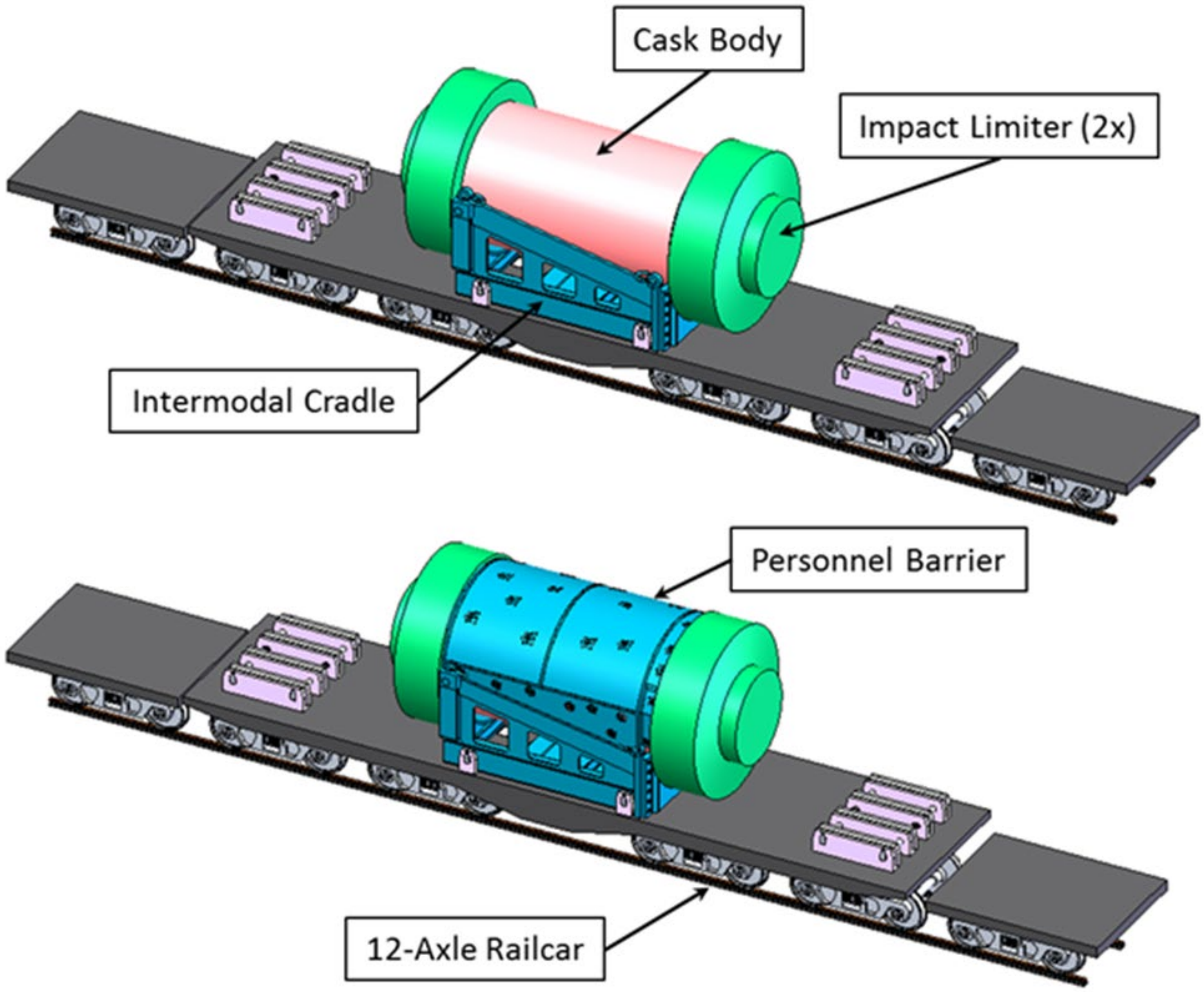


Figure 2-18: NAC-STC Package Ready for Transport

Following the transfer of the YR-MPC TSCs from the VCC into the NAC-STC, the cask inner lid is installed with metallic inner (containment) and outer O-ring seals. The NAC-STC cavity is then evacuated and backfilled with high-purity helium and the containment boundary O-ring seals (inner seals of lid and vent and drain port coverplates) are leakage tested using a helium Mass Spectrometer Leak Detection (MSLD) system to leak-tight criteria in accordance with American National Standards Institute (ANSI) N14.5-2014[46] . Following completion of inner lid containment leakage rate testing, the outer lid fitted with a single Viton O-ring and the transport pressure port cover fitted with double PTFE O-rings are installed to provide a secondary boundary. The volume between the inner and outer lid is evacuated through the interlid port by a vacuum pump and backfilled with helium. Pressure drop testing of the interlid volume is performed to show no leakage at a sensitivity of 10^{-3} atm-cm^3/s. Finally, the transport interlid port cover is installed with double PTFE O-rings and pressure drop tested to a sensitivity of 10^{-3} atm-cm^3/s. After loading the TSC in the NAC-STC cask and inner lid closure helium leakage testing, the NAC-STC provides the transport containment boundary under normal and accident conditions of transport.

The NAC-STC transportation package containment boundary, shown in **Figure 2-20**, includes the NAC-STC body, cask inner lid, drain and vent port coverplates, and inner lid and port coverplate metallic O-ring seals. The containment boundary consists of the cask's inner shell, the top and bottom inner shell transitions, the cask bottom forging, the upper cask forging, the inner lid, the vent and drain port coverplates, and the inner lid and port coverplates inner metallic O-ring containment seals. The NAC-STC containment seals are each individually inspected, replaced, and leakage tested prior to each loaded transport. During fabrication the cask containment boundary weldment including the inner shell, the top and bottom shell transitions, bottom forging, upper forging, and inner lid are hydrostatically tested per the American Society of Mechanical Engineers (ASME) Code, Section III, NB-6000 followed by helium leakage testing to confirm a total leakage rate of ≤ 2.0 x 10^{-7} cm^3/sec, helium (leak-tight in accordance with ANSI N14.5-1997. At the completion of fabrication, the inner lid and vent and drain port cover containment components and metallic O-ring seals are fabrication leakage rate tested to confirm that the individual leakage rate are ≤ 2.0 x 10^{-7} cm^3/sec, helium, in accordance with ANSI N14.5-2014[46] as specified in the Safety Analysis Report (SAR) Containment Evaluation.

Figure 2-19: NAC-STC Section Views[19]

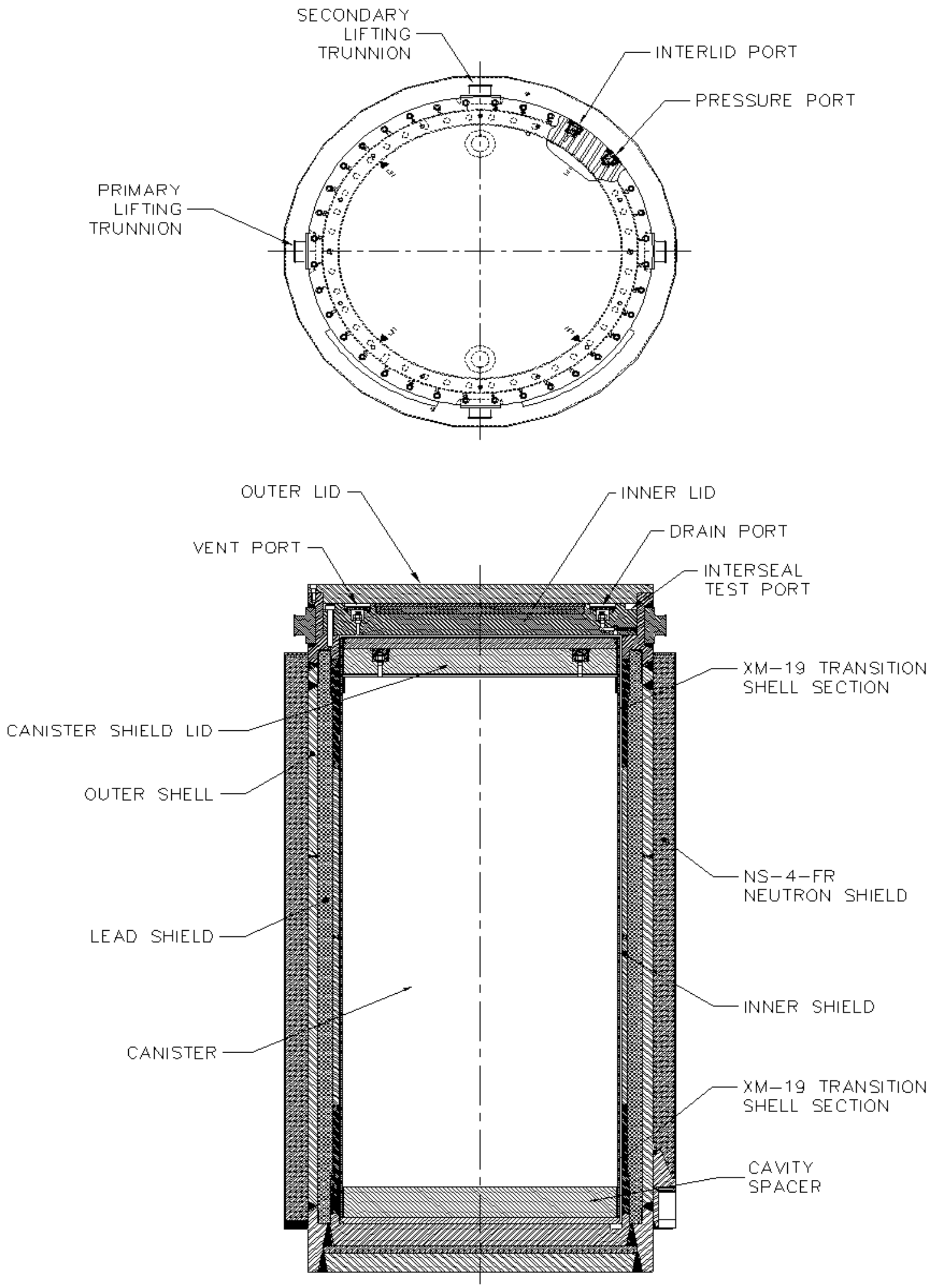


Figure 2-20: NAC-STC Containment Boundary[19]

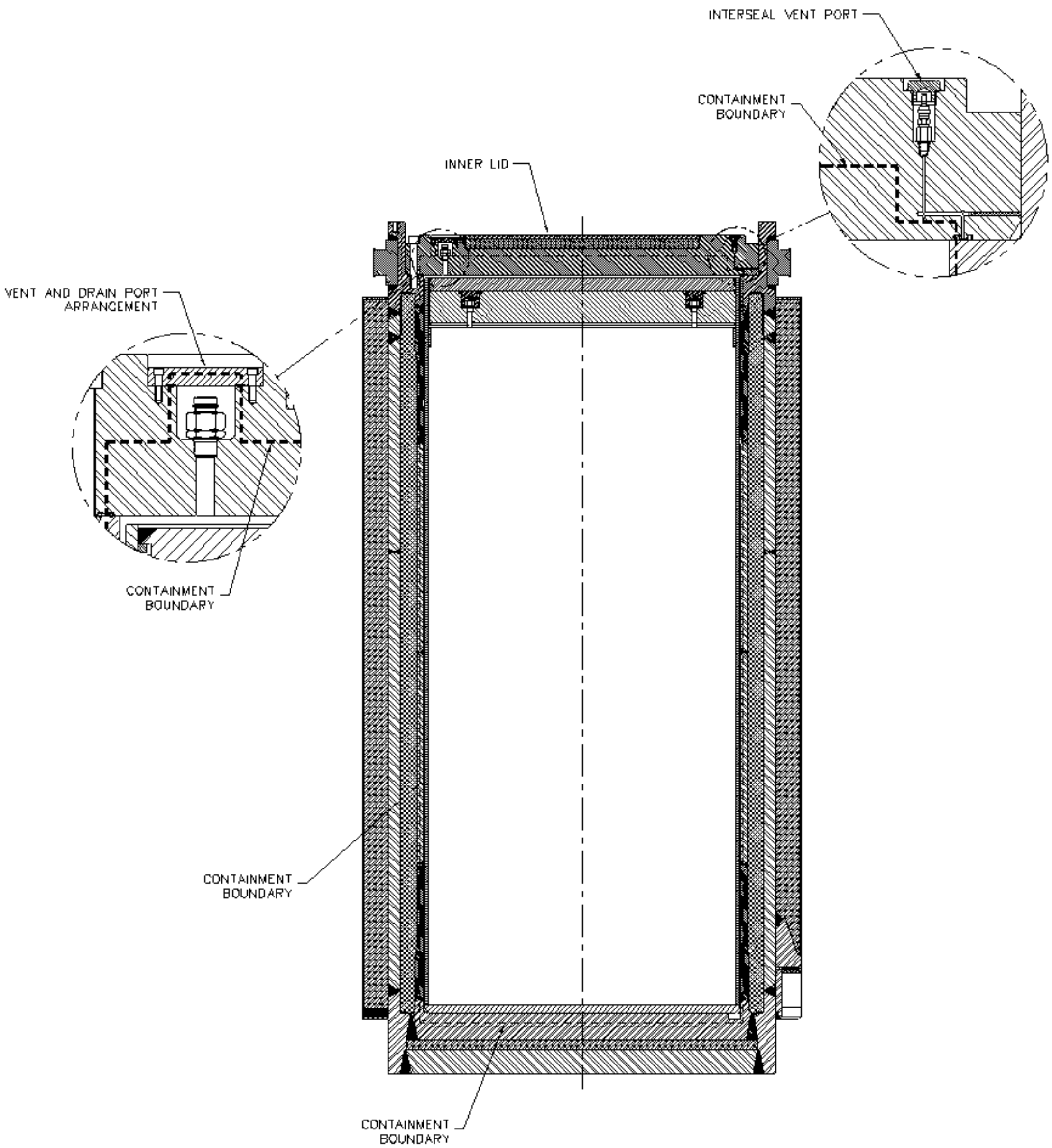


Figure 2-21: YR-MPC VCC Unloading Transfer Operation with TSC Partially Removed[19]

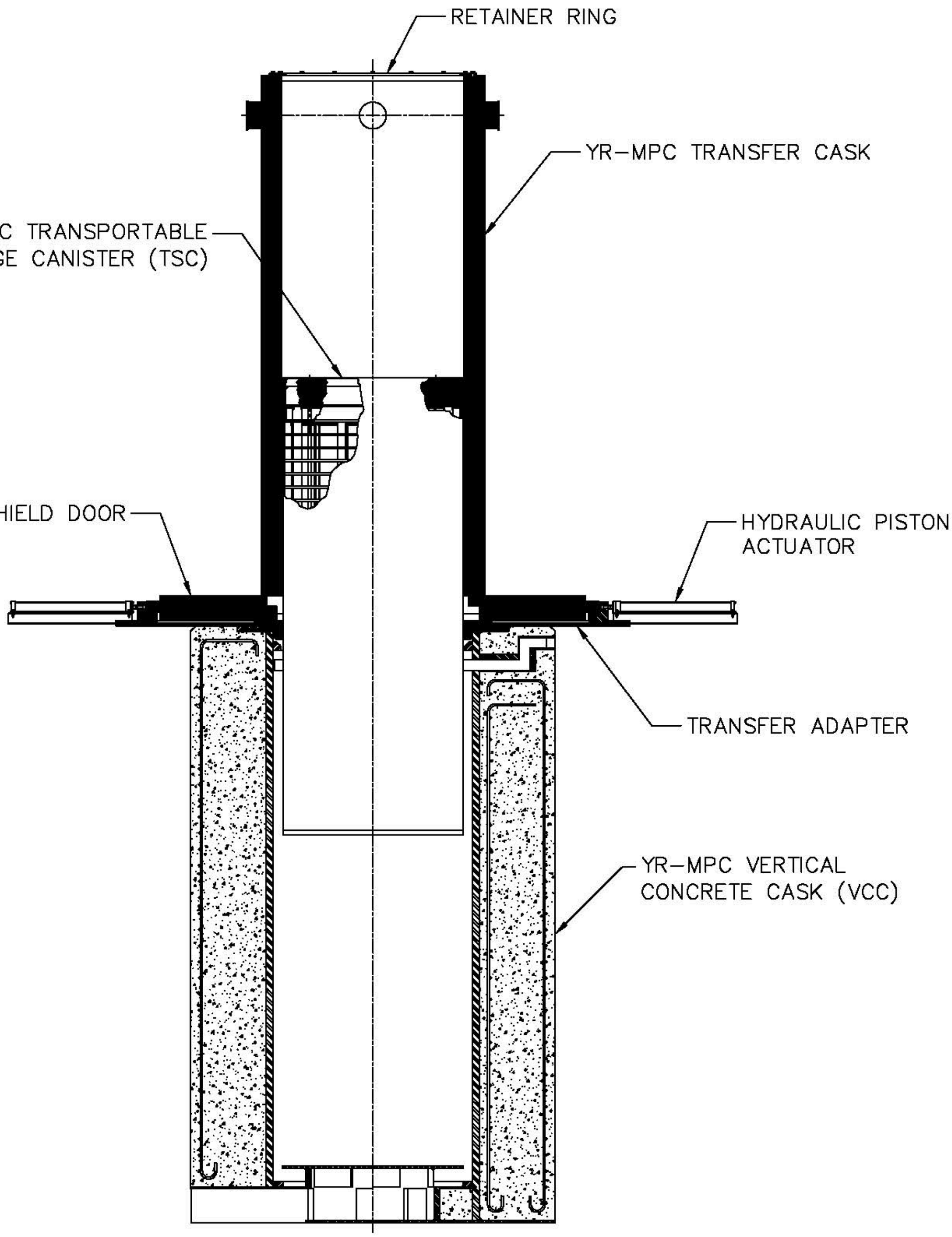
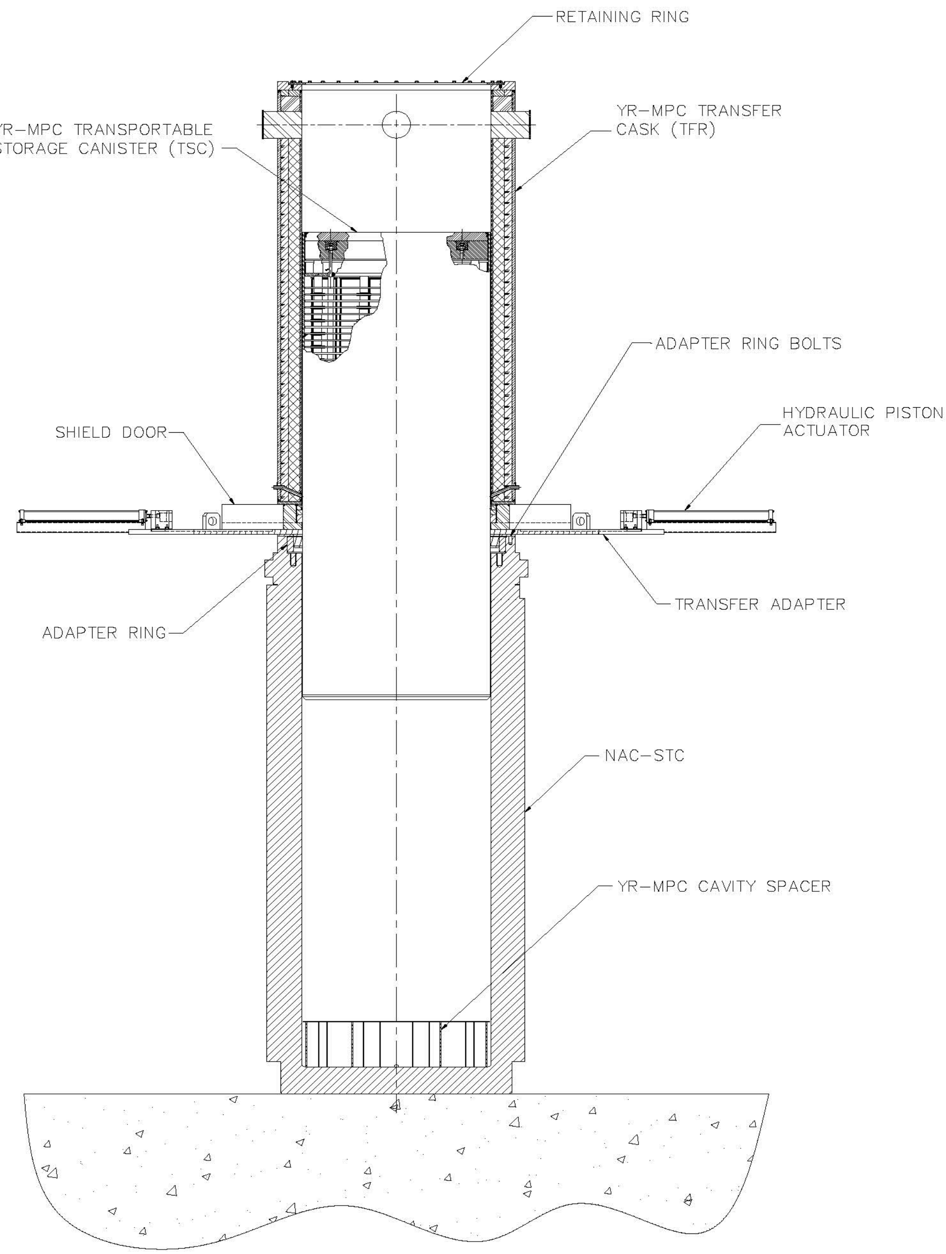


Figure 2-21 presents the operational equipment requirements for retrieving a loaded YR-MPC TSC from a YR-MPC VCC. Following VCC lid and shield plug removal, the transfer adapter is installed on the top of the VCC, and four bolts can be optionally used to secure the adapter plate to the VCC lid bolt circle. The swivel hoist rings and lifting slings, or alternative TSC lifting adapter plate, are installed and secured in the six bolt holes of TSC structural lid. The YR TFR, with the retaining ring installed, is then placed on top of the adapter plate using a YR TFR lift yoke combined with a qualified mobile crane or possibly a qualified gantry system as discussed below.

The Canister Handling Facility (CHF) is required per the CoC TSs to restrain or maintain the YR TFR on top of the VCC or the NAC-STC cask during the TSC transfer operations. (See **Figure 2-28** with the YR-TFR restraints during VCC loading operations). Alternatively, a seismically qualified gantry system with lifting slings and incorporating a hydraulic or air-operated chain hoist TSC lifting system may be used to satisfy the CoC requirements. The gantry system would be qualified to maintain the stability of the TFR and TSC during the TSC transfer operation. Additional details on the CHF requirements and the alternative gantry/chain hoist system are provided in **Section 6.0**. Once the CHF is in place to restrain and maintain the seismic stability of the YR TFR and a lifting system is attached to the TSC structural lid, the shield doors are then opened using the auxiliary hydraulic actuation system. The lifting slings are then retrieved using tag lines through the annulus of the TFR and connected to a suitable mobile crane hook, or the gantry system chain hoist TSC lifting system is connected to the TSC lid lift adapter. The TSC is then slowly lifted from the VCC cavity by the mobile crane or gantry system's chain hoist into the YR TFR annulus until the TSC is between approximately ½ to 1 inch below the TFR retaining ring. The shield doors are then closed and secured with lock pins. The TSC is then lowered to rest on the shield doors.

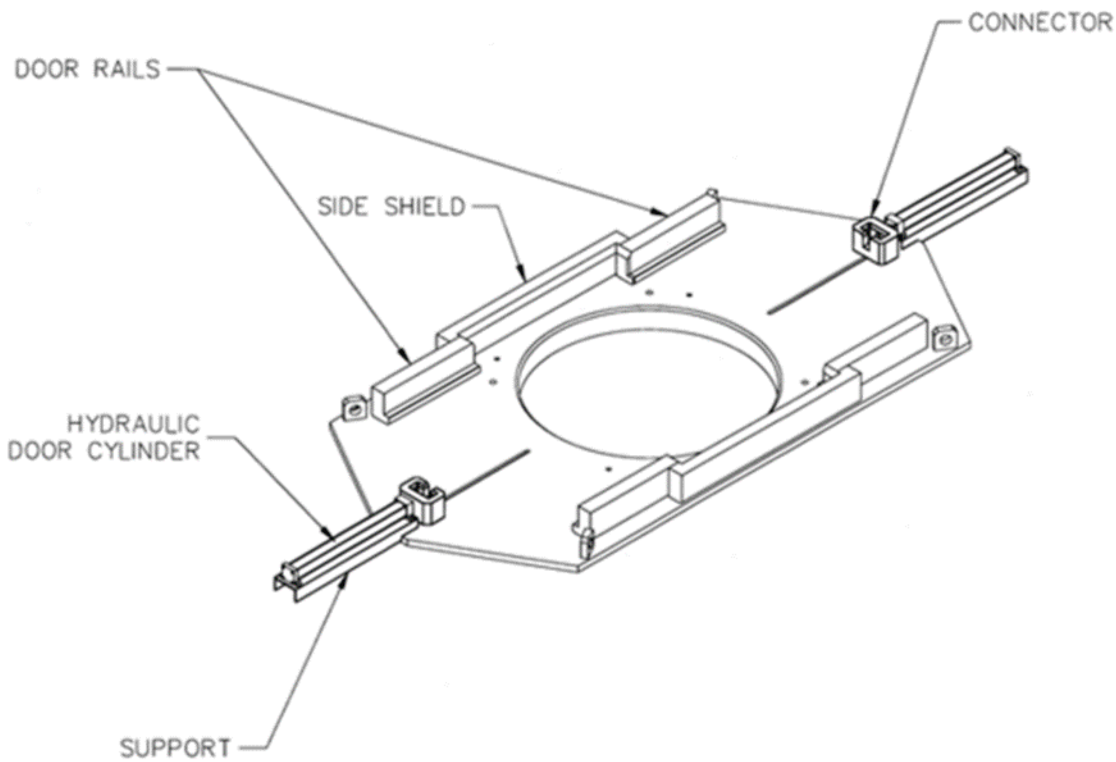
Figure 2-22 shows the next operational sequence where the TSC is transferred into the NAC-STC cavity. After the NAC-STC is uprighted from its shipping cradle, the cask is moved to the TSC Transfer Station location using the NAC-STC vertical lift yoke and a mobile crane. The outer lid bolts are removed, and the outer lid is removed using the outer lid lifting sling set and hoist rings, and temporarily stored while protecting the outer lid O-ring. The inner lid bolts are de-torqued and removed and the inner lid alignment pins are installed. The inner lid lifting slings and hoist rings are installed and the inner lid is removed and temporarily stored. The inner lid inner and outer metallic O-rings are removed. The O-ring grooves will be cleaned and inspected, and new seals installed on the inner lid prior to re-installation of the inner lid after TSC loading. The lower YR-MPC Transport Canister Spacer is then installed in the bottom of the TSC-STC cavity. The canister spacer axially positions the YR-MPC TSC in the analyzed position based on the SAR hypothetical accident conditions of transport.

Figure 2-22: NAC-STC Transfer Operation with YR-MPC TSC Partially Inserted[19]



The NAC-STC adapter ring, designed to protect the cask upper sealing surface and provide additional shielding, is installed and bolted in place. The transfer adapter is then moved from the unloaded VCC, or a second transfer adapter plate is used and bolted to the NAC-STC adapter ring bolt circle. The TFR containing a loaded TSC is then lowered in place on the top of the adapter plate and into the CHF or gantry system with integrated chain hoist. The YR TFR door lock pins are then removed, the TSC lifting slings or TSC lid adapter plate are engaged to the mobile crane or gantry system's hydraulic TSC chain hoist, and the YR-MPC TSC is lifted off the shield doors, the doors opened with the auxiliary hydraulic system, and the TSC is slowly lowered into the NAC-STC cavity to rest on the YR-MPC transport cavity spacer. **Figure 2-22** shows a YR-MPC TSC partially inserted into the NAC-STC during transfer from the YR TFR. After the removal of the YR TFR from the NAC-STC, the upper cavity spacer is installed on top of the TSC to ensure appropriate positioning and weight distribution during transport. **Figure 2-23** shows the Transfer Adapter required to align the TFR to the VCC and NAC-STC during TSC transfer operations.

Figure 2-23: YR-MPC TFR Adapter Plate[9]



As shown in **Figure 2-20**, the NAC-STC cask includes a vent port and drain port in the inner lid. The vent and drain ports each consist of a 1-inch quick disconnect fitting with a seal and a cover plate with redundant metallic O-ring seals that are secured with four ½-inch diameter bolts. However, for YR-MPC TSC transports there is no drain tube installed and connected to the drain port as all loading operations are performed dry. It is expected that TSC transfer operations will not be performed in inclement weather to prevent entry of snow, ice or rain entering the NAC-STC cavity or in high wind conditions to ensure safe crane and transfer operations. The NAC-STC inner lid contains redundant metallic O-ring seals and is secured to the cask body with 42 1-1/2-inch diameter bolts. The lid also includes a test port; with a $^{3}/_{8}$-inch diameter quick disconnect fitting and seal that is used to test the NAC-STC inner lid containment seal integrity. The inner lid and vent and drain port covers are all provided with redundant sets of metallic O-rings. **Figure 2-19** depicts the vent and drain ports and cover plates, as well as the lid test port configuration.

The unloading of a TSC from a VCC and transfer to a NAC-STC, and preparation of a NAC-STC for transport, will include the following high-level activities (detailed operations are described in **Section 6.1.3** and NAC-STC SAR[19] and NAC-MPC FSAR[50]):

1. At receipt on the site perform radiation and removable contamination surveys and record results. Inspect NAC-STC packaging for possible transport damage and record inspections results on cask receiving/loading report.
2. Using a horizontal lift beam, lift intermodal transport cradle containing the NAC-STC off of the over-the-road heavy haul trailer (HHT - goldhofer) with impact limiters and tie-downs installed and position the cradle on the ground adjacent to the TSC Transfer Station location. Alternatively, the NAC-STC can be uprighted directly from the intermodal transport cradle on the goldhofer per Step 3 below.
3. At the CHF on the TSC Transfer Station pad prepare the NAC-STC packaging for loading by removing the front and rear impact limiters, releasing front tie-downs, and cleaning the cask exterior of road dirt. Install the NAC-STC lift yoke to a suitable crane or gantry system and engage the yoke arms to the front lifting trunnions. Use the NAC-STC vertical lift yoke to upright the cask and position it on the TSC Transfer Station pad.
4. Remove 36 outer lid bolts and store. Using outer lid lift slings and hoist rings, remove the outer lid and store. Visually inspect outer lid bolts and seal.

   Note: As discussed earlier, it is expected that TSC transfer operations will not be performed in inclement weather to prevent entry of snow, ice or rain entering the NAC-STC cavity or in high wind conditions to ensure safe crane and transfer operations.
5. De-torque and remove the 42 inner lid bolts and store. Install the two lid alignment pins in their designated locations. Install inner lid lift slings and hoist rings and remove the inner lid and store.

   Note: Prior to inner lid re-installation the inner lid metallic O-rings will be replaced. Store inner lid and inner lid bolts to prevent damage to O-ring grooves/surfaces and threads.
6. Install NAC-STC cask adapter ring to protect cask body sealing surfaces and bolt to cask body.
7. Install YR-MPC lower transport cavity spacer in the base of the cavity.
8. Install Foreign Material Exclusion (FME) cover over open NAC-STC cavity to prevent intrusion of foreign materials and to protect from weather.
9. Prepare YR-MPC VCC for movement to the TSC Transfer Station location by performing radiation surveys and disconnecting temperature monitoring system.
10. If the VCC is required to leave the ISFSI pad to be positioned on the TSC Transfer Station pad, position the VCC HHT adjacent to the ISFSI pad loading dock position. Lower HHT jacks/pads, and install wheel chocks, aluminum drop restraints, and HHT to pad bridge plates.
11. Remove YR-MPC VCC inlet vent screens and install hydraulic jacks in the four vent openings.
12. Lift YR-MPC VCC approximately 4-5 inches using hydraulic pump and jacks.
13. Install four air pad units under the YR-MPC VCC bottom plate between the four vents (see **Figure 2-27**).
14. Lower the YR-MPC VCC onto the top of the air pads by lowering the hydraulic jacks.
15. Position Joseph Cyril Bamford telescope handler (JCB), or equivalent, adjacent to the HHT and extend the boom across HHT loading bed. Connect handling clamp and straps to YR-MPC VCC (see **Figure 2-29**).

16. Inflate air pads using a diesel-powered air compressor (minimum capacity 750 CFM) to lift YR-MPC VCC off ISFSI surface.
17. Using the JCB, pull and position the YR-MPC VCC on the HHT bed surface, and deflate the air pads. Disconnect from air supply and disconnect JCB from YR-MPC VCC.
18. Prepare HHT for movement by removing chocks, aluminum drop restraints, and retracting hydraulic jacks/pads.
19. Move HHT with loaded YR-MPC VCC to TSC Transfer Station (see **Figure 2-25**).
20. Position the HHT adjacent to the TSC Transfer Station. Lower HHT jacks/pads and install wheel chocks, aluminum drop restraints, and HHT to pad bridge plates.
21. Inflate air pads and use JCB or equivalent to move the loaded YR-MPC VCC to the transfer position.

    Note: Alternatively, if TSC Transfer Station is located on the ISFSI pad or on an extension of the pad, the VCC may be moved directly to the station using the hydraulic jacks, air pads and JCB or equivalent pusher to move the VCC from its storage position.
22. Remove the 6 YR-MPC VCC lid bolts and install lifting slings hoist rings to three lifting holes identified on the lid. Using a small crane, remove and store VCC lid and lid bolts.
23. Install hoist rings in the three lifting points of YR-MPC VCC shield plug and using slings and small crane, remove and store the YR-MPC VCC shield plug.
24. Remove structural lid lifting hole shield plugs and install and torque six special hoist rings in the TSC structural lid bolt holes. Install redundant lifting sling sets or install TSC lifting adapter plate if gantry system with single failure proof secure lift yoke with chain hoist system will be used.
25. Prepare YR TFR for receipt of the TSC by performing pre-use inspection and installing retaining ring and bolting to the TFR top forging.
26. Remove FME cover from the top of the NAC-STC cask opening the cask cavity for receipt of the loaded YR-MPC TSC.
27. Install transfer adapter plate (See **Figure 2-23**) on top of the VCC and install optional engagement bolts to restrain adapter plate. Connect auxiliary hydraulic actuating system to the transfer adapter door hydraulic cylinders. If second transfer adapter plate is available, install the plate on the top of the NAC-STC cask resting on the cask adapter ring and install engagement bolts to secure adapter plate to the adapter ring.

    Note: It is recommended that a second transfer adapter plate be procured to support the TSC transfer operation. A 2nd adapter plate would allow the YR TFR to be moved directly from the VCC to the NAC-STC without the need to set the YR TFR down to move the transfer adapter plate from the VCC to the NAC-STC.
28. Using a TFR lifting yoke connected to a suitable crane or gantry crane system with chain hoist system, lift TFR, with retaining ring installed, and set TFR down on top of the transfer adapter with connectors extended into the engage position (to engage the shield door mating connectors).

Note: The retaining ring bolted to the top of the TFR by 32 bolts prevents the TSC from being accidentally lifted out of the TFR cavity during TSC handling. The retaining ring is designed to lift the entire weight of the loaded TSC and TFR without failure.

29. Using the transfer adapter hydraulic system, open the two TFR shield doors allowing access to the TSC lifting equipment.
30. From the top of the TFR, using a man-lift and retrieving device, engage the redundant lifting rig sets to the mobile or fixed crane hook, or use hoist system (discussed further in **Section 6.0**) to engage TSC lifting adapter plate. Take up slack on TSC lifting slings or engage hoist system to TSC lift adapter plate.
31. Using the mobile/fixed crane, or hoist system, slowly withdraw TSC from VCC into the TFR ensuring the TSC is vertical and clears the VCC shield ring. When the TSC approaches and is within ½ to 1 inch of the retaining ring, stop lift and using the transfer adapter hydraulic system, close the shield doors and set TSC down on shield doors. Install shield door lock pins.
32. Disengage lifting slings from the crane hook and set them down on top of the TSC.
33. Using the lifting yoke or secure lift yoke on gantry system, lift the TFR off the top of the VCC and move the TFR to rest on the second transfer adapter plate installed on the NAC-STC cask. Set TFR down while engaging the connectors of the shield doors to the extended connectors on the transfer adapter plate.

    Note: If second adapter plate is not used or available, it may be necessary to set the TFR down on the TSC Transfer Station pad to allow movement of the transfer adapter plate from the VCC to the NAC-STC cask.

34. Disengage lift yoke and engage the crane hook to the TSC lifting slings or connect chain hoist to TSC lift adapter plate while maintaining TFR on the secure lift yoke. Remove the TFR shield door lock pins.
35. Lift TSC off shield doors approximately ½ - ¾ inch to prevent contact with the retaining ring and open the shield door hydraulics to open shield doors, and slowly lower the TSC into the cask cavity to rest on cavity spacer.
36. Disengage the TSC lifting slings from the crane hook and lower them on to the top of the TSC or disengage TSC adapter plate from chain hoist.
37. When lifting equipment is clear, close shield doors, install door lock pins, and remove TFR from the top of the NAC-STC.
38. Remove the lid slings or TSC lifting adapter and store. Unbolt cask adapter ring and remove transfer adapter and cask adapter ring, and store.
39. Install the upper transport impact limiter into the NAC-STC cavity in position on the top of the YR-MPC TSC.
40. Clean inner lid metallic seal grooves and install new inner and outer metallic O-ring seals and retention clips.
41. Install inner lid alignment pins and, using NAC-STC inner lid lifting slings and crane, install the closure lid.

42. Install 10 lid bolts equally spaced and tighten to hand tight. Remove alignment pins and install remaining 32 lid bolts. Torque all bolts to 2,540 ± 200 ft-lbs in accordance with the torquing sequence marked on the inner lid in 3 passes until all bolts are verified at final torque.
43. Remove vent port coverplate and connect vacuum pumping and helium backfill system to the vent port quick disconnect valve.
44. Operate vacuum pump until a final vacuum of ≤ 3 torr is reached and then turn off vacuum pump.
45. Backfill NAC-STC cavity with high-purity helium to a pressure of 1 atm and disconnect the vacuum and helium backfill system from the vent port.
46. Clean vent port coverplate metallic seal grooves and install new inner and outer metallic O-ring seals and retention clips.
47. While preparing loaded NAC-STC for transport, reinstall VCC shield plug and VCC lid and move empty VCC to appropriate location using the HHT and/or air pads and prepare to retrieve the next VCC to be unloaded.
48. Install vent port coverplate and torque to 300 ± 20 in-lbs.

    Note: As drain port is not required to be removed for access to the cavity there is no need to replace the drain port coverplate seals.

49. Remove vent port test plug, connect helium MSLD system to the port and evacuate the inter-seal volume to a pressure of < 0.1 torr to allow performance of the maintenance leakage rate test. Test is acceptable if detected leakage rate is ≤ 2 x 10^{-7} cm^3/s, helium with a test system sensitivity of ≤ 1 x 10^{-7} cm^3/s, helium. If test is acceptable, re-install the vent port coverplate test plug with new O-ring.
50. Remove drain port test plug, connect helium MSLD system to the port and evacuate the inter-seal volume to a pressure of < 0.1 torr to allow performance of the maintenance leakage rate test. Test is acceptable if detected leakage rate is ≤ 2 x 10^{-7} cm^3/s, helium with a test system sensitivity of ≤ 1 x 10^{-7} cm^3/s, helium. If test is acceptable, re-install the vent port coverplate test plug with new O-ring.

    Note: Although not specifically required as port coverplate is not required to be removed, it is recommended per latest NRC guidance that the test be performed as it is unknown when the coverplate was last removed and potentially not tested at that time.

51. Remove closure lid inter-seal test port plug, connect helium MSLD system to the port and evacuate the inter seal volume to a pressure of < 0.1 torr to allow performance of the maintenance leakage rate test. Test is acceptable if detected leakage rate is ≤ 2 x 10^{-7} cm^3/s, helium with a test system sensitivity of ≤ 1 x 10^{-7} cm^3/s, helium. If test is acceptable, re-install the inner lid inter-seal test port plug with new O-ring.
52. Using the NAC-STC lift yoke, lift loaded cask and engage cask rear trunnion recesses on transport cradle rear supports. Rotate the cask from vertical to horizontal orientation.

    Note: the intermodal transport cradle can be located on the ISFSI pad surface or on the off-site HHT. As required, the intermodal transport cradle can be lifted horizontally using a horizontal lifting yoke to move the loaded cradle from the pad surface to or from the HHT.

53. Install front tie down over cask upper forging.
54. Install top and bottom impact limiters and install tamper indication device between upper impact limiter to cask to detect tampering during transport.
55. Perform final radiation and contamination surveys. Apply fissile material labels on the package.
56. Install personnel barrier and install padlock barrier access portal.
57. Apply applicable placards to transport vehicle.
58. Complete all shipping documentation and provide special instruction to carrier/shipper for an Exclusive Use Shipment.

Note: The NAC-STC transport cask systems provided to perform YR-MPC TSC transports from the YR site will be in full compliance with the maintenance program as specified in Chapter 8 of the NAC-STC Safety Analysis Report (SAR), which specifies the required maintenance program for the cask (see NAC-STC Maintenance Schedule Table in **Section 6.1.3**). NAC or the cask supplier would certify that the cask is in compliance with the current annual maintenance program, which would include dye penetrant (penetrant testing), examination of the lifting trunnion surfaces and welds, and replacement of quick disconnects and neutron shield relief devices.

Equipment and Auxiliary System Requirements:

To perform the above sequence of operations, a number of ancillary devices, equipment, and systems would be required. These ancillary equipment and systems, along with a description of their purposes and availability are listed below. In addition, see **Section 10.0** for a recommendation to compile a complete listing of all equipment, components, supplies, M&TE, miscellaneous materials, etc. The listing will also address responsibility for providing the equipment and components and provides a cross reference to the applicable CoC requirement.

Heavy-Haul Trailer and Tractor (Prime Mover):

A special onsite HHT design has been developed to transport the loaded and empty YR-MPC VCC to and from the ISFSI pad and TSC Transfer Station. Jacks are provided to raise the trailer deck height level with the ISFSI pad height (approximately 30 inches), and to provide stability to the trailer during YR-MPC VCC loading and movement. The HHT is analyzed and reinforced to support the loaded YR-MPC VCC weight, in addition to the weight of the YR TFR and Transfer Adapter, during the original TSC loading operations at YR. The trailer and tractor combination has been designed to limit the maximum ground loading during transport to 100 psi or less. (See **Figure 2-24** and **Figure 2-25**). (*Note: As the identical HHT will be required for de-inventory projects at Maine Yankee, Connecticut Yankee, and Dairyland Power Cooperative (DPC) LACBWR, it is recommended that a new HHT be procured from the original manufacturer, Talbert Manufacturing, Inc. of Rensselaer, IN to original NAC Fabrication Specification requirements).*

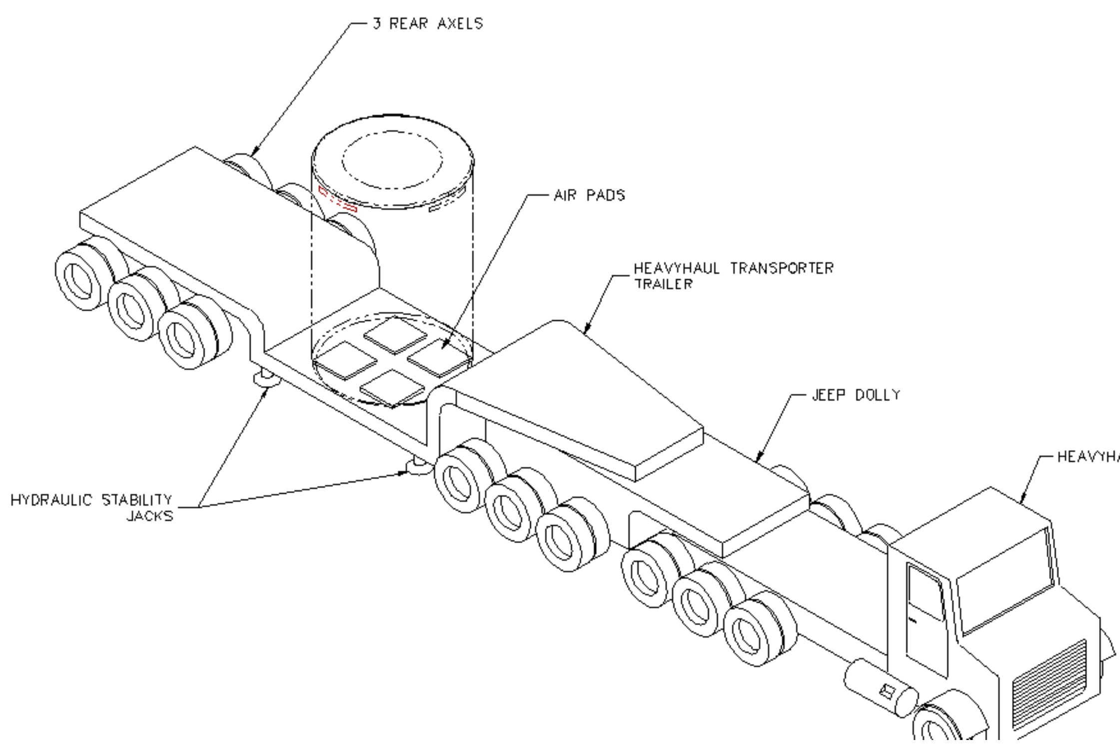
Over the Road Heavy-Haul Trailer and Tractor (Prime Mover):

A second HHT (goldhofer) and tractor are needed for the transport of the NAC-STC from the TSC Transfer Station to the off-site railcar transloading facility. This HHT would be capable of securing the intermodal transport cradle containing a NAC-STC package in accordance with NRC and DOT requirements.

YR TFR and Retaining Ring:

There currently is no YR TFR at the YR site as the original TFR was sold to DPC LACBWR. Either a new TFR can be fabricated or a potential lease of the YR TFR at LACBWR can be pursued. If required, the new TFR will be procured in accordance with the NAC's approved Design and Licensing Drawings and Fabrication Specification.

Figure 2-24: NAC YR-MPC Heavy-Haul Trailer System[9]



YR TFR Transfer Adapter:

The Transfer Adapter Plate (**Figure 2-23**) is used to hydraulically operate the YR TFR shield doors. The adapter incorporates two hydraulic cylinders mounted on each end of the plate that extend female connectors that are used to engage the male connectors on the shield doors. The hydraulic cylinders are operated by a separate auxiliary hydraulic system including hydraulic pump, hoses, and valves. Currently there is no transfer adapter at the YR site. It is expected that a minimum of at least one new Transfer Adapter Plate will need to be procured and fabricated for use during the TSC transfer operation in accordance with NAC's approved Design Drawings and Fabrication Specification. As noted in the operational sequence, it is recommended that a second transfer adapter plate be procured to support the TSC transfer operation. A second adapter plate would allow the YR TFR to be moved directly from the VCC to the NAC-STC without the need to set the YR TFR down to move the transfer adapter plate from the VCC to the NAC-STC. *Note: Transfer Adapter Plates fit all NAC-MPC VCCs so a set of two adapters could be used at YR, CY and LACBWR.*

Auxiliary Hydraulic System for Transfer Adapter:

An electrically powered, high-pressure hydraulic pump, hoses, valves, and connectors are required to operate the hydraulic cylinders mounted on the transfer adapter to open and close the TFR shield doors to allow the TSC to be lowered into or lifted from the VCC or the NAC-STC. The auxiliary hydraulic system is installed after the transfer adapter is placed on the VCC and/or NAC-STC. An auxiliary hydraulic system is available for lease from NAC and was last utilized at the DPC LACBWR project. A single hydraulic system with a second set of supply and return hoses would be capable of operating two separate transfer adapter plate hydraulic cylinder sets.

Auxiliary Lifting Rigs:

A number of slings and rigging attachments are required to handle various YR-MPC components and to safely operate the system. The sling systems are designed to meet the requirements of ANSI N14.6[22] and ASME B30.9[23], as applicable, and to comply with the guidance provided in the Nuclear Regulatory Report, NUREG-0612[47] for handling heavy loads. Sling sets for critical loads are designed to provide a load rated capacity of at least 600% of the load being lifted. Each sling set for critical loads is load tested to 300% of the design lifting capacity prior to delivery. Redundant sling sets are designed to 300% of the load and tested to 150%. There are no lift rigs currently at the YR site and a complete set of new lifting rigs including associated hoist rings and turnbuckles will need to be procured and tested prior to the start of the YR de-inventory campaign.

The following auxiliary lifting rigs are utilized to operate the system for transfer and loading operations at YR:

- YR-MPC TSC Redundant Lifting Rig. This lifting rig uses a redundant (2X) three-point lift connected to a master link(s). This lifting rig is used to retrieve loaded TSCs from the YR-MPC VCC and for transfer to the NAC-STC Transport Cask. Each of the two sets of three-legged slings is designed for a load capacity of 300% of the weight of a loaded TSC. Alternative lifting slings or equipment arrangements may be used based on facility requirements such as a TSC Transfer Adapter Plate used in conjunction with a chain hoist system.
- YR-MPC Transfer Adapter Lifting Rig. This lifting rig is used to place and remove the Transfer Adapter assembly onto the VCC or NAC-STC using a four-point lift. The four-legged sling set is attached to the four lifting lugs or hoist rings on the Transfer Adapter using shackles.
- YR-MPC VCC Lid Lifting Rig. This lifting rig is used to install and remove the VCC lid using a three-point lift. The three-legged sling is attached to the VCC lid by three hoist rings.
- YR-MPC VCC Shield Plug Rig Set. This lifting rig is used to install and remove the VCC shield plug using a three-point lift. The three-legged sling is attached to the shield plug by three hoist rings.
- TFR Retaining Ring Lifting Rig. This lifting rig is used to install and remove the retaining ring using a three-point lift. The three-legged sling set is attached to the retaining ring by hoist rings.
- NAC-STC Outer Lid Lifting Rig. This lifting rig is used to install and remove the cask lid using a four-point lift. The four-legged sling is attached to the cask lid by four hoist rings.

- NAC-STC Inner Lid Lifting Rig. This lifting rig is used to install and remove the cask lid using a four-point lift. The four-legged sling is attached to the cask lid by four hoist rings.
- NAC-STC Transport Cask YR-MPC Cavity Spacer Lifting Rig. This lifting rig is used to install and remove the YR-MPC transport cavity spacers using a three-point lift. The three-legged sling is attached to the spacer by three hoist rings. The lift rig will be used to install the appropriate cavity spacer prior to TSC loading and remove it after TSC unloading from the NAC-STC. The YR-MPC cavity spacers will be required to be removed from the empty NAC-STC prior to return shipment and shipped separately in an IP-1 box/container.
- NAC-STC Impact Limiter Lifting Rig. This lifting rig is used to remove and install the impact limiters to the front and rear of the NAC-STC. The four-legged sling is attached to the four lifting lugs welded to the top of the impact limiter using shackles.

<u>Lifting Jacks and Air Pad Rig Set:</u>

The jacking system and the air pad system (**Figure 2-27**) are required for movement of the VCC. The hydraulic jacking system is used to lift the YR-MPC VCC to allow placement of the air pad rig set under the VCC. The air pad set allows movement of the VCC to and from the transporter, and on the ISFSI pad. A set of four hydraulic jacks is used, one placed under each of the four air inlets. The hydraulic jacking system includes a control panel, an electric hydraulic oil pump, an oil reservoir, and necessary hydraulic hoses, valves, and fittings. The jacks have a limited lift height to ensure the loaded YR-MPC VCC does not exceed a 6-inch lift height. In normal operation, the jacks are used to raise the cask approximately 4 to 5 inches to permit installation and removal of the four air pads under the VCC base plate. The air pad set lifts the VCC off the surface using a compressed air flow (minimum of 750 CFM) provided by a diesel-driven air compressor, which provides a thin layer of air between the VCC and the surface. The complete air pad set has a lifting capacity of 366,000 lbs. The VCC can then be moved by a JCB telescopic handler, suitable towing vehicle or forklift provided with an appropriate VCC attachment device. A control system is provided to regulate the compressed air flow to each of the four air pads and to maintain a uniform lifting height. Upon completion of the planned VCC movement, the air pad set is deflated and the jacking system is then re-installed to raise the VCC to allow removal of the air pads and to lower the VCC into position (see **Figure 2-29** and **Figure 2-30**). There are no jack or air pad systems currently at YR. Both the hydraulic jack and air pad systems are available for lease from NAC after refurbishment, or new systems can be procured.

<u>YR-MPC VCC Attachment Device and Associated Strapping and HHT Bridge Plates:</u>

- A VCC attachment device consisting of essentially a 120 to 150-degree curved piece of steel with a special designed attachment connection for connecting the steel curved VCC capture device to the JCB telescope handler or equivalent VCC push vehicle. A strapping system is utilized to connect the two ends of the curved steel device to positively capture the VCC to allow it to be moved to and from the ISFSI pad and HHT in a controlled manner (see **Figure 2-29**). Two steel bridge plates are used to fill the gap between the HHT trailer bed and the surface of the pad. The plates are provided with handles to facilitate installation and removal.

Mobile Diesel-Powered Air Compressor:

A diesel-powered air compressor with a rated capacity of approximately 900 CFM is required to properly operate the air pad system. The air compressor will need to be located in proximity to the TSC Transfer Station. There are currently no diesel air compressors at YR. NAC has a single KAESER Mobilair 260 T air compressor meeting project requirements available for lease.

Diesel Electric Generator:

A small electric generator will be required to operate electrically powered equipment including the transfer adapter auxiliary hydraulic system pump, lifting jacks hydraulic pump, vacuum pump, Helium MSLD, etc. A new generator may need to be purchased to provide electrical power at the TSC Transfer Station pad as a generator or electric power may not be available or of sufficient power requirements to meet operating equipment electrical needs at the YR ISFSI site.

Vacuum Pumping and Helium Backfill System:

Following loading of the YR-MPC TSC into the STC and installation and torquing of the lid, the cask cavity is evacuated to ≤ 3 torr using a vacuum pumping system connected to the vent port quick disconnect coupling. This allows backfilling of the cask cavity to 1 atm with high-purity helium. The vacuum pump skid generally includes a high-efficiency, large-capacity vacuum pump, pressure and vacuum gauges, isolation valves, and high vacuum piping and hoses for connecting the vacuum pumping system to the TSC vent port opening. The potentially contaminated exhaust of the vacuum pump will require routing to a portable HEPA system. If contamination is detected during evacuation of the NAC-STC cavity loaded with a YR-MPC TSC, the source of the contamination will be required to be determined prior to final preparations for shipment of the package. (*Note: The YR-MPC TSCs may have residual removable contamination as a result of in-pool loading as allowed NAC-MPC TS LCO 3.2.1*[45]). The high-purity helium supply is connected directly to the vacuum pumping skid to allow helium backfill after isolation of the vacuum pump without the need to disconnect and reconnect piping and uses the same vacuum/pressure gauges. A supply of helium bottles and a bottle rack will need to be supplied and stored at the TSC Transfer Station location. A Vacuum Drying System (VDS) and Helium Backfill System are not currently available at the YR site. A NAC system may be available at the time of the de-inventory project but is not currently available for lease. If required, a new VDS and Helium Backfill System can be procured and delivered to the site in accordance with NAC Design Drawings and approved test procedures. *Note: The VDS and Helium Backfill System would be suitable for use at all NAC-MPC and NAC-UMS sites as connecting quick disconnects are identical between the two systems*.

Helium Mass Spectrometer Leak Detection (MSLD) System:

Prior to transport of the loaded NAC-STC transport cask, the containment boundary seals of the inner lid, and vent and drain port coverplates will require replacement and maintenance leakage rate testing to leak tight criteria as specified in the NAC-STC SAR[19] using a helium MSLD system including a calibrated leak. The non-containment seals of the outer lid, and interlid and pressure port covers will be verified as properly assembled by performance of gas pressure drop leakage tests to confirm no leakage past the seals at a minimum leakage test sensitivity of $1x10^{-3}$ cm^3/sec. These tests will require a gas pressure drop leakage test system. Additional equipment required for pressure drop and helium evacuated envelope leakage testing would include a pressurized gas supply, high purity helium (≥ 99.1%), appropriate tubing, valves, calibrated pressure and vacuum gauges of the appropriate sensitivity, connectors to mate with the vent, drain and interlid port quick disconnect valves, and leak test port connecters.

Replacement O-Ring Seals:

Following replacement of the inner lid and vent and drain port coverplates metallic O-ring seals, a helium leakage rate test is required to be performed on each containment closure component using a helium MSLD. The maintenance leakage rate testing of the NAC-STC package containment inner lid and vent and drain port coverplate O-ring seals is to confirm a leakage rate of ≤ 2.0 x 10^{-7} cm^3/sec, helium at a test sensitivity of ≤ 1.0 x 10^{-7} cm^3/sec, helium. The testing requirements and procedural guidance are specified in Chapter 7, Section 7.4 of the NAC-STC SAR. There is no MSLD or gas pressure drop test systems currently available at the YR site and a new system will be required to be leased or procured and specialized connectors for and connection to the NAC-STC containment leakage test ports will need to be procured. *Note: The MSLD and pressure drop leak test systems can be utilized at all sites loading a NAC-STC packaging.*

Cranes:

A number of overhead lifting devices would be required for the operations of sufficient capacity to meet the requirements of the NAC-MPC CoC 1025 TSs Appendix B, Section B 3.5, "Canister Handling Facility (CHF)" located at a TSC Transfer Station. It is estimated that a Canister Transfer Facility pad (or an extension of the current ISFSI pad) of approximately 25 x 35 feet elevated to approximately 27 inches will be required to be constructed within the ISFSI site perimeter. It is unknown if such a pad can be constructed within the current ISFSI site fenced boundary. The design loading capacity for the pad would be required to support a stack-up loading of approximately 400,000 lbs over the NAC-STC baseplate cross section of 5,800 in^2 (baseplate diameter of 86.7 inches).

At the TSC Transfer Station pad, a CHF will be required to meet the criteria specified in Section B 3.5 of the TSs, and any stationary or mobile crane utilized to lift and handle the loaded YR TFR and NAC-STC must meet the requirements of MPC CoC TS B 3.5.2.1.3 or B 3.5.2.2[45], respectively. **Figure 2-28** shows the TFR restraint system used to stabilize the TFR on top of the VCC during original TSC loading operations. The restraint system was attached to a plant building structure and connected to attachments welded to the outer shell of the TFR. In addition, if a stationary crane is not single-failure-proof, an impact limiter is required to ensure a TSC drop does not breach the canister. One large-capacity crane would be required for vertical lifting and movement of the YR TFR, the vertical lifting and movement of the NAC-STC, and the upending and down-ending of the NAC-STC from and to the intermodal transport cradle located on the goldhofer, or on the ground and subsequently lifted horizontally and loaded onto the goldhofer. A smaller crane would be required for lifting ancillary items, such as the VCC shield plug, VCC lid, transfer adapter, NAC-STC closure lid, transport impact limiters, and personnel barrier.

An alternative to the location and use of mobile cranes would be to design and deploy a seismically qualified, single-failure-proof gantry crane system provided with a Secure Lift Beam provided with an integral hydraulic or air-powered chain hoist system. This system would allow the direct movement of the loaded YR TFR from the top of the VCC to the top of NAC-STC cask for TSC transfer without the need to set down the TFR on the pad surface, with the TSC lowered by the chain hoist with the TFR maintained attached to the lift yoke arms. A similar system is currently being deployed at the Taiwan Power Company's Kuosheng Nuclear Station in Taiwan, and a Secure Lift System with integral chain hoist was utilized for MAGNASTOR System TSC transfer operations at Dominion's Kewaunee Nuclear Station. The system would also be adaptable to other storage and transport cask system designs.

Man-lift:

A minimum of one man-lift capable of accessing the top of the YR TFR when in stack-up position on the VCC or NAC-STC will be required for retrieval of the TSC lifting slings. Minimum lift height would be approximately 35 feet.

Impact limiters:

The NAC-STC will arrive with two impact limiters according to the requirements of the SAR. The impact limiters would be fabricated as part of the transport cask procurement and fabrication.

Intermodal Transportation Cradle and Tie-down Straps/Restraints:

An intermodal transportation cradle/shipping frame, associated tie-down straps, and restraints would need to be fabricated for each of the NAC-STC casks. The equipment will be designed to allow for horizontal handling and intermodal transfer between transport modes. Intermodal transport cradles have been designed by NAC and fabricated for the NAC-STC casks supplied to China. The NAC-STC casks currently being used in China utilize an intermodal transportation skid/shipping frame, tie-down straps, and restraints. This equipment allows for horizontal transfer of the NAC-STC between transport modes. If these designs continue to perform satisfactorily in transport operations, these components would be fabricated for use in the U.S.

Personnel Barrier:

As required by the NAC-STC CoC, a personnel barrier would be placed around the loaded package. The personnel barrier matches the outer diameter of the impact limiters and spans the distance between them. The NAC-STC intermodal transport skid and personnel barriers are used with ten of the NAC-STC casks in China. The other four NAC-STC casks being fabricated will be supplied with them. If these designs continue to perform satisfactorily in transport operations, these components would be fabricated for use in the U.S. There are no unique requirements that would present expected complications with the lead time and cost of obtaining personnel barriers.

Hydraulic Bolt Torquing Equipment and Standard Tools:

To properly install and torque the 42 NAC-STC inner lid bolts to the required torque of 2,540 ± 200 ft-lb, a hydraulic torquing device capable of torques up to 3,000 ft-lbs may be required. A number of standard tools and equipment will be required to remove and install other NAC-STC components, VCC components, TFR retaining ring, cradle tie-downs, etc. A final listing of required fittings, connectors, and tools will be prepared as part of the final preparation for project performance.

YR TFR Lift Yoke and NAC-STC Lift Yoke:

Lifting yokes for both the vertical handling of the YR TFR and rotation and vertical handling of the NAC-STC are required. All NAC designed lift yokes meet the design, testing and inspection requirements of ANSI N14.6 and design safety factors defined in NUREG-0612[47]. Designs exist for both lifting yokes, but the YR TFR lifting yoke is not available on site and may not be available for lease. No NAC-STC Lift Yokes have been fabricated to date for use in the US. Designs fabricated for use in China have operated satisfactorily and similar designs could be readily fabricated for use in the US. The NAC-STC lifting yoke would be supplied as part of the NAC-

STC cask supply package and would be procured and fabricated as part of the cask fabrication project.

Horizontal Intermodal Transport Cradle Lift Beam:

The horizontal intermodal transport cradle lift beam would be used to lift and move an empty or loaded transport cradle containing an empty or loaded NAC-STC package with impact limiters and personnel barrier installed at the loading site, transloading (intermodal transfer) site, and/or at the cask receiving and unloading location. A design for the intermodal transport cradle and the horizontal cradle lift beam has been developed and fabricated for the NAC-STC deployments in China and similar designs could be fabricated for use in the US.

NAC-STC Transport Cask YR-MPC Cavity Spacer:

Two YR-MPC cavity spacers in accordance with the approved NAC-STC SAR License Drawing will be required for each NAC-STC cask. The lower YR-MPC cavity spacer is 14.0 inch in height and 70.6 inch in diameter and weighs approximately 350 lbs. The upper YR-MPC cavity spacer is 28.0 inch in height and 70.6 inch in diameter and weighs approximately 520 lbs. Each spacer will be required to be removed from the cavity of the NAC-STC prior to empty return shipment and stored and shipped in an IP-1 shipping box/container.

Based on the demobilization or disposal of essentially all cask loading equipment from the YR site upon completion of the fuel loading campaign, it is expected that essentially all of the identified equipment and systems will be required to be procured or leased from NAC, as described above.

Note: The TFR, transfer adapter, HHT, lifting yokes, mobile and fixed lifting and handling equipment, lifting rig sets, and other auxiliary equipment and systems will be required to be maintained, inspected, load and/or functionally tested as required by the NAC-MPC and NAC-STC Operations Manuals, SAR and FSAR, and component specific maintenance manual, as appropriate, prior to use on the YR site.

Figure 2-25: Loaded VCC on HHT

Figure 2-26: VCC Lid Installation on VCC Positioned on HHT

Figure 2-27: NAC YR-MPC Air Pad System[9]

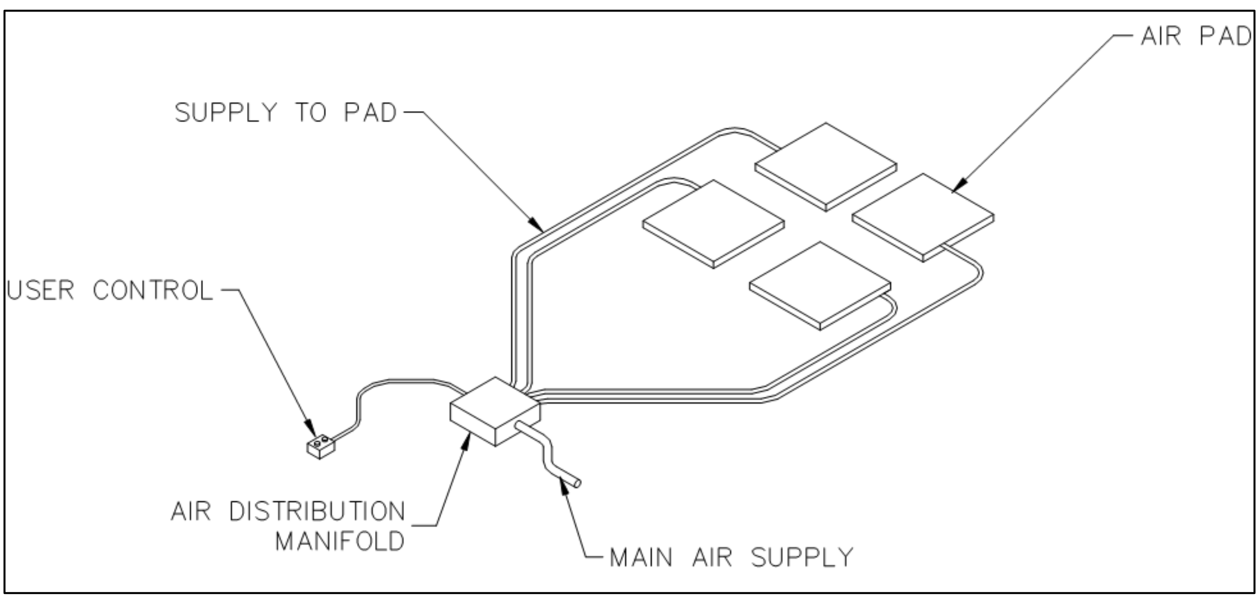


Figure 2-28: YR-TSC Insertion into VCC with YR-TFR Restraints Installed

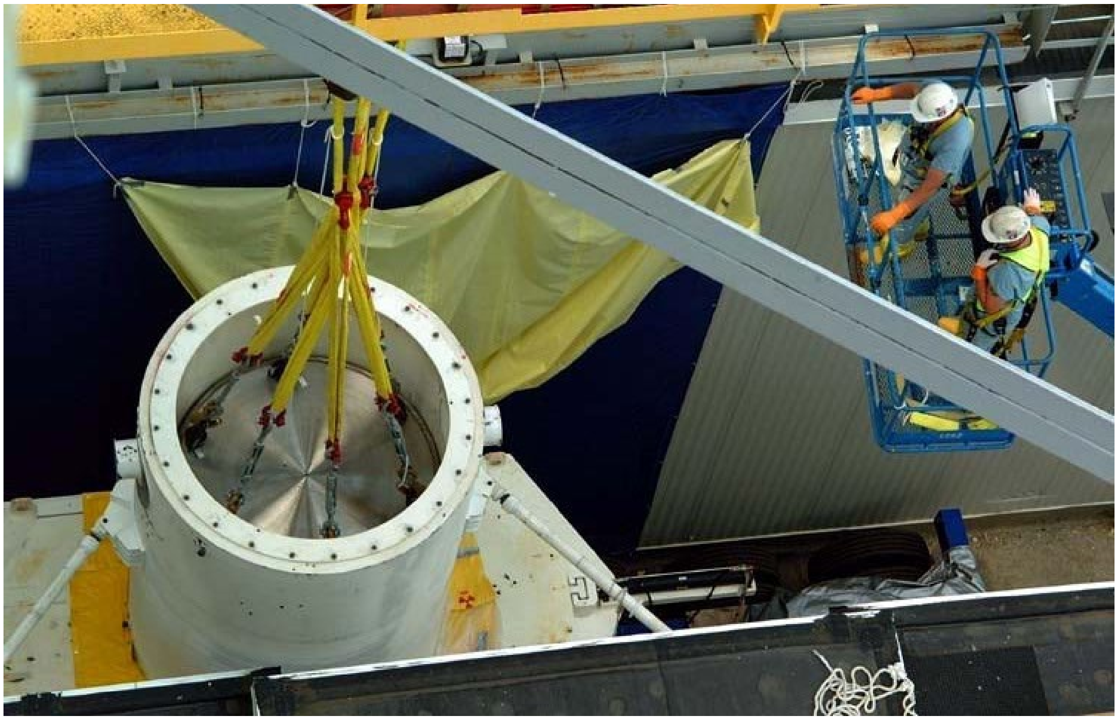


Figure 2-29: NAC VCC Movement from HHT to ISFSI Pad on Air Pads and Engaged to JCB Telescopic Handler

Figure 2-30: NAC VCC Movement to/from ISFSI Pad on Air Pads

3.0 TRANSPORTATION ROUTE ANALYSIS

This section describes the available routes identified to transport the transportation casks from YR for delivery to a Class I railroad and subsequent rail movement to GCUS. A number of HHT, barge, and rail routes were reviewed and are presented. As discussed in **Section 3.5**, the team down-selected from the identified number of options available and chose a total of six scenarios to consider further using the MUA process, as covered in detail in **Section 5.0**.

3.1. Heavy Haul Trucking Routes

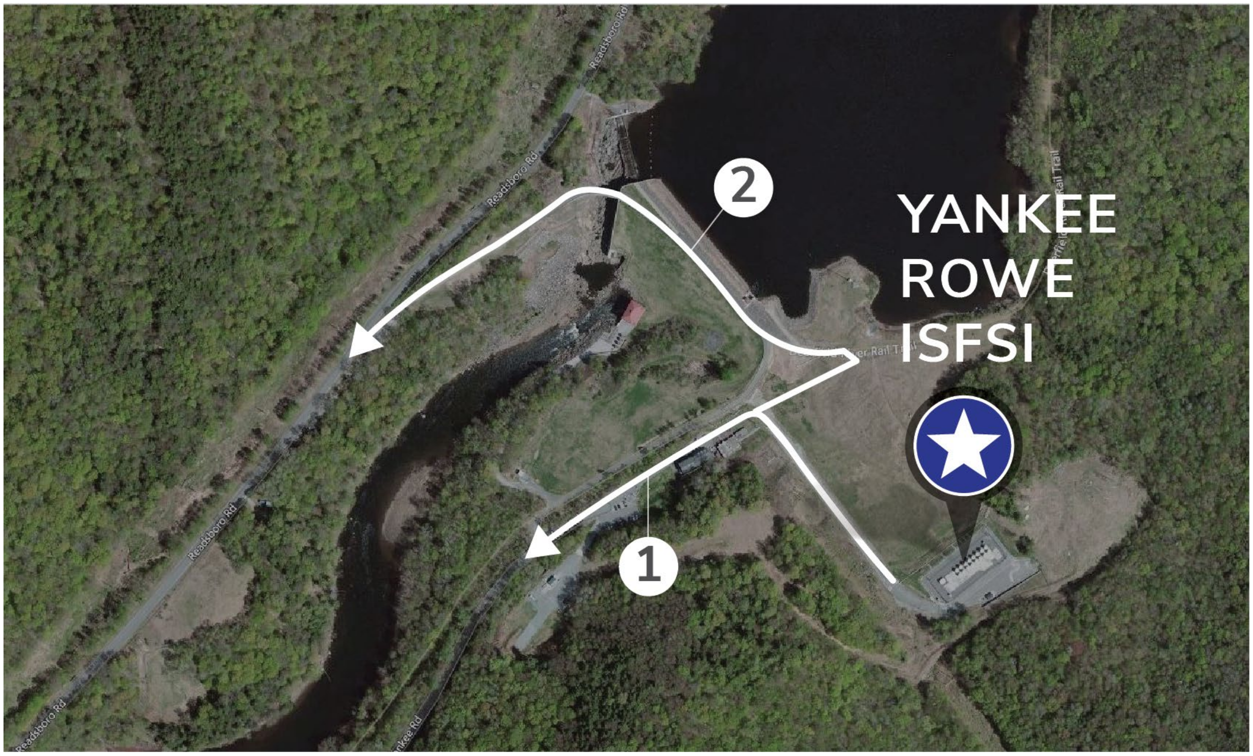
YR is located on the Deerfield River at the Sherman Reservoir in Franklin County near the town of Rowe, MA at 49 Yankee Road. The site is located in the northwest corner of Massachusetts approximately 0.5 miles south of the VT border, 3.5 miles northwest of the town of Rowe and 48 miles north of Pittsfield, MA. Two main roads lead into the plant from different directions: Readsboro Road/River Road from the west leads to Sherman Dam Road, and Yankee Road/ Monroe Hill provides access east of Deerfield River. The plant is located in an isolated, rural area in hilly terrain with various grades on the local two-lane roads around and leading to the site. The length of the access road from the ISFSI to Yankee Road is approximately 900 ft. The roads leading from the site have various grades and are narrow. Road surveys were conducted in preparation for the movement of the steam generators and the reactor pressure vessel (RPV) to the location where the components were transloaded from truck to rail at River Road, just outside the eastern entrance to Hoosac Tunnel. Multiple routes were identified as possible HHT routes in NAC's NSTI report for the YR site. This information is dated and any HHT route from the ISFSI would require new road and bridge surveys prior to movement which will include applications for HHT oversize and overweight permits.

HHT transport from YR heading either east or west is possible. However, in order to travel north on Readsboro Road, there is a hairpin curve which would have to be traversed (Path 2 in **Figure 3-1**). This hairpin turn is approximately 150 degrees, roughly the maximum curvature a heavy haul trailer of this type, carrying a cask of the same weight and dimension as being used in this campaign, can safely negotiate. A prime mover and pusher would be required or a vehicle with a steerable rear. Various trailer configurations can be used to move the casks from the ISFSI to various alternate loading sites. The physical road surveys will determine the best equipment to be used for the road haul at the time of the shipments. According to START data, there are no state-designated Hazardous Materials (HAZMAT) routes from YR, although the steam generators and the RPV were moved by HHT from the site a short distance to a portion of the mainline track where they were loaded onto rail cars.

Several of the large components were removed from the site by HHT in the 1990's to the closest rail location where the components were transloaded onto rail cars for shipment to disposal locations. There was a short rail siding (which has since been removed) located at the eastern opening of the Hoosac Tunnel, in Florida, MA, at which the railroad granted permission for transloading the RPV onto a rail car on the mainline track which crosses River Road.

In November 1993, the four steam generators, weighing 150 tons each, were removed from the plant and were shipped by HHT to this track and were transloaded onto railcars and shipped to Barnwell, SC for disposal. This location is on the mainline track at the mouth of the tunnel. The HHT route was approximately 7 miles from YR, crossing the Sherman Dam onto Readsboro Road and River Road, through the town of Monroe and Florida, MA to the rail siding located just outside the eastern entrance to the Hoosac Tunnel. At that time, the rail route was the Guilford System-Canadian Pacific (DH)-CSX-NS. The truck haul took approximately six hours.

Figure 3-1: Path from the ISFSI Across the Site to the Nearest Public Roads



The largest component to be removed from the site was the RPV which was loaded onto HHT in 1997 and travelled the same truck route as the steam generators, approximately 7 miles across the Sherman Dam and onto Readsboro Road and River Road, through the town of Monroe and Florida, MA, at a reported speed of 1 mph, until it reached the mainline track which still intersects River Road. The RPV was shipped by special train from the loading location to Barnwell, SC. The train consisted of an engine, two buffer cars, the load car (a private 18-axle shift-able car), two buffer cars and a passenger car to house people accompanying the shipment (not security personnel). The transit time was eight days. The specialized rail car that was used has the ability to shift 12" vertically and 14" horizontally. The railroad granted 48 hours to conduct the transload operation and secure the RPV onto the rail car. Once the RPV was loaded onto the rail car it was hauled through the tunnel to Mohawk rail yard where it was interchanged with the Canadian Pacific Railroad. A total of five railroads were in the route to Barnwell, SC.

The spillway bridge on the Sherman Dam was replaced prior to the HHT movement of the RPV.

This HHT route is still viable although there are multiple challenges with conducting the transloads at this location, including the ability to obtain permission from the owner to completely curtail all trains running through the tunnel in both directions while a loading campaign is conducted. At one time, there was a rail siding here which would have allowed a shipper to load cars while the railroad continued to move trains through the tunnel. Unfortunately, it was removed, along with the switch. Although it may be possible to reinstall a switch and a maximum of two car lengths of track at this location, the current owner, Pan Am Railways (PAR), would have to grant permission for the construction and use of any adjacent railroad property. The operating railroad for the PAR at this location is the Pan Am Southern Railroad (PAS), which has advised that there is not enough room at this location to load the entire train. It indicated that, at most, there is room to add two car spots and replace the switch. PAS expressed concern as to how this may interfere with current train operations. Currently, the railroad is not willing to grant permission to load on the mainline because of the impact on its rail network. For this reason, alternate sites were identified where more efficient transload operations could be conducted and are listed in **Section 3.2**.

A more detailed discussion of the Hoosac Tunnel loading option, including the challenges of loading at this location from rail, truck, and safety perspectives, is presented in the following section.

Since there is no direct rail access or water access at YR, HHT will be required to transport the casks from the ISFSI to any rail or barge transload sites. A physical road survey will be required for the heavy haul routes from the ISFSI along the entirety of Yankee Road to any transload site. In addition, an engineering survey will be required of the spillway bridge and the Sherman Dam to ensure the HHT can safely cross these structures 16 times without causing failure or damage to the bridge or the dam. The responsibility for conducting these surveys lies with the shipper.

Because the Sherman Dam is privately owned, permission to travel over the dam will have to be obtained from the owner.

START[1] was used to create routes to sites it identified as potential transload locations where the transportation casks could be loaded onto rail cars. Routes were configured to use interstate highways wherever available to avoid using two-lane country roads and potentially alleviate congestion if these options were available.

In addition to the START-identified rail sidings, several other potential transload sites within close proximity to YR were identified. Although the MUA selected site for the rail transload operation is not the closest in mileage to the ISFSI, it provides distinct advantages over the other options and is located 1.5 miles from the interchange yard between the short line and the Class I carrier.

The closest rail track to YR is at the Hoosac Tunnel east portal mainline track; the second closest track is located just west of the tunnel, in North Adams, MA. There are no rail sidings suitable for conducting the transload at either of these locations.

Table 3-1 identifies the closest rail tracks and sidings identified in this assessment, with length of track and any restrictions or benefits associated with the siding. A HHT will be required to reach all of the listed rail tracks and potential sidings.

Figure 3-2, **Figure 3-3**, **Figure 3-4**, **Figure 3-5**, **Figure 3-6**, and **Figure 3-7** present the six HHT routes to the down selected, evaluated options for transloads in the vicinity of the ISFSI.

Table 3-1: Nearest Rail Tracks to the YR Site

Track Location	Siding Length (ft)	HHT to Track (miles)	Site Description	Challenges/Considerations
Eastern Portal Hoosac Tunnel, Florida, MA	0	7	The siding used in the past has been removed.	The only track at this location is the mainline track that runs through the tunnel. There is no siding at this location and the railroad advises there is not enough room to install the required footage to load a 4-5 car consist or for the complete train consist. Nevertheless, the duration this line would be blocked to perform the transload activity would likely also be a challenge to the rail operator due to the traffic on this line.
Eastern Portal Hoosac Tunnel, Mainline track at River Road, Florda, MA	0 Potential lease of mainline track	7	No existing sidings. Use of 1,200' of mainline track for loading 4 casks at once or 600' to load 2 casks at once Note: Potential compromise described in **Section 3.2.3**.	There are seven major challenges with using mainline track for loading operations at this location: (1) Permission of the operating rail line and its parent, (2) Curtailment of all trains operating through the tunnel during transload operations, (3) Limited time window for conducting transloading and securement operations (4) Constricted operating area due to overhead wires, limited turning radius for trucks, etc. (5) Impeding automobile traffic during staging and loading (6) Additional switching at the end of each day and (7) Tourist activities at the tunnel present additional security issues not present at other loading sites.
North Adams, MA Western Portal of Hoosac Tunnel	No existing sidings identified	18	Operating Track and Trolley Museum tracks	It is not practical to load on the operating mainline tracks and the Trolley Museum has limited space for conducting a loading campaign. The private cars housed at the museum would need to be relocated during the campaign and the track condition would require evaluation for loading purposes (verus stationary parking of historical cars).

Figure 3-2: HHT Route from YR to Transload Site at Westfield, MA[6]

Figure 3-3: HHT Route from YR to Transload Site at Deerfield, MA[6]

Figure 3-4: HHT Route from YR to Transload Site at Bellows Falls, VT[6]

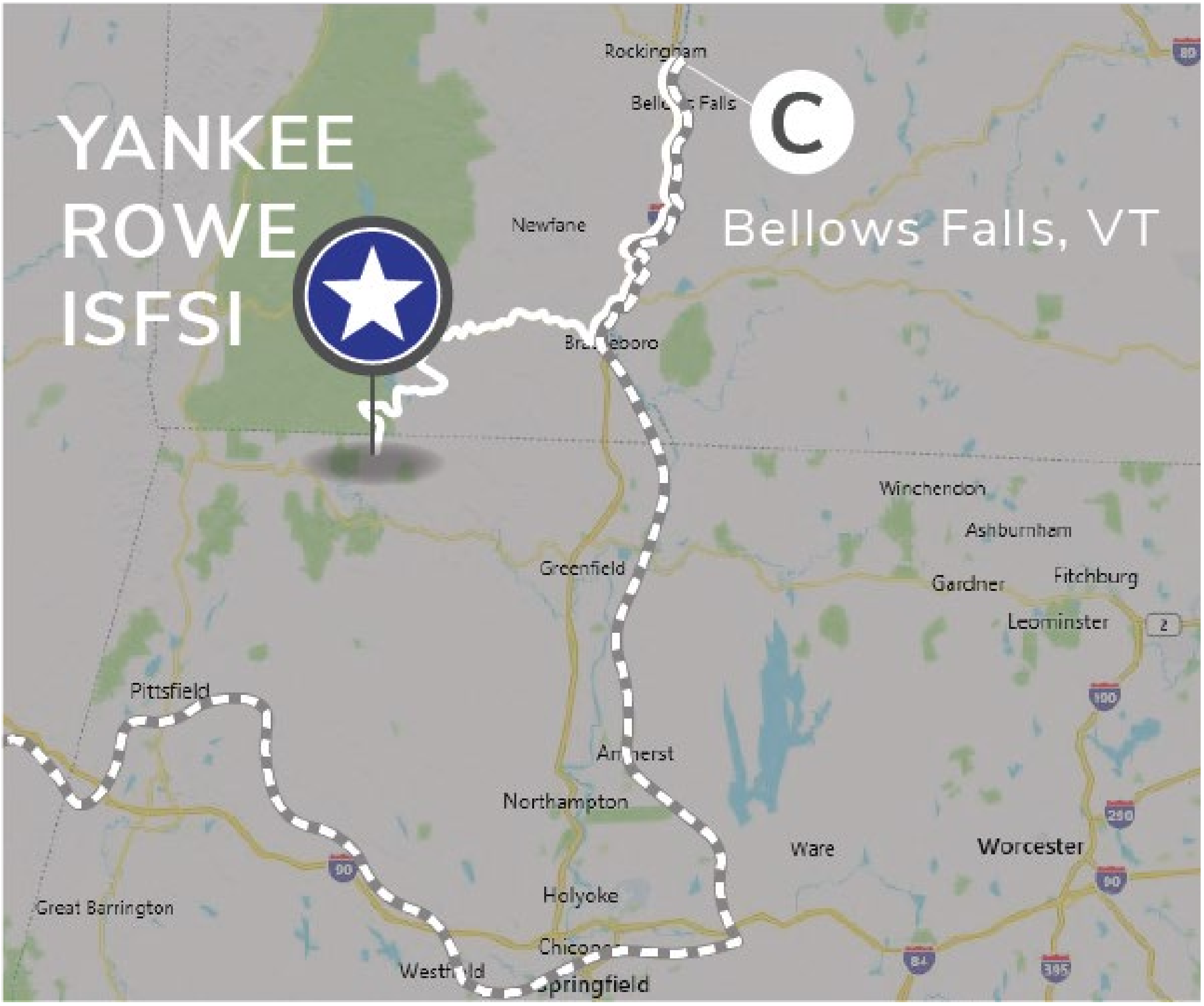


Figure 3-5: HHT Route from YR to Transload Site at Bennington, VT[6]

Figure 3-6: HHT Route from YR to Transload Site at Shelbourne Falls, MA[6]

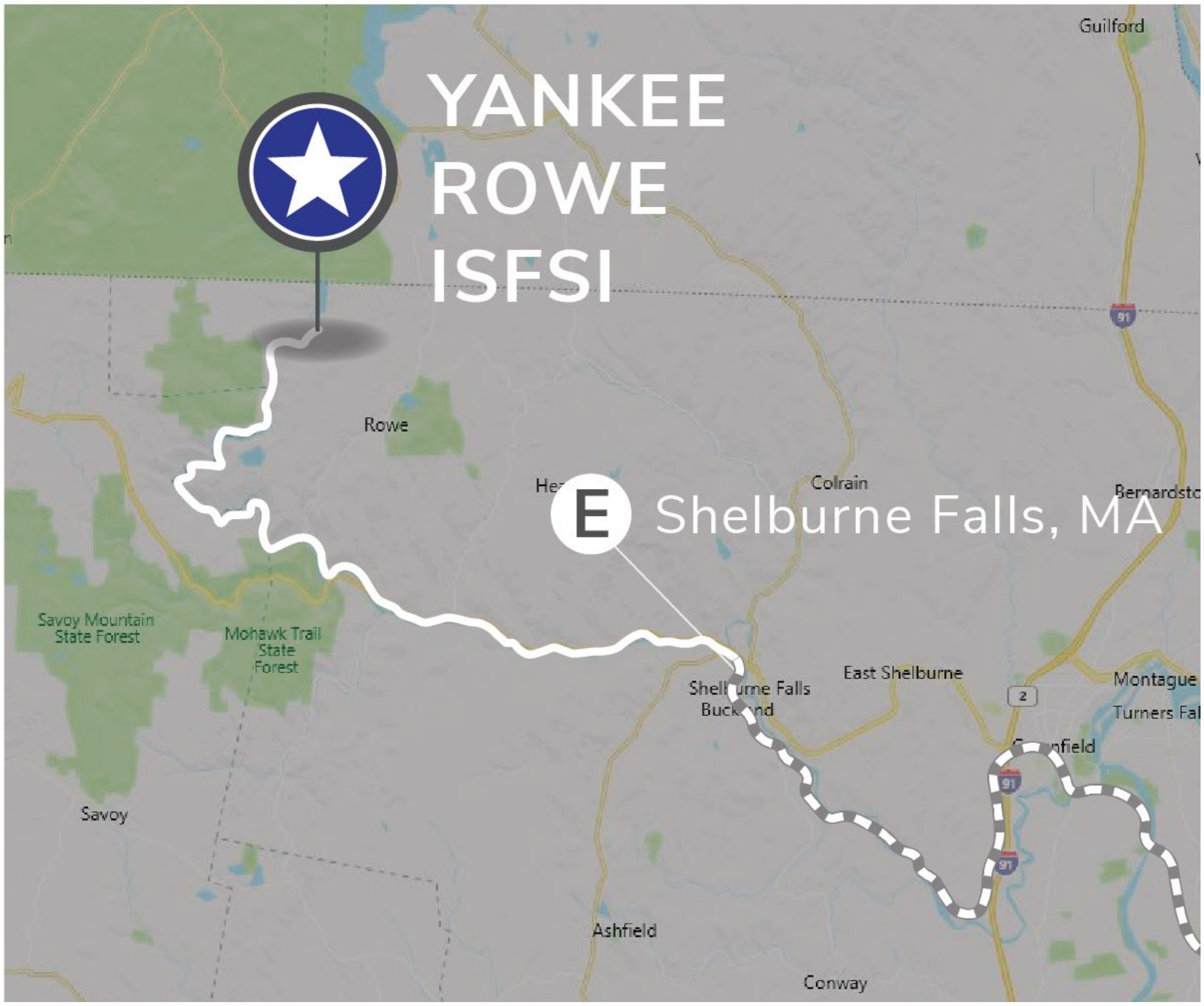


Figure 3-7: HHT Route from YR to Transload Site at North Adams, MA[6]

3.2. Rail Access Locations

3.2.1. Rail Infrasctructure

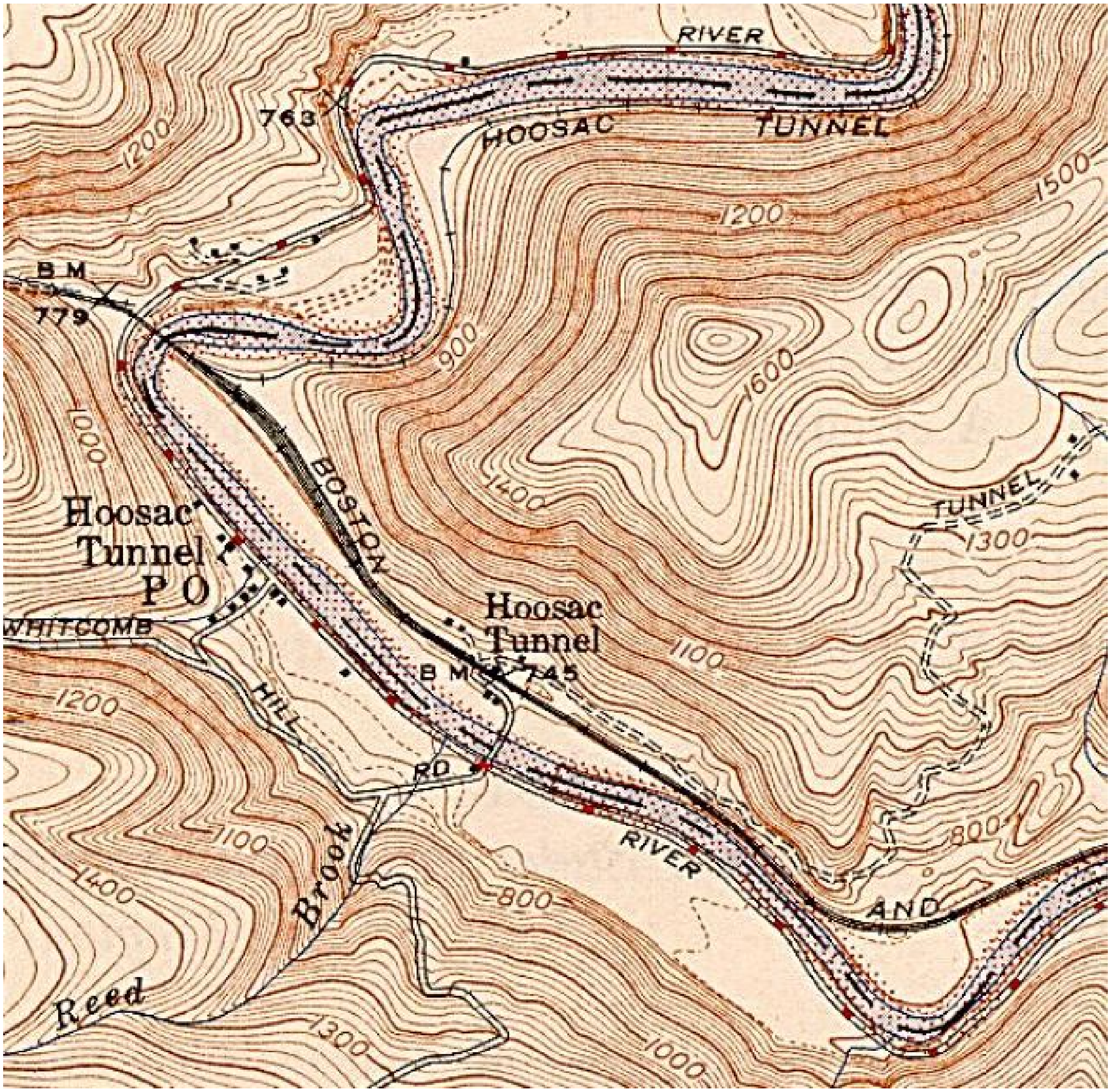
YR is no longer rail served; however, the plant was originally directly served with rail coming into the plant to the Cask Receiving Area next to the Refueling Building and the area was designed to support a 130-ton railcar[24]. At that time, the name of the railroad serving the plant was *The Hoosac Tunnel and Wilmington Railroad,* which ran from the Hoosac Tunnel to Wilmington, VT. This was one of the predecessor railroads to the Boston & Maine Railroad, which became the Guildford System Railroad at the time of the outbound rail shipments. A map of the old railroad is shown in **Figure 3-8**. The railroad track leading to the plant was submerged and is presumed to no longer physically be in place; this portion of the track was abandoned at the time of the submersion. The Hoosac Tunnel and Wilmington Railroad's track was located on the eastern side of Deerfield River running along the riverbank from YR. The Guildford System Railroad was purchased by the PAR which is the holding company that owned the track in 2019. It was operated by the PAS, which is a subsidiary of the PAR.

On June 1, 2022, Class I railroad CSX Transportation purchased the PAR. The PAS (the prior operating railroad for PAR) was owned 50% by PAS and 50% by NS. As a result of the CSX purchase of PAR, CSX is now a 50% owner of PAS. For anti-trust and competitive reasons, CSX and NS have designated an operating company to run the former PAS track. The new operating railroad is the Berkshire & Eastern Railway (B&E), a subsidiary of the Genesee & Wyoming Inc (G&W).

Substantial funds are being invested in track infrastructure upgrades on the prior PAR rail track by the new owners. Consolidation of operations will occur to improve the quality of service, reliability, and transit times as the acquisition results in reduced interchanges between carriers in this region.

CSX is investing over $100 million in the PAR infrastructure, with $50 million expected to be spent in the first 3 years for rail track improvements. The Hoosac Tunnel maintenance is included in the acquisition. It is likely some of the interchange points between short line railroads in the region and CSX may change in the future (to avoid duplicate interchange points); however, no specific operating changes have been announced at this time and therefore, none of the routes identified in this Chapter are being updated. Each of the interchange points is still valid for current traffic; PAR was never shown in the identified routes and PAS will remain “named” in the routes, post-acquisition.

Figure 3-8: YR Site Rail Access Through Hoosac Tunnel



It is no longer possible to restore the track into the plant "... because the construction of the Cockwell (formerly Bear Swamp) Pumped Storage Plant resulted in submersion of the rail line to Yankee Rowe (TOPO 1993b)."[5] Without conducting a physical survey of the old railbed, it is not known whether the track is physically still in place, submerged, or if the roadbed is the only remnant of the old track that once served the plant.

Historically, New England has had many small independent railroads operating throughout the geographical area. Some of these railroads have existed since 1840 but substantial consolidation of the railroads has occurred in this area. A number of these smaller railroads were purchased by conglomerates, competitors or were abandoned and are defunct.

In addition to the closest tracks to the site (listed in **Table 3-1**), several Class II and Class III railroads are within close proximity to the ISFSI (listed in **Table 3-2** and **Table 3-3)**. The track configurations or available sites are not ideal for loading trains at the majority of these sites for a variety of operational reasons. The three closest Class I carriers are located from 63 to 130 road miles from YR. The distance between YR and the six sites selected for evaluation, all served by either Class II carriers or short line railroads, range from 18 to 68 miles from the ISFSI.

Table 3-2 shows the Class I Railroads closest to YR.

Table 3-2: Class I Railroads in the Region Closest to YR

Railroad	Nearest Transload
CSX	Westfield, MA; Springfield, MA; Rotterdam Junction, NY; New Haven, CT
NS	Mechanicville, NY
CP	Mechanicville, NY

Table 3-3 lists the railroads in the general geographic area.

Table 3-3: Class II , Class III and Switching Railroads Near YR

Railroad	Railroad Class	Notes
B&E	Class II Carrier Largest Regional Carrier in New England	Hoosac Tunnel track- closest mainline to YR, no close sidings Interline settlement carrier for CSX Operates in VT, NH, ME MA, CT, NY Operating arm of former PAR [2]
VTR	Class II Carrier	Hoosick Junction, NY; Bellows Falls, VT; White River Junction, VT
PVRR	Class III Carrier	Junction settlement carrier for CSX; Operating in Westfield, Holyoke and South Hampton, MA, privately held, but for sale. Owned by the Pinsly Group.

[2] Note PAS (Pan Am Southern LLC) was the operating railroad for PAR which is a holding company that owns this track. PAS is a subsidiary of PAR which is jointly owned by NS and PAR. Other trackage rights are in place for use of this track with CP. As the operating railroad, PAS conducts all clearances and makes operational decisions on use of the track. As of June 1, 2022, CSX is the owner of the former PAR track and now half owner of the PAS. B&E will be the new operating railroad for PAS.

Railroad	Railroad Class	Notes
NECR	Class II Carrier	Operates in VT, MA, NH; White River Junction, VT; Brattleboro, VT; Palmer, MA, Millers Falls, MA. Operates 394 miles of track.
ST	Class II Carrier	Springfield, MA, owned by PAR.
HRRC	Class II Carrier	Operates between New Haven, CT and Pittsfield, MA and Newburgh, NY. Privately held
MC	Class II	Operates on the eastern peninsula of MA

3.2.2. Transload Sites

A. 100 Springdale Road, Westfield, MA (See **Figure 3-9**)

Figure 3-9: Westfield, MA Transload Site

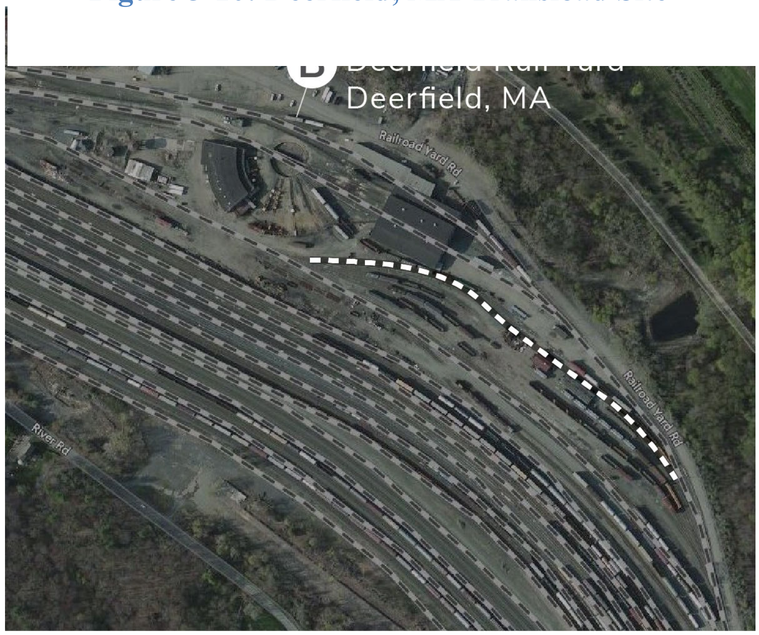
Although this location is 68 miles from YR, it offers amenities, including existing security and transportation features, which are the most attractive of the evaluated transload sites. The location is a private manufacturing facility secured with a fenced perimeter, fixed lighting, and onsite guards with 24/7 coverage. There is an existing rail siding served by the PVRR which is inside the fenced area. The site is located in an industrial area. New track is being installed (approximately 1,500 feet), including a second switch for the new track which would allow the shipping campaign to be conducted without interrupting other loading or unloading activities. The PVRR has secured a lease to establish a transload facility on part of the site, mostly for bulk materials. The railroad is interested in allowing an independent party to transload HAZMAT on the track. Although a crane is planned for the PVRR transload operation, it will not have enough capacity to transload the casks and therefore a mobile crane would be required for the transfer. Permission would have to be granted by the landowner. It is reported that there is no ammunition storage on site.

The PVRR would serve the site on demand, as needed, to pull the loaded trains and would immediately proceed approximately 1.2 miles to the interchange with CSX. This further simplifies the chain of custody rules for movement of this commodity.

Using this site for the transload would require a 68-mile heavy haul truck movement from YR to the transload location in Westfield, MA. Depending on the number of HHT used, it would be possible to move all 4 casks in tandem for loading within the secure site without outside interference. Although START[1] identifies the HHT transit time as 32 hours, a more realistic transit time would be 4 hours (one way). The rail route would be 1,084 miles from Westfield, MA to GCUS via PVRR-Westfield-CSX. This route would involve one interchange between the Class III and Class I carriers. It is the most direct of the rail options investigated.

B. Deerfield Rail Yard, Deerfield MA (See **Figure 3-10**)

Figure 3-10: Deerfield, MA Transload Site



Deerfield rail yard is an active freight rail yard located 36 miles from YR, a relatively short HHT distance. There is plenty of rail track within the rail yard. However, it is an active railyard and it may be difficult to run a transload campaign in the yard without affecting railroad train operations. A track with the total length of 1,241 feet was identified as a possible loading location. It would be necessary to fence and light the perimeter of the track used for the transload, which may present operational challenges and could impede operations for the railroad in this active rail yard. Permission must be granted from the PAS (the operating railroad of the PAR holding company), with the understanding that a specific dedicated track would be necessary for the length of the loading campaign. At present, there are other active shippers on the perimeter of the yard, including an LPG transload. The railyard is close to a residential area, which may present a security problem. If this location were used for the rail transload facility, the route would be PAS-Springfield-CSX. The total rail miles from Deerfield, Massachusetts to GCUS would be 1,123. START[1] identified a different route which included an additional Class II carrier.

Figure 3-11: Bellows Falls, VT Transload Site

C. 46 Steamtown Rd., Bellows Falls, VT (See **Figure 3-11**)

This location is an existing transload facility called Riverside Reload Center in Bellows Falls, VT which is served by the VTR. The site has 15 flatcar spots (approximately 1,300 feet) in the interior of the property as well as 40 railcar holding spots which are located adjacent to the transload facility, in the railyard.

Currently forest products, metals, building materials and bulk commodities like limestone, road salt, fertilizers and grain are transloaded at the site. The HHT route is 62 miles from YR and the rail route to GCUS is 1,190 miles via VTR-NECR-Springfield-CSX.

Using this transload facility would require a 62-mile HHT move from the ISFSI at YR traveling north of the site into the state of VT. The rail route would include two Class II railroads before interchanging with the Class I railroad. The route START selected is VTR- Bellows Falls, VT-NECR- Palmer-CSX, the total rail miles is 1,190 from Bellows Falls VT to GCUS.

Figure 3-12: North Bennington, VT Transload Site

D. 206 Harwood Rd., Bennington, VT (See **Figure 3-12**)

This location is a private facility which sits adjacent to the VTR mainline but currently does not have a rail siding. While it may be possible to add a rail siding into the facility, an evaluation would be required to determine if this is feasible due to elevation differences between the site and the railroad. It is also an active business and any loading campaign would likely interfere with daily operations which appear to involve dump truck movements of stone and gravel into and out of the site.

If a siding were installed at this business, the route would be VTR-PAS-CSX. The HHT mileage would be 30 miles from YR to the site and total rail miles from the transload site to GCUS would be 1,250 miles.

E. 14 Depot Street, Shelburne Falls, MA (See **Figure 3-13**)

This location is rail served by PAS. It has a limited amount of track and is the home of the Shelburne Falls Trolley Museum. To run the campaign at this site, the track may require refurbishing and the trolley cars would have to be temporarily relocated offsite. It appears there is 1,072 feet of contiguous track, just enough room to conduct a transload. However, it is tight for truck turns for entering and exiting the site and is in a tourist area surrounded by housing developments; the location is neither fenced nor secured.

Figure 3-13: Shelburne Falls, MA Transload Site

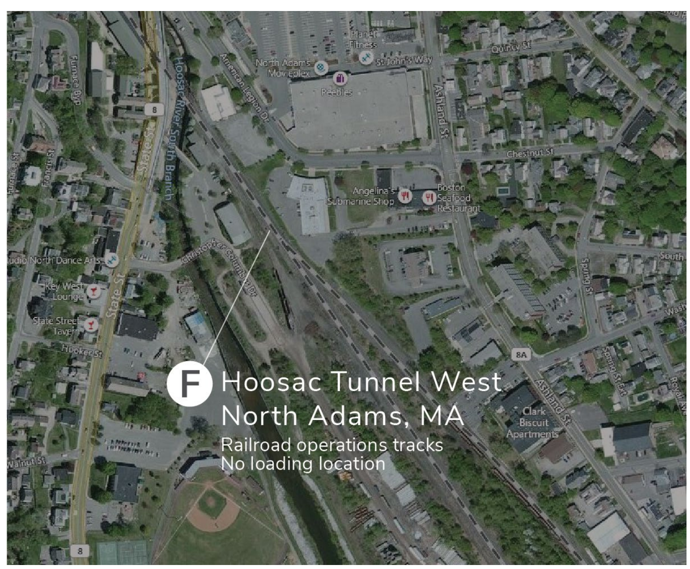
The heavy haul road transport is 25 miles from YR to Shelburne Falls, Massachusetts.

It is 1,139 miles from Shelburne Falls to GCUS and the route includes two short lines before interchange with the Class I carrier. START identified the route as PAS-PVRR-CSX; however, the actual route would be PAS-Springfield-CSX.

F. North Adams, MA - Hoosac Tunnel West (See **Figure 3-14**)

North Adams is on the west side of the Hoosac Tunnel. There is only one active private rail siding in North Adams, MA. Although there are plenty of operating tracks in place, there are no viable rail sidings in North Adams to establish a rail transload facility. There is a historic railroad building and track located here, but this track is not in optimum condition for conducting an active transload operation and there is not enough room to accommodate the loading and shipping campaign. This location is 18 road miles from YR and 1,038 rail miles to GCUS via the START generated route PAS-Mechanicville-CP-Rotterdam Junction-CSX. However, the practical route would be PAS-Rotterdam Jct.- CSX.

Figure 3-14: North Adams, MA (Hoosac Tunnel West) Transload Site



The down-selection process, discussed in **Section 3.5**, summarizes the rationale for those sites that were not considered as viable options for the MUA evaluation.

There is precedence for shipping large and heavy components from the site during decommissioning. The following components were moved by HHT from YR to the mainline track located at the eastern portal of Hoosac Tunnel:

- Four reactor coolant pumps (50 tons each), the pressurizer (150 tons), and two steam generators (550 tons each) were shipped to the Energy Solutions low-level radioactive waste disposal facility in Clive, UT (Johnson 2006)[5]".

- The four steam generators were removed from the plant in 1993.

- The reactor pressure vessel was shipped on April 27, 1997 by truck and transloaded onto rail for movement to the low-level waste disposal site in Barnwell, SC. **Figure 3-15** shows the YR RPV on a specialized rail car entering the eastern end of the Hoosac Tunnel. The RPV was 27 feet long x 12 feet wide and was placed into a shipping container with dimensions of 28 feet long and 13 feet in diameter, weighing 365 tons. It was loaded onto the railcar using a jack and slide method. Once loaded onto the railcar, the RPV travelled through nine states to deliver the package to Barnwell[25].

Figure 3-15: Removal of YR Pressure Vessel

These components were transloaded from trucks to rail cars for the long-distance rail movement to the disposal sites. One of the people involved in managing the RPV shipment advised the railroad granted a defined period of 48 hours to conduct the transloading of the RPV and commented that the railroad was not enthusiastic about the arrangements due to the interruption of train operations which halted all train traffic moving through the tunnel. This transload operation took place 22 years ago and although it worked at the time, the commodity required less stringent monitoring and security mandates and operational constraints. Fewer trains moved through the tunnel in 1997 than today.

The fact the railroad allowed the use of its mainline track to load the RPV and steam generators was an exception and likely because it was extremely difficult to move directly by truck to the destination and vastly more expensive due to the large size and weight of the components. Today it continues to be unusual for a railroad to grant permission to load on its mainline especially where it must shut down operations in order to allow the loading to take place.

When the switch and small siding were in place, this may have been a good location for transloading one or two components at a time as loading conceivably could take place simultaneously while trains continued to move through the tunnel. The fact that the siding (even if reinstalled at considerable expense) would not be long enough to accommodate holding four cask cars, let alone the entire train, makes loading for this shipping campaign with this commodity more time consuming and more complicated. It will require additional equipment, personnel, and handling (switching) to execute the operations safely and within the regulations.

Figure 3-16: Track across bridge to the East of Hoosac Tunnel[51]

Today the mainline is operated by the PAS and the tunnel is part of an active rail system moving trains eastbound and westbound enabling interchange activities with three Class I carriers in New York and two Class I carriers in Massachusetts, Maine, and New Brunswick. There is a single track through the tunnel, approaching from both the eastern and western portals. A bridge lies approximately 800 feet south of the eastern portal entrance which has one remaining set of active tracks on it which are offset from the center of the bridge, as shown in **Figure 3-16**. The second set of tracks has been covered with wood for vehicle access by the railroad. There is double track 665 feet south of the bridge. There is a double track (operating tracks, not sidings) north of the tunnel at North Adams, MA.

Currently, there are overhead wires on poles surrounding the entrance to the landing area outside the eastern portal which affects ingress and egress to the track, as shown in **Figure 3-17**. The PAS reports trespassers are commonplace at the tunnel (See **Figure 3-18**) although they have attempted to deter entrance into the tunnel by adding doors.

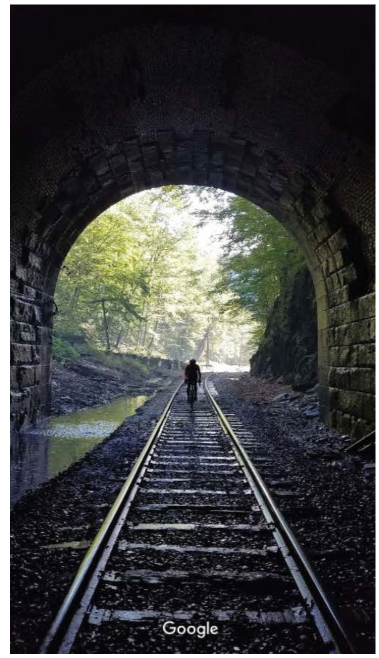
Figure 3-17: Overhead Obstacles Affecting Approach to Hoosac Tunnel

The PAS has confirmed the following:

- 8-10 trains travel through the tunnel daily.
- The prior siding was removed due to lack of use.

- The prior switch was removed.
- There is insufficient room at the prior siding location to install enough track to accommodate the train length needed for transloading four casks.
- There are no existing sidings in North Adams, MA or around the eastern portal that can be used to conduct the loading campaign. Only operating tracks are located at North Adams.
- Trespassers are commonplace here and the tunnel is considered a tourist attraction.
- Currently there are no railroad crews available to service the eastern portal track if used for conducting a loading operation.
- An additional rail crew and two locomotives will be required on-site during the transloading operation. The crew will perform the required switching at the beginning and end of each loading day, placing the empty cask car on the transload track and removing the loaded cask car from the transload track, replacing it into the rail secure area. The crew will then inspect and open the track for resumed train traffic. All additional costs will be paid by the shipper.
- In lieu of the operating scenario described in **Section 3.2.2**, if a car was loaded without the establishment of a rail secure area, the railroad will insist on running a special train to interchange with the Class I carrier. It will not allow the less-than-full train to be stored on railroad property to await the balance of the loaded cars. This complicates matters because the Class I carrier also will refuse to allow the loaded cars to be stored on railroad property; a supplemental rail secure area would thus be required on private railroad track in the interchange city. In this scenario, an additional security crew would be required at the private track and additional freight costs would be incurred for the duplicate movements.

Figure 3-18: Hoosac Tunnel Trespassers



At the time this report was written, the east portal of the Hoosac Tunnel was deemed an insufficient option for loading trains due to the fact the only viable place to load a train would be to use the private mainline track owned by PAR (operated by PAS). It would involve curtailing all rail traffic during the loading campaign. The original rail siding and switch was removed, and there is limited room to replace them. The cost to replace the switch and two rail spots would be prohibitive relative to the small number of casks to be shipped in this campaign, additional handling and cost would be required to switch and store the two loaded casks while loading the remaining train. Additional costs and time would be incurred to create duplicate "rail secure areas" for both the loading and staging sites to remain in compliance with safety and security regulations.

3.2.3. Exploring The Hoosac Tunnel Loading Options

The eastern portal of the Hoosac Tunnel is not the optimum transload location for this loading and shipping campaign, when compared to other sites. If, however, one wanted to load at the eastern portal of the Hoosac Tunnel, the following scenario would provide the best opportunity for concurrence by the railroad, as it would present a scenario where the transload of two cars could conceivably occur – even though to would require the railroad to halt all train movements through the area, it would limit these cessation periods to 12 hours at a time. This may still present a serious operating problem for the railroad as 8-10 trains move through the tunnel per day and stopping normal operations, even for 12 hours per day, may severely impact the traffic flow networks for four different Class I carriers and at least five Class II and Class III carriers and the associated customers who move rail traffic in and through the area.

Figure 3-19: Overview of Track Configuration and Layout from Transload Site to Rail Secure Area[6]

Key:

Blue track: transload track (single) at mouth of Hoosac Tunnel: 220'

Green track: railroad bridge track (single) south of the transload track

Purple track: 665' of single line track to reach double track

Red track: 700' of track for Rail Secure

<u>Establish Rail Secure Area for Staging Empty & Loaded Train:</u>

Rather than duplicating the transloading scenario of the RPV, it is suggested that the shipper lease 700 feet of track south of the railroad bridge (south of River Road) where a rail secure area would be established, as depicted in **Figure 3-19**. This would require fencing, lighting, and a permanent security detail to guard the staging area when loaded cask cars are present. The leased track is where double track is still in place and would allow the railroad to resume traffic through the tunnel once the transloading has stopped for the day.

Figure 3-20 presents an approximation of the required security perimeter around the rail secure area. It may not be possible to establish this security perimeter due to the close proximity of the double tracks to one another. Operating rules dictate that no temporary or permanent structure may be erected closer than 15' from the centerline of the track. At the widest point between the tracks, there only appears to be 15' with an average of 13'.

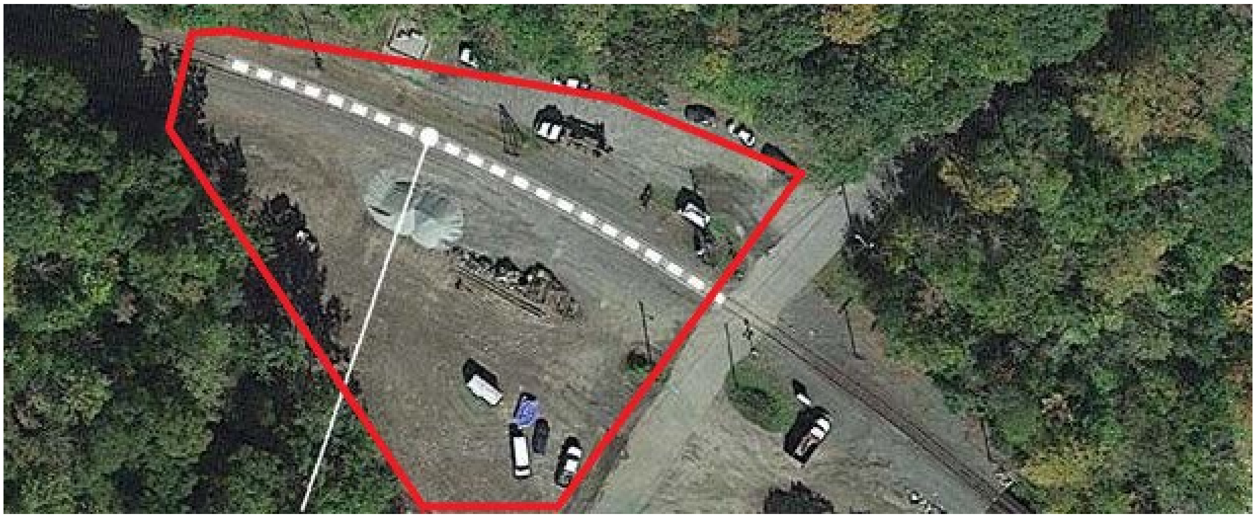
Figure 3-20: Representation of the Security Perimeter around the Rail Secure Area[6]

An additional operations factor is that the crossover allowing movement between one track to another is located another 1.69 miles south of the Rail Secure Area resulting in a fair amount of switching required for movement of one car. The four empty cask cars, one buffer car and security car would be staged south of River Road on the double track mainline, approximately 665 feet south of the bridge. Order for placement of the cars from the farthest southern point to the loading location would be buffer car one, security car, buffer car two, empty cask car one, empty cask car two, and empty cask car three, empty cask car four. This area of the double track will be enclosed with fencing and lighting to create a defined area for staging the empty train and for the subsequent placement of the loaded cask cars until all four cask cars are loaded and the train is ready to be released. This rail secure area would be in use for approximately 25 days.

Preparing Transload Site

The shipper would also lease approximately 220’ of track (and associated land) just outside the mouth of the Hoosac Tunnel, north of River Road, where the transload operation will take place; see **Figure 3-21**. It will be necessary to enclose the area with fencing for security during the transload operation and will involve excluding the tunnel entrance from the transload perimeter. This area will have to be reverted to its normal (non-secured) condition at the end of the loading and securing activities after each cask is loaded (at the end of the day). It will be re-erected prior to the next loading cycle. It cannot remain in place as 8-10 trains will need to travel over this track and through the tunnel.

Figure 3-21: Area to be Leased at the Mouth of Hoosac Tunnel



Operations Sequence

Just before the loading operation is to begin, the railroad locomotive will back into the rail secure area and connect to the first load car (cask car 4). It will pull the car from the fenced area, travel north over the bridge and place it north of River Road, approximately 220 feet from the intersection of the track and the road, on the single track mainline. The crane would move into place, parallel to the track, next to the staged empty cask car north of River Road. It will take approximately two hours to erect the crane; this could be completed while the first HHT carrying cask 1 is traveling from YR to the temporary rail transload facility. The fence will be erected to secure the transloading site.

The HHT would take approximately four hours to reach the rail transload area at River Road. The truck would cross the rail track and stop approximately 400 feet after crossing the track. It will back up to position itself parallel to the crane, as shown in **Figure 3-22**, taking roughly 30 minutes. The loading operation commences with the removal of the securement from the HHT and moving the cask and skid from the trailer onto the railcar. The HHT will pull away from the crane after the lift and align itself as required to make a left turn onto River Road in order to return to YR for reloading. The HHT will proceed along the road with the police and private escorts required in accordance with the issued road permits. It will take approximately four hours for the return trip.

Figure 3-22: HHT Positioning Path[6]

As the HHT leaves the transload site, the temporary fencing will be locked, securing the temporary rail transload area with the workers and loaded cask inside, until the securement activities have been completed. Once completed, the railroad crew will approach from the south, pass the staged cars on the right, cross the bridge, and connect with the loaded cask car. It will pull the loaded cask car south of the bridge using the single mainline track leading to the double track, bypassing the staged cars in the rail secure area crossing over to the eastern track entering the rail secure area from the south to push the loaded car into the storage track behind the buffer car, advancing the entire train forward by one car length. The perimeter will again be secured by locking the fence and initiating security procedures. This process will be repeated four times until the train is loaded, which is estimated to be 20 days (operations only). Each car will be handled twice before the train is ready to be released.

At the end of each load day, the transload crew will remove the fencing from the mouth of the tunnel and across the railroad track to allow ingress and egress along the track. PAS will resume moving trains through the tunnel bypassing the rail secure area. The security team will be on-site 24/7 to monitor the loaded cask cars and perform safety and security tasks as required in the permits and regulations.

Note: PAS will require an additional crew while loading operations are taking place. This crew and the associated locomotives will be on standby to perform the required switching once the cask and skid have been loaded and secured to the cask car. The crew will then pull the loaded cask from the loading site and place it at the back of the secure staged area and push all the cars forward by one car spot. All additional costs are to be paid by the shipper.

The loading configuration of the HHT will depend on the ability of the selected HHT equipment to negotiate the required backing-up procedure to place the HHT at the proper location for loading next to the crane. The HHT must be able to navigate the terrain of River Road and the ground conditions of the loading location as well as the overhead wires and other solid obstructions shown in **Figure 3-17,** to back up the 150-foot trailer into proper placement. This will allow vehicle traffic to continue to move on River Road during the loading operations.

Finally, **Table 3-4** provides a comparison of potential transload sites located at the East Portal of the Hoosac Tunnel and at Westfield. Although the HHT travel costs to the East Portal of the Hoosac Tunnel will be lower than to the Westfield site and the Hoosac Tunnel site has some historical backing to acting as a transload site for YR, the remainder of the criteria all require less resources and costs for the Westfield site than the East Portal of the Hoosac Tunnel site.

Table 3-4: Comparison of the East Portal Hoosac Tunnel and Westfield Transload Sites

Criteria	Westfield Site	Hoosac Tunnel Site
HHT Travel Time	4 hours	4 hours
HHT Travel Cost	$399,900 more than to Hoosac Tunnel	$399,900 less than to Westfield
Track Configuration for Loading Train Consist	Ideal	Constricted requiring double handling of each car
Dedicated Train Crew for Loading	Not Required	Required
Special Trains	Not Required	$9,000 x 4
Track Lease for Rail Secrure Area	Not Required	$96,000
Lease Track for Transload Site (220 feet)	Not Required	$35,200
Fencing	Existing	Must be added in two locations
Lighting	Existing	Must be added in two locations
Security	Existing	Must be added in two locations
Additional Costs for Duplicative Infrastructure at Transload Site	None	If required, $250,000 for a switch and $105,000 for installing two car spots
Additional Costs for Duplicative Switching and Secondary Crews at Loading Site	None	$12,800 (Switching) $36,000 (Crew)
Double handling	No	Yes, each car handled twice
Network impact on railroad train operations	No	Yes, with curtailment of 8 to10 trains per day
Historically a Transload Site used by YR	No	Yes

Requirements

The shipper must receive permission from the railroad to load at this location, lease the required track for conducting the transload (220'), lease the track for establishing a rail secure area for staging the train and provide continuing services to erect and remove the fencing at the mouth of the tunnel before and after each loading. The greatest hurdle may be the reluctance of the railroad to agree to stop all rail traffic during a specified amount of time. The campaign is anticipated to last 20 days, so the impact of holding trains for approximately 12 hours a day, every three days, will be a major factor for the operating railroad, as well as the other Class I, Class II, and Class III carriers whose traffic will be impacted by the stoppage. There may be associated costs for the train curtailment if approved. Finally, there simply may not be footage between the double track to erect the required fencing and lighting to isolate the rail secure area without impeding traffic moving on the second track parallel to the rail secure area. Generally, no obstruction is allowed to be constructed closer than 15' from the centerline of the track. There is between 13 and 15 feet between the double tracks at the widest point. The railroad will have to approve a variance allowing the fence to be erected at the rail secure area closer to the mainline track than rules allow, which will impact the ability of other dimensional traffic to travel past the rail secure area.

There is a good chance that the railroad may require the replacement of the switch and a two-car length siding in order to allow one to load at the mouth of the tunnel. Without the track lease for staging the cars in close proximity to the siding, the operation will be more cumbersome and expensive, so they need to be established concurrently. The PAR tariff states that no HAZMAT will be allowed to be stored on railroad property so that is a hurdle because the best track for establishing a rail secure area near the tunnel is south of the bridge.

3.3. Barge Loading Locations

The YR plant does not have direct water access. The site is located approximately 69 road miles from the closest water served facility where casks could be loaded onto barges or vessels for movement. The closest port is in Albany, NY and it has direct rail service via the Albany Port District Railroad. It is a switch carrier for CSX operating 23 miles of track and interchanging only with Class I carrier CSX in Albany, NY. The next closest port locations are Boston, MA at 129 miles and New Haven, CT at 131 miles from YR.

A HHT would be required for the first leg of any barge or vessel movement from the site.

3.4. Barge Unloading Locations

Barge unloading locations have been identified in other studies close to GCUS; however due to the fact that there is no direct barge access at or close to YR, no barge unloading sites were specifically considered for this campaign. In addition, the MUA screening of the HHT to barge options negated the need to present a barge unloading location for this movement.

3.5. Down-Selected Transportation Routes

Considering the large number of potential HHT transportation routes identified in the previous sections, a set of screening criteria was developed and applied to down-select a small group of options considered to be viable for further investigation. Since the YR site is only accessible by HHT, this down-select was based on comparing the HHT routes against one another and resulted in a reduced number of HHT routes to be evaluated by the MUA. The criteria utilized are as follows:

1. The time and/or distance to be traveled by the conveyance 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 overpack loading 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 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.[3]
11. Other.

Some of the potential transportation routes had unique characteristics that did not correlate with any of the 10 listed criteria above. These characteristics greatly reduced the viability of the transportation route; therefore, an 11th category, "Other", was included to the screening criteria so that the unique criterion could be captured.

The above criteria were applied to a number of potential routes, to screen them before they are assessed in the MUA process. After applying the above screening criteria (see **Table 3-5)**, a total of six possible routes were identified and are included for further evaluation in the MUA (**Section 5.0**):

1. HHT from YR ISFSI to Westfield, MA and then by rail to GCUS on PVRR and CSXT rail lines through Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-23** (i.e., referred to as "A. HHT/Rail: Transload in Westfield, MA" route in the MUA).

[3] 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, secure communication, HAZMAT bill of laden, safe-haven identification, emergency response planning, etc.

2. HHT from YR ISFSI to Deerfield Rail Yard in Deerfield, MA and then by rail to GCUS on PAS, PVRR and CSXT rail lines through Northampton, MA, Westfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-24** (i.e., referred to as “B. HHT/Rail: Transload in Deerfield, MA” route in the MUA).
3. HHT from YR ISFSI to Bellows Falls, VT and then by rail to GCUS on VTR, NECR, CSXT rail lines through Brattleboro, VT, Greenfield, MA, Springfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-25** (i.e., referred to as “C. HHT/Rail: Transload in Bellows Falls, VT” route in the MUA).
4. HHT from YR ISFSI to Bennington, VT and then by rail to GCUS on VTR, PAS, CPRS, and CSXT rail lines through Eagle Bridge, NY, Mechanicville, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-26** (i.e., referred to as “D. HHT/Rail: Transload in Bennington, VT” route in the MUA).
5. HHT from YR ISFSI to Shelburne Falls, MA and then by rail to GCUS on PAS, PVRR, and CSXT rail lines through Greenfield, MA, Springfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-27** (i.e., referred to as “E. HHT/Rail: Transload in Shelburne Falls, MA” route in the MUA).
6. HHT from YR ISFSI to Hoosac Tunnel West in North Adams, MA and then by rail to GCUS on PAS, CPRS, and CSXT rail lines through Eagle Bridge, NY, Mechanicville, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS as shown in **Figure 3-28** (i.e., referred to as “F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA” route in the MUA).

Table 3-5: Routes Versus Screening Criteria

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT to Hoosac Tunnel (East Portal) via Yankee Road, Depot Street, Readsboro Road, and River Road then rail to GCUS, multiple rail lines (PAS-CSXT-NS-CSXT-NS or PAS-PVRR-CSXT-NS-CSXT)			X	X		X		X			
HHT to Hoosac Tunnel (East Portal) via Yankee Road, Monroe Hill Road, Hazelton Road, Tunnel Road, and River Road then transload to rail to GCUS, multiple rail lines (PAS-CSXT-NS-CSXT-NS or PAS-PVRR-CSXT-NS-CSXT)			X			X		X			
HHT to Hoosac Tunnel (East Portal) via Readsboro Road and River Road then transload to rail to GCUS, multiple rail lines (PAS-CSXT-NS-CSXT-NS or PAS-PVRR-CSXT-NS-CSXT)						X		X			
HHT to Hoosac Tunnel (West Portal) via Readsboro Road, River Road, Whitcomb Hill Road, and Mohawk Trail to North Adams, MA then transload to rail to GCUS, multiple rail lines (PAS-CPRS-CSXT)											
HHT to Hoosac Tunnel (West Portal) via Readsboro Road, Kingsley Hill Road, Main Road, and Mohawk Trail to North Adams, MA then transload to rail to GCUS, multiple rail lines (PAS-CPRS-CSXT)											Essentially duplicate of previous route with potential tight turn on to Kingsley Hill Road

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT to Hoosac Tunnel (West Portal) via Old Railroad Grid, Harriman Station Drive, Main Street, River Road and Beaver Street to North Adams, MA then transload to rail to GCUS, multiple rail lines (PAS-CPRS-CSXT)	X										
HHT to transload sites West of North Adams, MA	X	X	X	X	X	X	X	X			
HHT to Bellows Falls, VT via VT-9 and I-91 then transload to rail at 46 Steamtown Road to GCUS, multiple rail lines (VTR-NECR-CSXT)											
HHT to Bellows Falls, VT via MA-2 and I-91 then transload to rail at 46 Steamtown Road to GCUS, multiple rail lines (VTR-NECR-CSXT or VTR-NECR-CSXT-NS-CSXT)	X							X			
HHT to Bellows Falls, VT via VT-100 then transload to rail at 46 Steamtown Road to GCUS, multiple rail lines (VTR-NECR-CSXT or VTR-NECR-CSXT-NS-CSXT)	X							X			
HHT to transload sites North of Bellows Falls, VT	X	X	X		X	X	X	X			
HHT to Bennington, VT via VT-9 then transload to rail at 206 Harwood Hill Road to GCUS, multiple rail lines (VTR-PAS-CPRS-CSXT)											
HHT to Bennington, VT via US-7 then transload to rail at 206 Harwood Hill Road to GCUS, multiple rail lines (VTR-PAS-CPRS-CSXT)	X										

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT to Shelburne Falls, MA via MA-8A and MA-2 then transload to rail at 14 Depot Street to GCUS, multiple rail lines (PAS-PVRR-CSXT)											
HHT to Shelburne Falls, MA via MA-8A and MA-2 then transload to rail at 14 Depot Street to GCUS, multiple rail lines (PAS-PVRR-CSXT or PAS-PVRR-CSXT- NS-CSXT)			X								
HHT to Shelburne Falls, MA via MA-2 then transload to rail at 14 Depot Street to GCUS, multiple rail lines (PAS-PVRR-CSXT or PAS- PVRR-CSXT-NS-CSXT)		X	X					X			
HHT to Shelburne Falls, MA via Avery Brook Road and MA-2 then transload to rail at 14 Depot Street to GCUS, multiple rail lines (PAS-PVRR-CSXT or PAS-PVRR-CSXT-NS-CSXT)	X							X			
HHT to Deerfield, MA via Monroe Hill Road and MA-2 then transload to rail at East Deerfield Yard to GCUS, multiple rail lines (PAS-PVRR-CSXT or PAS-PVRR-CSXT-NS-CSXT)		X	X					X			
HHT to Deerfield, MA via MA-2 and MA-116 then transload to rail at East Deerfield Yard to GCUS, multiple rail lines (PAS-PVRR-CSXT or PAS-PVRR-CSXT-NS-CSXT)	X	X	X					X			
HHT to Deerfield, MA via VT-100 then transload to rail at East Deerfield Yard to GCUS, multiple rail lines (PAS-PVRR-CSXT)											

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT to transload sites East of Deerfield, MA	X	X		X	X	X	X	X	X		
HHT to Westfield, MA via MA-2 and I-91 then transload to rail at 100 Springdale Road to GCUS, multiple rail lines (PVRR-CSXT or PVRR-CSXT-NS-CSXT)		X	X					X			
HHT to Westfield, MA via I-91 then transload to rail at 100 Springdale Road to GCUS, multiple rail lines (PVRR-CSXT)											
HHT to transload sites South of Westfield, MA	X	X	X	X	X	X	X	X	X		
Rail Only from YR Site						X					Placement of rail tracks from the site to the nearest Class I is prohibitively expensive.
Barge from YR Site	X					X	X				No practical barge off-loading locations.
HHT Only from YR Site	X										Not desireable.

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 will be significantly in excess
2. Clearance limits on routes
3. Sustained travel on routes with steep grades
4. Bridge(s)/overpass(s) weight limitation
5. Natural features make overpack loading 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 Shipments

Figure 3-23: HHT to 100 Springdale Road, Westfield, MA then Transload to Rail

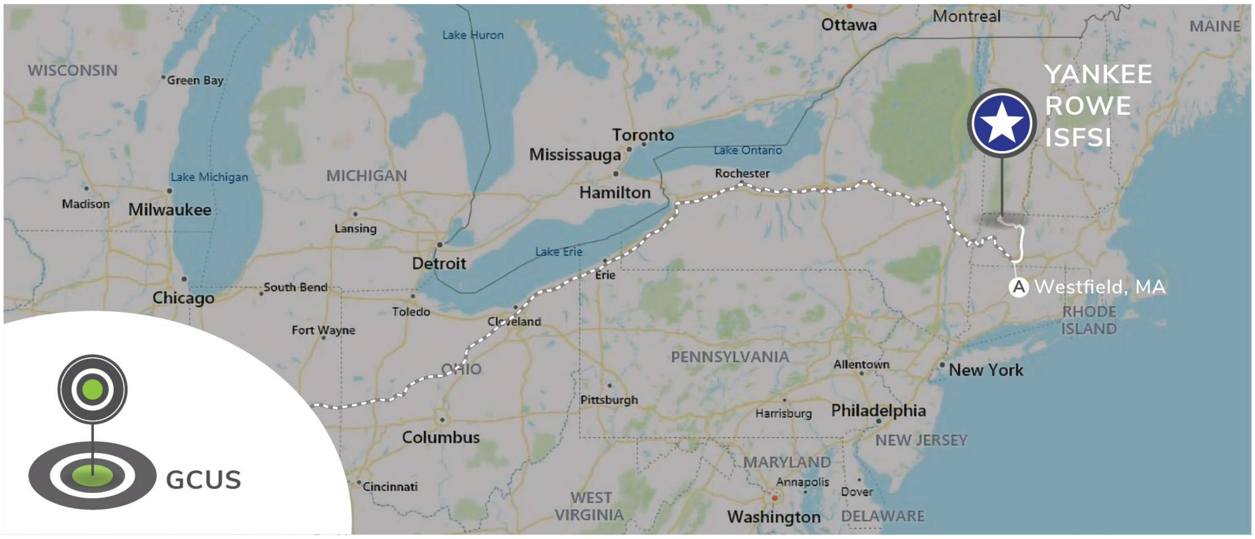


Figure 3-24: HHT to East Deerfield Yard in Deerfield, MA then Transload to Rail

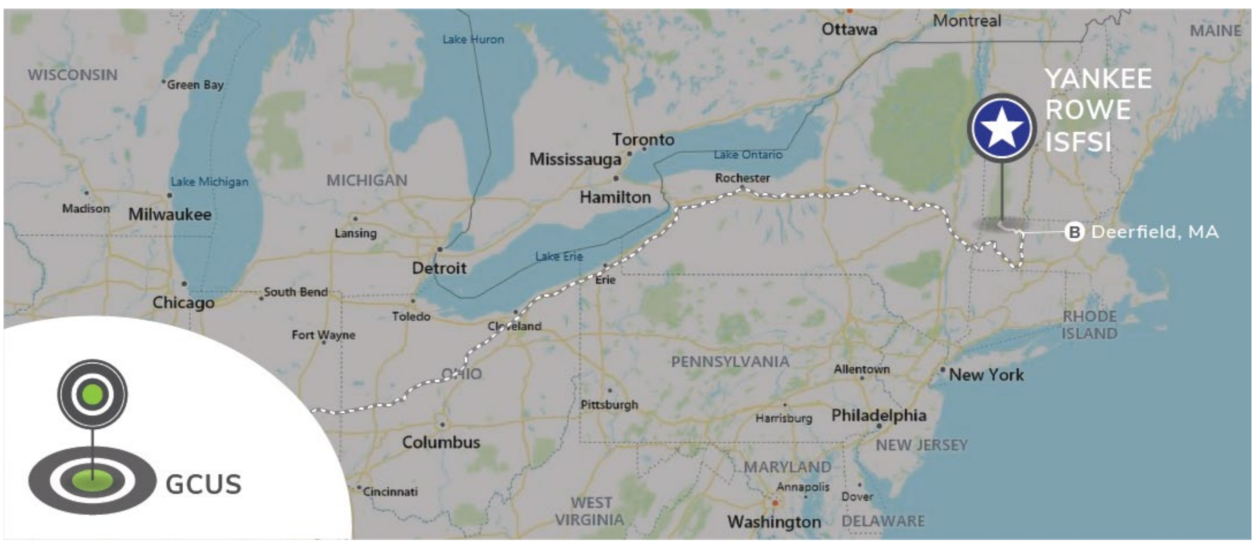


Figure 3-25: HHT to 46 Steamtown Road, Bellows Falls, then Transload to Rail

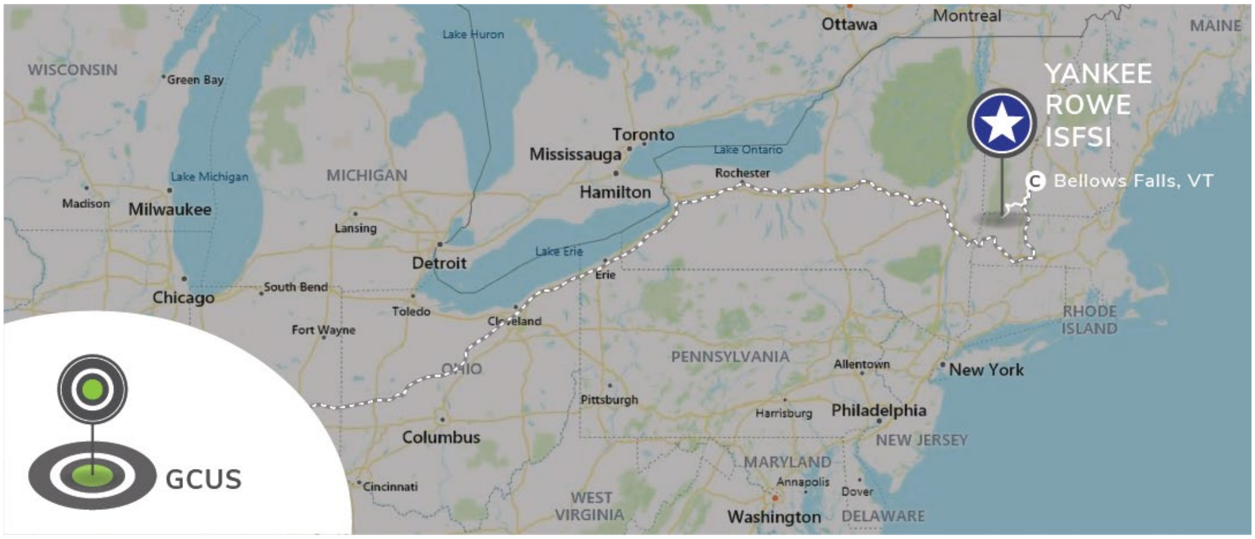


Figure 3-26: HHT to 206 Harwood Hill Road, Bennington, VT then Transload to Rail

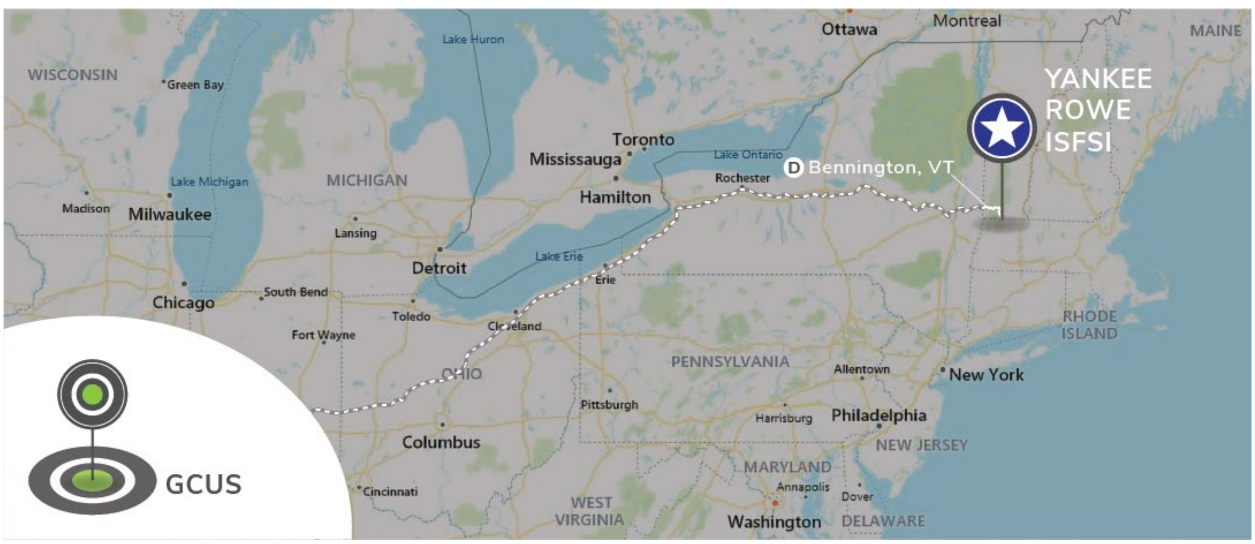


Figure 3-27: HHT to 14 Depot Street, Shelburne Falls, MA then Transload to Rail

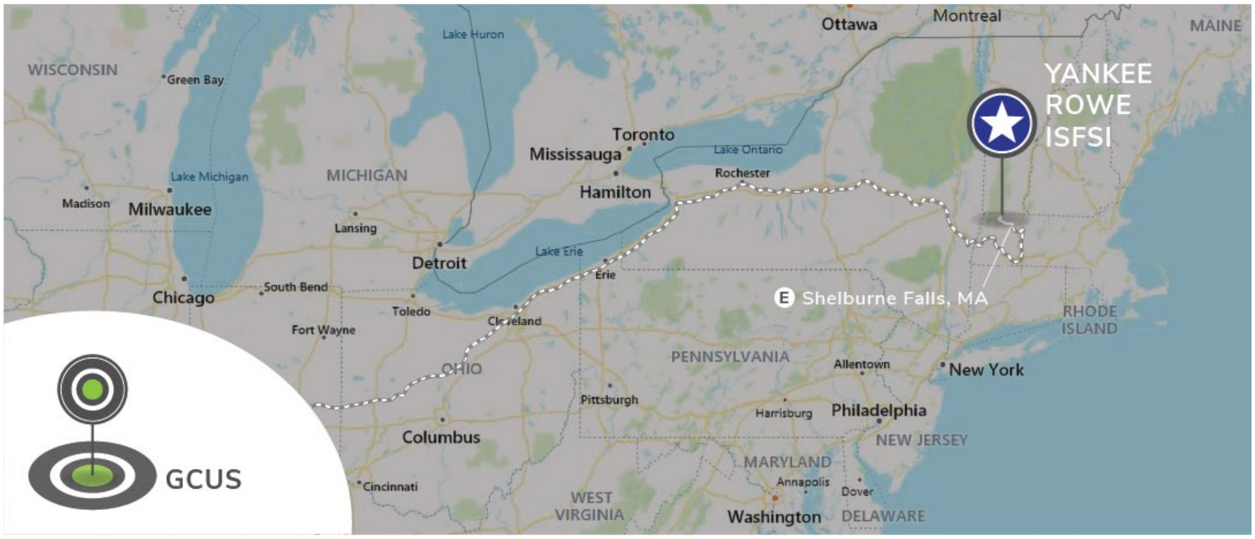
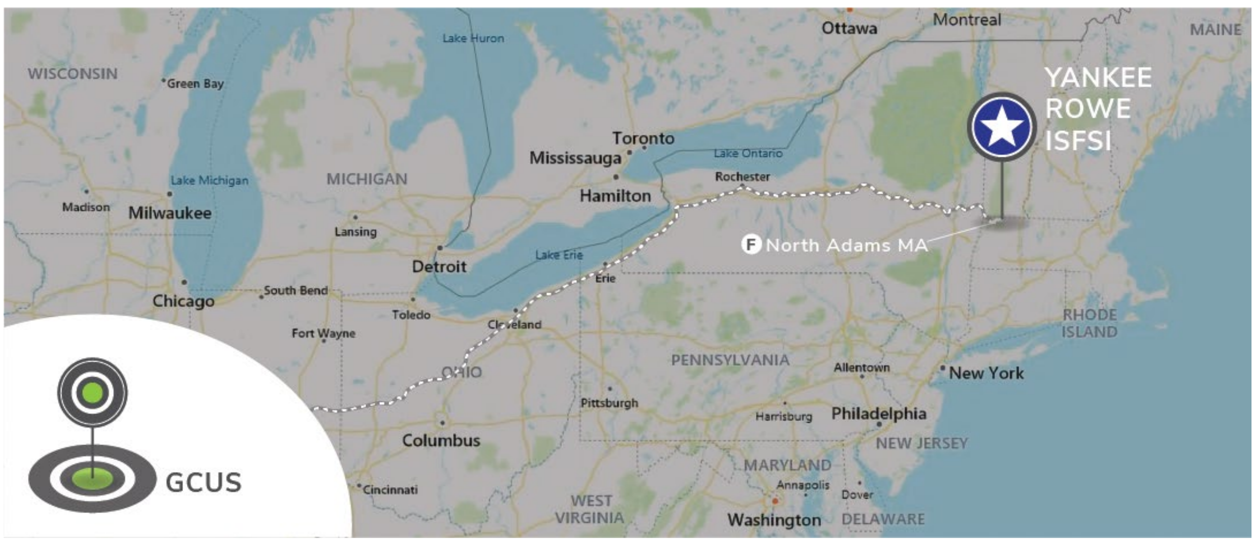


Figure 3-28: HHT to Hoosac Tunnel (West Portal) via North Adams, MA then Transload to Rail



4.0 PARTICIPATING ENTITIES

This section identifies participating entities/persons this report assumed would be involved in the overall de-inventory implementation for the YR ISFSI and summarizes some aspects of their potential roles. By providing this information, which is current as of the date of this report but can be out of date with new events (e.g., elections), 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 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,[4] 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.[5] 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. 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.[6]

---

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

[5] 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. 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. 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.

[6] Although this report assumes that DOE would be the responsible entity for a 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.

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

- Utility employees;
- Subcontractors: crane suppliers, riggers, etc.;
- Transportation personnel: truck operator, rail carrier, barge transportation operator, private escorts for dimensional loads, State Police or 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 as required by 10 CFR 73.37, 10 CFR 71.97, and as recommended in NUREG-0561 Revision 2[26];
- TRANSCOM or similar satellite and associated continuous in-transit communication service provider(s); and
- Transportation emergency responders.

The participating entities/persons can be categorized into the functional groups identified in **Table 4-1**. Please note that an evaluation of tribal entities that might be impacted during de-inventory operations was performed. None were identified within the transportation routes analyzed for the report.

Table 4-1: Participating Entity Functional Identification

Function Group	Entity/Persons
Site	Site Management
	Safety
	Quality
	Document Control
	Security
	Craft support
	Support functions

Function Group	Entity/Persons
Transportation	Transportation Supervision
	Equipment Operator (driver)
	Security
	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)
	NRC
	DOT
	Pipeline and Hazardous Materials Safety Administration (PHMSA)

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) As specified in paragraphs (b), (c), and (d), each licensee shall provide advance notification to the governor of a State, or the governor's designee, of the shipment of licensed material through 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.
>
> (b) Advance notification is required under this section for shipments of irradiated reactor fuel in quantities less than that subject to advance notification requirements of § 73.37(f) of this chapter.
>
> (c) (1) The notification must be made in writing to the office of each appropriate governor or governor's designee and to the Director, Division of Security Policy, Office of Nuclear Security and Incident Response."

Similarly, NRC regulations in 10 CFR 73.37 and guidance in NUREG-0561 address the provision of advance notification of shipments to States and Tribes as well as other aspects of shipment coordination and communication with participating entities. Therefore, notification of governing authorities is required to coordinate transport in an actual de-inventory campaign. For transport of radioactive material[26], the government agencies listed in **Table 4-1** ("Authorities") issue regulations concerning the packaging and transport of radioactive materials.

Listed below is contact information for some of the relevant state (Massachusetts) government 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.

Massachusetts - Office of the Governor

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

Massachusetts Governor Charlie Baker
Massachusetts State House, 24 Beacon St.
Office of the Governor, Room 280
Boston, MA 02133
Telephone: (617) 725-4005
https://www.mass.gov/person/charlie-baker-governor

Massachusetts Emergency Management Agency (MEMA)

Listed below is the contact information for the Massachusetts Emergency Management Agency

Dawn Brantley, Acting Director
Massachusetts Emergency Management Agency
400 Worcester Road, Framingham, MA 01702
Telephone: (508) 820-2010
Email: dawn.brantley@state.ma.us

Massachusetts Department of Transportation (MASSDOT)

Listed below is the contact information for the Massachusetts DOT.

Jamey Tesler (Secretary)
Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116
Telephone: (857) 368-4636
https://www.mass.gov/forms/contact-massdot

The Oversize-Overweight Permits Unit issues permits for oversize/overweight loads to travel on state and federal highways. For more information, contact:
Highway Division (MASSDOT)
Jonathan Gulliver - Highway Administrator
10 Park Plaza, Boston, MA 02116
All departments (857) 368-4636
Highway Call Center (857) 368-3500

Massachusets – Individuals to Receive Advance Notification of Radioactive Material and Nuclear Material Shipments (Part 37, 71, 73)

Listed below is the contact information for the Governor's designee for individuals to receive advance notification of radioactive material and nuclear material shipments.

Dawn Brantley, Acting Director
Massachusetts Emergency Management Agency
400 Worcester Road Framingham, MA 01702
Phone: (508) 820-2010
24-hour phone: (508) 820-2000
Fax: (508) 820-2030
Telephone: (617) 590-3360

Alternate(s):
Pat Carnevale, Deputy Director
Massachusetts Emergency Management Agency
400 Worcester Road Framingham, MA 01702
Phone: (508) 820-2056
24-hour phone: (508) 820-2000
Fax: (508) 820-2030
Telephone: (508) 988-0915

Site Management Provider

ISFSI Manager Bryan Lovin
Telephone: (413) 424-5261 extension 303
Email: blovin@3yankees.com.
http://www.yankeerowe.com

Heavy-Haul Transportation Service Providers

Barnhart Crane & Rigging

25 Mill Street
Middletown, CT 06457
DiVincenzo, Dave
Telephone: (860)740-6627
www.barnhartcrane.com

Railroad Transportation Contacts

PVRR
Operations Contact: Pete Petree
407-880-8500
P.O. Box 967
Plymouth, FL 32768

For local Massachusetts contact: Chelsea Derouchey
170 Lockhouse Road
Westfield, MA 01085
Telephone: (413) 355-6848 / (206) 546-7200

Cask Supplier

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

NAC International
http://www.nacintl.com/
NAC Atlanta Corporate Headquarters
3930 East Jones Bridge Road
Peachtree Corners, Georgia 30092
Tel 770-447-1144
Fax 770-447-1797

There are no federally recognized tribes that would require notification.

5.0 MULTI-ATTRIBUTE UTILITY ANALYSIS

As noted in **Section 3.0**, there are several potential routes for shipping the NAC STCs from the YR ISFSI to a railcar on a Class I railroad that can take the NAC STCs to their penultimate or ultimate destination (e.g., a consolidated interim storage site or a repository, respectively). Each of these routes require HHT shipment from the ISFSI, as there are no direct rail or barge routes from the ISFSI. However, 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 (i.e., attributes). The MUA provides a transparent, rational, and defensible analysis that is easy to explain and 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 those objectives. Utility theory is a systematic approach for quantifying an individual's or team of individuals' ratings/preferences (note: when "preference" is used together with "route" there is a specific connotation not intended to be covered in this analysis, thus "rating," "ranking," or "priority" will be used in its stead when associated with a route). 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 decision makers' preferences.

The MUA has been selected as the assessment approach for purposes of this report to evaluate the viable HHT routes (options) for moving the NAC STCs containing SNF and GTCC LLW from the YR ISFSI. In this section, an MUA using a value model, which identifies preferences of attributes, relative importance of meeting an attribute, and/or tradeoffs between attributes, will be used to establish a prioritized list of HHT routes from the YR ISFSI.

5.1. Description of MUA Applied to the YR ISFSI

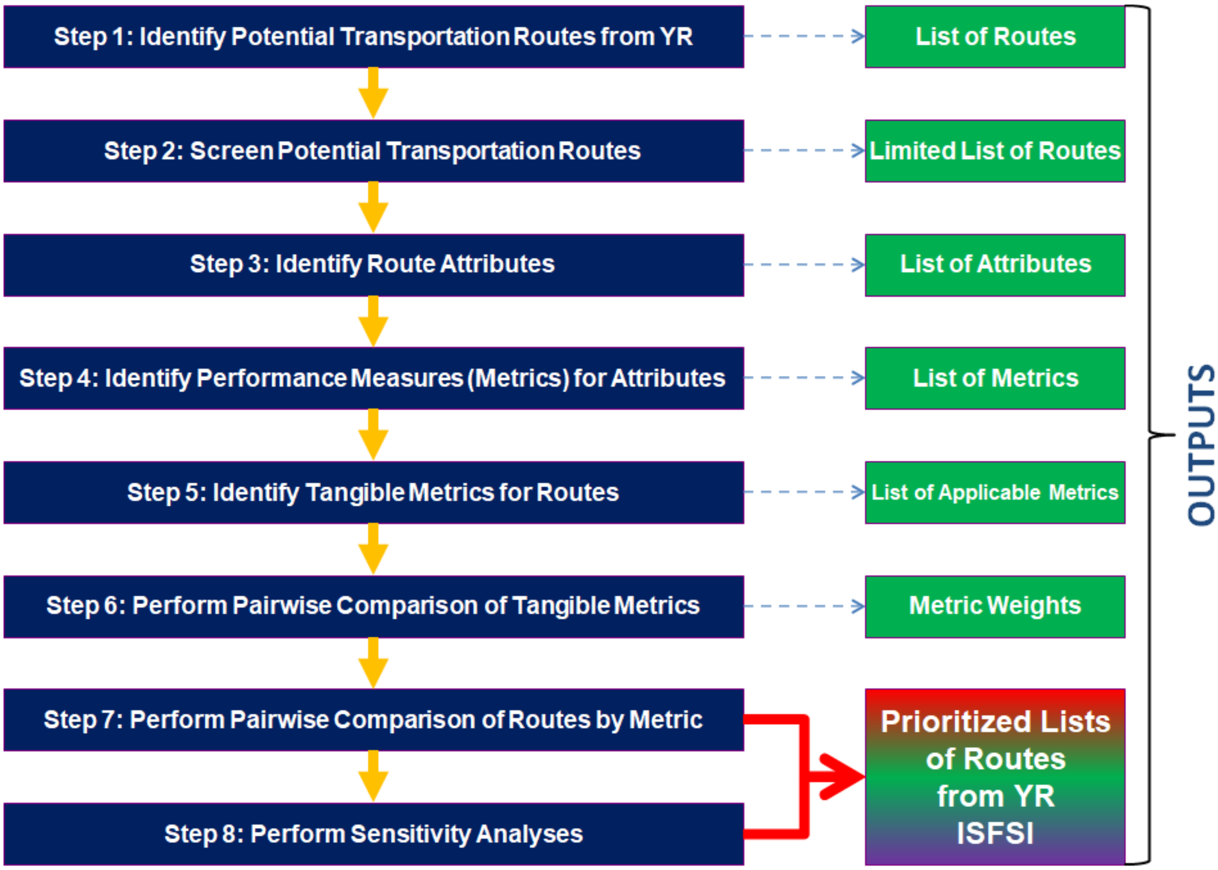
MUA is a straightforward concept. The three primary steps typically followed to frame the analysis are: (1) identify a set of objectives/attributes that an 'ideal' option will achieve; (2) define a set of performance measures (i.e., metrics) that provide a clear definition of each objective/attribute; and (3) identify or define alternative options that should be considered. Once alternative options (routes and modes, if available), objectives (attributes), and performance measures (metrics) have been clearly defined, the preferences 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 between the performance measures for each route against one another. 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 YR ISFSI are identified in **Figure 5-1** and were performed as follows:

1) Identified the potential modes and routes for transporting the NAC STCs from the YR ISFSI (see **Section 3.0**).
2) Due to the larger number of potential routes identified in Step 1 from the YR ISFSI, a set of screening criteria was developed 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) Identified the general attributes associated with the routes and the activity of shipping the NAC STCs from the YR ISFSI; see **Section 5.3.1**.
4) For each identified attribute, identified 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, examined each attribute's metrics and identified the ones that could tangibly differ between two or more of these modes and routes; see **Section 5.3.1**.
6) Each team member performed a pairwise comparison between each of the tangible metrics, which was subsequently quantified and resulted in a relative ranking of the metrics based on individual ratings and were 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 collective team performed another pairwise comparison between the tangible metrics for each route (to ensure the SMEs' preferences were incorporated and not diluted by the ratings of other individuals), and the results were 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 were 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 **Section 5.5**.

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

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



5.2. Description of Evaluated Routes

As noted in **Section 3.0**, there are numerous possible HHT routes from the YR ISFSI (Step 1). The general sequences of the transportation operations for these routes fall into the following category: transport by HHT directly to an existing rail transload facility (HHT to rail) or establish a private transload facility.

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 to reduce the HHT routes to the six routes identified in **Section 3.5**[7]:

1) The time and/or distance to be traveled by the conveyance 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 overpack loading 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 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 3-5**. The routes unscreened and remaining to be evaluated by the MUA are as follows:

A. HHT from YR ISFSI to Westfield, MA and then by rail to GCUS on PVRR and CSXT rail lines through Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “A. HHT/Rail: Transload in Westfield, MA” route in the MUA).
B. HHT from YR ISFSI to Deerfield Rail Yard in Deerfield, MA and then by rail to GCUS on PAS, PVRR and CSXT rail lines through Northampton, MA, Westfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “B. HHT/Rail: Transload in Deerfield, MA” route in the MUA).

[7] Several of these screening criteria use the term “significant.” This term is frequently justified through a relative comparison between identified routes (e.g., one route may be identified as requiring a single bridge to be upgraded, whereas another route may require several bridges to be upgraded). In a few cases, the opinions of the SMEs were used to screen a route using this term or not to screen a route based on, for example, historical experiences.

C. HHT from YR ISFSI to Bellows Falls, VT and then by rail to GCUS on VTR, NECR, CSXT rail lines through Brattleboro, VT, Greenfield, MA, Springfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “C. HHT/Rail: Transload in Bellows Falls, VT” route in the MUA).

D. HHT from YR ISFSI to Bennington, VT and then by rail to GCUS on VTR, PAS, CPRS, and CSXT rail lines through Eagle Bridge, NY, Mechanicville, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “D. HHT/Rail: Transload in Bennington, VT” route in the MUA).

E. HHT from YR ISFSI to Shelburne Falls, MA and then by rail to GCUS on PAS, PVRR, and CSXT rail lines through Greenfield, MA, Springfield, MA, Pittsfield, MA, Canaan, NY, Chatham, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “E. HHT/Rail: Transload in Shelburne Falls, MA” route in the MUA).

F. HHT from YR ISFSI to Hoosac Tunnel West in North Adams, MA and then by rail to GCUS on PAS, CPRS, and CSXT rail lines through Pownal, VT, Eagle Bridge, NY, Mechanicville, NY, Schenectady, NY, Utica, NY, Syracuse, NY, Rochester, NY, Buffalo, NY, Erie, PA, Cleveland, OH, Sidney, OH, Indianapolis, IN, Terre Haute, IN, Effingham, IL, ending on rail at GCUS (i.e., referred to as “F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA” route in the MUA).

5.3. Evaluation of Routes

To evaluate each of these six 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 six 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 changes to the weighting of the metrics had on the route hierarchy.

5.3.1. Identification of Attributes and Metrics

The attributes identified that can characterize the ‘ideal’ route are identified 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 [27][28][29][30][31][32] , and also based on the large body of past MUA activities having been performed on nuclear waste management evaluations.[33][34][35][36]

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 subject matter 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 six 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 13 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[8]	On-Site Rental Equipment Costs (e.g., mobile cranes)	N	Since all routes were by HHT, no differences for on-site rental equipment costs were expected.
	Hardware Procurement Costs (e.g., transfer cask)	N	Hardware is expected to be relatively the same for all the HHT routes.
	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	N	No improvements are expected to be necessary for any of the HHT routes as all the routes are expected to sufficient infrastructure to ensure acceptable off-loading capabilities.
	Labor and Permitting Costs	Y	Labor and permitting costs are expected to vary slightly by route due to the distance the HHT has to travel, resulting primarily in higher permitting costs and to a lesser extent higher labor costs.
	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	Y	All routes are by HHT and a small difference in the trailer rental costs may occur especially for the longer routes.
	Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)	Y	Rail routes take different length routes and will have different numbers of interchanges.

[8] 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
	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 (hairpin/switchback curves).
	Impact of Weather to Route (e.g., limited availability of route or instability of weather)	N	Local weather phenomena are expected to impact shipments from YR all the same way.
	Number of Water Areas Nearby Route (e.g., number of bridges crossed)	Y	According to START[1] the mileage over water shows some differences.
	Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)	Y	START[1] identifies some distinguishable differences for number of environmentally sensitive areas traversed between the evaluated routes.
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 significant differences between the number of these mass gathering places along the routes.
	Number of Tribal Lands Crossed	N	Based on results from START[1], the routes showed very little 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 our experts opinions and will consider nearby features of the routes.
Permitting	Ease of Permit Procurement	N	Since all the routes are by HHT, the permit pulling is expected to be essentially the same for each route.

Attribute	Metric	Y/N	Comments
	Number of Permits	Y	Number of permits for each HHT route are dependent on the length of the route and the number of States crossed by the route.
	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	Hardware is expected to be the same for all routes.
	Availability of Specialty Equipment (e.g., rigging, transfer cask)	N	Speciality equipment such as a transfer cask, rigging, and a heavy haul truck (goldhofer) will be required for each route.
Safety	Cumulative Worker Exposure (α handling time & number of workers)	N	All HHT routes are expected to result in approximately the same cumulative worker exposure.
	Cumulative Population Dose along Route (α population density)	Y	According to START[1], the population exposed along a route may vary significantly between various routes (noting all exposures will meet regulatory limits and be neglibibly small).
	Risks Associated with Number of Lifting Activities	N	Number of lifting activities will be the same for each of the HHT routes.
	Average Accident Frequency on Route	Y	According to START[1], the average accident frequency along a route may vary significantly 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 evaluated routes.
	Duration for Infrastructure Improvement (e.g., including dredging, fixing rail line)	N	No significant infrastructure improvements are expected on any of these routes.

Attribute	Metric	Y/N	Comments
	Ease of Access to Transload Site (e.g., consider usage of existing site)	Y	Some of the transload sites from HHT to rail are much better prepared for making the transloads than other sites.
	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)	N	Each of these routes is by HHT and hence the size of the conveyance will be the same for each route.
Security/ Vulnerability	Security Vulnerability of Route	N	Each HHT route is considered to have the same security vulnerability (no barge and no on-site rail 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 HHT 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 between these metrics was performed by each of the 12 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 12 individuals of the Orano-led team to ensure a reasonable cross-section of preference 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 "Cost of Rail Transport" metric (e.g., the perceived favorability of the route due to its rail costs relative to the rail costs for other routes) is pairwise compared against the other metrics on a favorability scale. For example, the "Cost of Rail Transport" metric is rated mildly favorable against the "Number of Sensitive Environmental Areas Nearby Route" and is rated more unfavorable against "Public Acceptability of Route." These ratings are interpreted to mean that there is a mild benefit seen to selecting a route with a larger number of sensitive environmental areas nearby the route, since these areas are not impacted by these shipments, if it results in cheaper rail transport costs to the destination. However, if there were an improvement (decrease) in the cost to transport that resulted in decreased public acceptability, then this will be a more unfavored/discouraged outcome (e.g., transloading at a site that results in reduced costs of rail transport due to decreased distance to the destination site but may be in a more populated area and is not as acceptable to the public relative to an alternative transload site that results in increased rail travel distances and hence increased rail transport costs but in a less populated area, the site further from the destination would be favored by this evaluation that uses only two metrics).

With 13 tangible metrics to be evaluated, 78 pairwise evaluations had to be performed by each individual. **Attachment A** shows the entire pairwise evaluation for these metrics. Note, 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 (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).
- 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 twelve 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).

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

   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).

$$\bar{B}_m = \left\{\frac{\sum_{p=1}^{P}\left(\sum_{i=1}^{7} N_{m,p}^{i}\, W_i\right)}{P}\right\} \Big/ \sum_{m=1}^{M}\left\{\frac{\sum_{p=1}^{P}\left(\sum_{i=1}^{7} N_{m,p}^{i}\, W_i\right)}{P}\right\}$$

where B = averaged biased relative weight.

4) The "Maximum" value as established from the 12 individual assessments.

Results from all 12 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 preferences (based on average weighting method) are Cumulative Population Dose, Public Acceptability, and Average Accident Frequency, which rated at about 10.3%, 9.3%, and 9.0% of the total weight, respectively. The tangible metrics with the least preferences (based on average weighting method) are Number of Water Areas Nearby Route, Labor and Permitting Costs, and Number of Sensitive Environmental Areas nearby Route which rated at about 6.28%, 6.31%, and 6.53% of the total weight, respectively. The preferences/ranking and weights of all the tangible metrics in descending order (based on average weighting method) are shown in **Table 5-3**.

These results also show negligible differences between the average weighting method and the biased weighting method, which indicates a fairly uniform assessment by the 12 individuals. However, at the extremities of the individual assessments (i.e., the minimum and maximum values), there are some significant findings including:

- The Ease of Access to Transload Site metric, which ranked 4th overall, was ranked highest overall by an individual at 14.1% (as clearly seen in **Figure 5-2**) indicating a wide range of importance levels for this metric between the individual evaluators. This metric also was ranked fairly low by another individual at 6.3% giving it the largest range between maximum and minimum.
- The Public Acceptability metric, which ranked 2nd overall, had the second highest favorable ranking by an individual at 13.0%, but was also ranked fairly low by another individual at 6.4% (having the one of the highest ranges between the minimum and maximum).
- Overall, the safety metrics ranked at or near the top in preference for everyone's assessment.
- The metric with the least difference between minimum and maximum values was the Route Environment Characteristics metric, which ranked near the middle of importance of all the metrics and hence, showed a fairly robust rating.

Finally, the minimum and maximum values listed in **Table 5-3** provide ranges of values to be used in the sensitivity analyses performed in **Section 5.5**.

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
Cost of Rail Transport		X						Route Environment Characteristics
Cost of Rail Transport							X	Number of Water Areas Nearby Route
Cost of Rail Transport							X	Number of Sensitive Environmental Areas Nearby Route
Cost of Rail Transport					X			Number of Non-Easily-Mobilizable Populations
Cost of Rail Transport							X	Public Acceptability of Route
Cost of Rail Transport						X		Number of Permits
Cost of Rail Transport			X					Cumulative Population Dose along Route
Cost of Rail Transport							X	Average Accident Frequency on Route
Cost of Rail Transport					X			Transit Duration per Conveyance and Consist
Cost of Rail Transport				X				Ease of Access to Transload Site

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

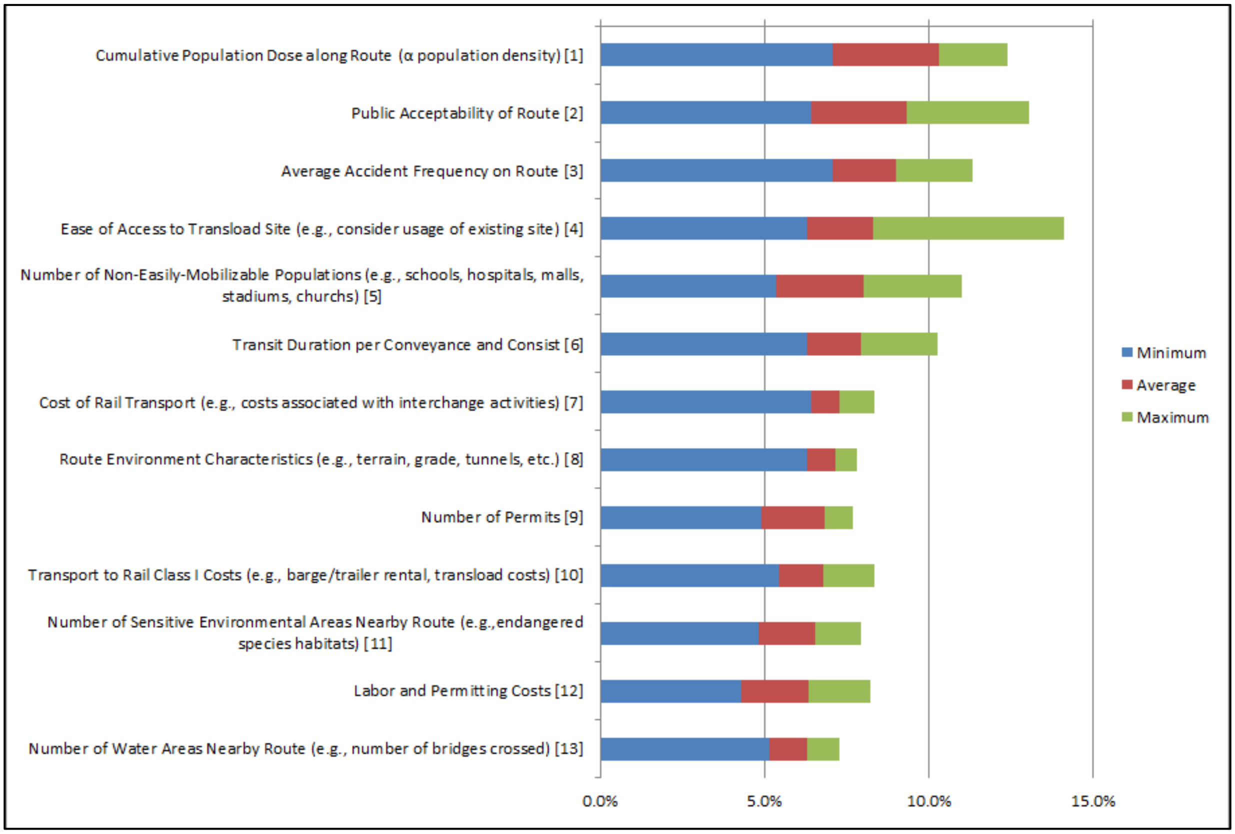


Table 5-3: Weighting of Tangible Metrics

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
1	7.1%	10.31%	10.31%	12.4%	Cumulative Population Dose
2	6.4%	9.31%	9.31%	13.0%	Public Acceptability
3	7.1%	8.99%	8.99%	11.3%	Average Accident Frequency
4	6.3%	8.28%	8.28%	14.1%	Ease of Access to Transload Site
5	5.3%	8.00%	8.00%	11.0%	Number of Non-Easily-Mobilizable Populations
6	6.3%	7.94%	7.94%	10.3%	Transit Duration per Conveyance and Consist
7	6.4%	7.28%	7.28%	8.3%	Cost of Rail Transport

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
8	6.3%	7.16%	7.16%	7.8%	Route Environment Characteristics
9	4.9%	6.83%	6.83%	7.7%	Number of Permits
10	5.4%	6.78%	6.78%	8.3%	Transport to Rail Class I Costs
11	4.8%	6.53%	6.53%	7.9%	Number of Sensitive Environmental Areas Nearby Route
12	4.3%	6.31%	6.31%	8.2%	Labor and Permitting Costs
13	5.1%	6.28%	6.28%	7.3%	Number of Water Areas Nearby Route

5.3.3. Route Assessments

With the ranking/preference 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 preference was afforded greater influence than were the preferences of the other individuals on the team if there was a difference.

An alternative approach would have been 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 preferences can be established, and this will lend itself to ensuring a fairly consistent basis in the selection of the preferences (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/preliminary 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/preliminary data used to perform this comparison by metric is provided here.

5.3.3.1. Labor and Permitting Costs

For the labor and permitting costs, the longer HHT routes are expected to have higher costs relative to the shorter HHT routes for two primary reasons: (1) the longer routes would likely require more permits as they travel through more jurisdictions and hence would have higher permitting costs associated with them and (2) labor costs for the longer routes are expected to be marginally higher due to the longer travel time. In addition, HHT routes that cross state borders would also incur higher permitting costs and depending on state hand-off requirements may marginally increase the transit time and hence, labor costs. Otherwise HHT labor costs are expected to be the same for each of the HHT routes with loading and unloading activities essentially being identical.

5.3.3.2. Transport to Rail Class I Costs

For the transport to rail costs (not including on-site costs), each of the six HHT 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: (1) an 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. Since the crane rental cost is approximately the same for each HHT route, only mild differences were identified between some of the routes for this metric and these differences were attributed to the rental durations associated with the different length routes.

5.3.3.3. Cost of Rail Transport

For the cost of rail transport, the rail portion of each of the routes was evaluated based on distance traveled and, in this case, more importantly the number of rail carriers involved. For route A (HHT/Rail: Transload in Westfield, MA), only one short line rail carrier would be involved in moving the casks to GCUS. For routes B (HHT/Rail: Transload in Deerfield, MA), C (HHT/Rail: Transload in Bellows Falls, VT), and E (HHT/Rail: Transload in Shelburne Falls, MA), two short line rail carriers would be involved in moving the casks to GCUS. For route D (HHT/Rail: Transload in Bennington, VT), two short line rail carriers and one additional carrier would be involved in moving the casks to GCUS. For route F (HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA), one short line rail carrier and one additional carrier would be involved in moving the casks to GCUS.

5.3.3.4. Route Environmental Characteristics

Each of the HHT routes analyzed in this MUA are challenged by the curvature of the county roads found around the YR site. All the routes were identified by the team to be essentially of similar difficulty to traverse (similar characteristics) with the exception of one hair-pin turn identified on the route from the YR ISFSI to the Hoosac Tunnel West in North Adams, MA. So, this route was identified to be mildly unfavorable relative to the other routes. In addition to the curvature of the roads, each of the routes was identified by the START program[1] to have to traverse through 5 or 6 tunnels, which were all deemed to pose no issue to the transport of the casks to the GCUS.

5.3.3.5. Number of Water Areas Nearby Route

Using data produced from the START program[1], each route could be evaluated for the number of water crossings the route traverses. Based on these results (see **Attachment D**), the number of water crossings ranged from 168 to 220. Route E has the least number of water crossings (168 crossings) followed by Route D (175 crossings), Route A (204 crossings), Route E (206 crossings), Route B (207 crossings), and Route C (220 crossings). Since the number of crossings is similar between each of these routes, only mild differences were identified in the pairwise comparison by the team.

5.3.3.6. Number of Sensitive Environmental Areas Nearby Route

Using data produced from the START program[1], each route could be evaluated for the number of sensitive environmental areas nearby the route per square mile. Based on these results (see **Attachment D**), the number of sensitive environmental areas ranged from 6.28 to 11.81 per square mile. Route A has the least number of sensitive environmental areas (6.28/mi^2) followed by Route B (7.07/mi^2), Route E (7.17/mi^2), Route C (8.37/mi^2), Route D (11.37/mi^2), and Route F (11.81/mi^2). Since the number of sensitive environmental areas is similar between each of these routes, only mild differences were identified in the pairwise comparison by the team.

5.3.3.7. Number of Non-Easily-Mobilizable Populations

Using data produced from the START program[1], each route could be evaluated for the number of non-easily-mobilizable populations (mass gathering places, educational institutions, and special age groups [day care and nursing homes]), 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 Route F (1,114), followed by Route D (1,128), Route A (1,170), Route E (1,229), Route B (1,233), and Route C (1,286). Since the number of non-easily-mobilized populations is similar between each of these routes, only mild differences were identified in the pairwise comparison by the team.

5.3.3.8. Public Acceptability of Route

The public acceptability of the five HHT to rail routes to be evaluated varied between each of the routes based on a conglomeration of the following factors: the perception of the acceptability of the HHT to rail transload site (e.g., a transload site at an armory was deemed to be more attractive than one near a public park); the perception of moving SNF into another state for transload would likely not be well received by the other state; the proximity of activities to tourist attractions (e.g., the Bennington ski resort); and the view of the public would be to minimize the duration of the transit of the SNF. Based on these factors, the routes with transload sites in Vermont (Routes C & D) rated poorly against the other routes. Route A rated favorably over all the other routes, as its transload site appears to be at an armory that is fenced and guarded already. Route B rated favorably over all the other routes, except Route A, as its transload site is fairly distant from any public spaces and any homes. Routes E and F rated similarly, though Route F was slightly favored over Route E due to public proximity to the transload site. Finally, Routes C and D also rated similarly, but below Routes E and F primarily because Routes C and D have transload sites in Vermont whereas E and F remained in Massachusetts and route C was slightly favored over Route D due to Route D's transload site's proximity to the Bennington ski resort.

5.3.3.9. Number of Permits

As noted in **Section 5.3.3.1**, the HHT portion of the routes would require permits for each jurisdiction the HHT traverses through, as well as an additional permit if a State border is crossed by the HHT. Hence, the greater the distance the HHT travels on each of these routes, the greater the number of permits are expected to be required and if the HHT portion of the route crosses into another State then additional permits are expected to be required. No permits are required for the rail portion of these routes.

5.3.3.10. 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 transportation casks 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 preferences 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 5-4**. Those routes with the lowest total exposed populations are favored over the other routes.

Table 5-4: Route Averaged Population Density Along Each Route

ID	Route Description	Average Population Density (Persons/Square Mile)[1]	Total Exposed Population Estimate[2] (Thousands)
A	HHT/Rail: Transload in Westfield, MA	826	560
B	HHT/Rail: Transload in Deerfield, MA	853	572
C	HHT/Rail: Transload in Bellows Falls, VT	822	596
D	HHT/Rail: Transload in Bennington, VT	872	532
E	HHT/Rail: Transload in Shelburne Falls, MA	849	572
F	HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	877	537

[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.

[2] Established by multiplying the cumulative population density by the route distance and the buffer width (1,600 m).

5.3.3.11. 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 5-5**), 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 5-5** provides the cumulative accident rate for the entire route, which was used to perform this evaluation.

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

Accident Rate (per mi/yr)	Route					
	A. HHT/Rail Westfield, MA	B. HHT/Rail Deerfield, MA	C. HHT/Rail Bellows Falls, VT	D. HHT/Rail Bennington, VT	E. HHT/Rail Shelburne Falls, MA	F. HHT/Rail Hoosac Tunnel West in North Adams, MA
Average Accident Rate	0.018	0.010	0.013	0.008	0.009	0.008
Factor Increase Over Lowest Rate	2.25 x	1.25 x	1.625 x	1 x	1.125 x	1 x

5.3.3.12. Transit Duration per Conveyance and Consist

Since each of the routes from YR involved first HHT conveyance to a transload site where the cask is then transloaded to rail consist and subsequent shipped to GCUS, all loading and transload activities are essentially the same for each of the routes and the only differences in the total duration are expected to be due to the transit duration of the HHT and rail portions of the route. START[1] provides an estimate of the distances traveled by each conveyance in a route and the total transit time for the route. **Table 5-6** provides a breakdown by route.

Table 5-6: Route Transit Durations[1]

Distance (miles)	Route					
	A. HHT/Rail Westfield, MA	B. HHT/Rail Deerfield, MA	C. HHT/Rail Bellows Falls, VT	D. HHT/Rail Bennington, VT	E. HHT/Rail Shelburne Falls, MA	F. HHT/Rail Hoosac Tunnel West in North Adams, MA
HHT	68	32	62	30	21	18
Barge	0	0	0	0	0	0
Rail	1,084	1,123	1,190	1,025	1,139	1,038
Total Duration (hrs)	32	33	35	31	33	30

Note: all transit times are based on START results that assume travel at posted speed limits and on one, one-way trip. In reality, the HHT cask shipments would be able to traverse this route to Westfield, MA in less than one day. The anticipated average speed of travel would be 10 mph and perhaps higher due to the interstate portions of the movement with total transport time being 6-8 hours. The values shown above do not account for the multiple trips that would be required by HHT to and from the site.

Using the data in **Table 5-6** from START[1] the pairwise comparisons were performed between the various routes. Since the total duration is similar between each of these routes, only mild differences were identified in the pairwise comparison by the team.

5.3.3.13. Ease of Access to Transload Site

For the ease of access to the transload site metric, each HHT to rail transload site was evaluated for its current ability to host the transload activity, considering the following characteristics: the ease of access for the HHT and the rail cars to the site, the presence of the needed infrastructure (e.g., security fencing, crane access to the rail line), and the ability to handle and load a full rail consist). Considering these characteristics, the Route A transload site in Westfield, MA was deemed to be the easiest of the evaluated transload sites to load a rail consist because it is easily accessible by HHT and rail (though owner negotiations would have to be performed for access), has a security fence, has ample crane and HHT maneuvering (flat) space, has ample rail line to load a full consist of 5 casks, sufficient lighting, full-time security guards, and has access to a rail line with available transit slots. The transload site in Bellows Falls, VT for Route C also has many of these features (but no security fence) and was deemed to be the second easiest of the evaluated transload sites to load a rail consist. The transload site in Deerfield, MA for Route B is a small rail yard that was deemed to be the third easiest of the evaluated transload sites to load a rail consist with many of the positives of the previous two sites, but no security fence and because the rails are fairly close to one another it was deemed to be more challenging to load a full consist at this site as only a few of the tracks would have sufficient room to accommodate a crane and room for a HHT. The remaining transload sites rated as follows (from easier to harder): Route E at Shelburne Falls, MA; Route F at Hoosac Tunnel West in North Adams, MA; and Route D at Bennington, VT. Each of these last three transload sites provide an additional challenge to securing the site, loading a full consist, and/or providing easy access to the site and hence, rated lower during the evaluation.

5.4. Route Recommendations

Using the metric information identified for the routes listed in the previous section, the Orano-led team held conference calls 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' preferences 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 and metric.

Figure 5-3 provides an example of the pairwise comparison performed by the de-inventory team for the metric related to the Cumulative Population Dose along Route (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 Cumulative Population Dose along Route 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 second row of the evaluation (excluding the header row) shows that the A. HHT/Rail: Transload in Westfield, MA route is mildly favorable when compared to the C. HHT/Rail: Transload in Bellows Falls, VT route for the metric related to the Cumulative Population Dose along Route, which is reflective of the information provided in **Section 5.3.3.10**.

With 13 tangible metrics and 6 routes to be evaluated, the team performed 195 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** and **Figure 5-4** shows the resulting relative weighting of the routes in order of the highest rated (A. HHT/Rail: Transload in Westfield, MA) to the least rated (C. HHT/Rail: Transload in Bellows Falls, VT). **Table 5-8** 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 5-2**.
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 5-2**.

Figure 5-3: 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
Cumulative Population Dose along Route (α population density)	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

As shown in **Figure 5-4** and **Table 5-7**, the routes with the highest ratings (based on average weighting method) are: route A. HHT/Rail: Transload in Westfield, MA, and route F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA. The route with the least favored rating (based on average weighting method) is route C. HHT/Rail: Transload in Bellows Falls, VT. The top route is favored by just 1% or more over the other five routes, indicating the preference of this route over the others is not overwhelming. The route at the bottom of the list is separated by just over 1% from the one above it, indicating the preference against this route is not overwhelming.

Figure 5-4: Resulting List of Prioritized Routes From YR ISFSI Site

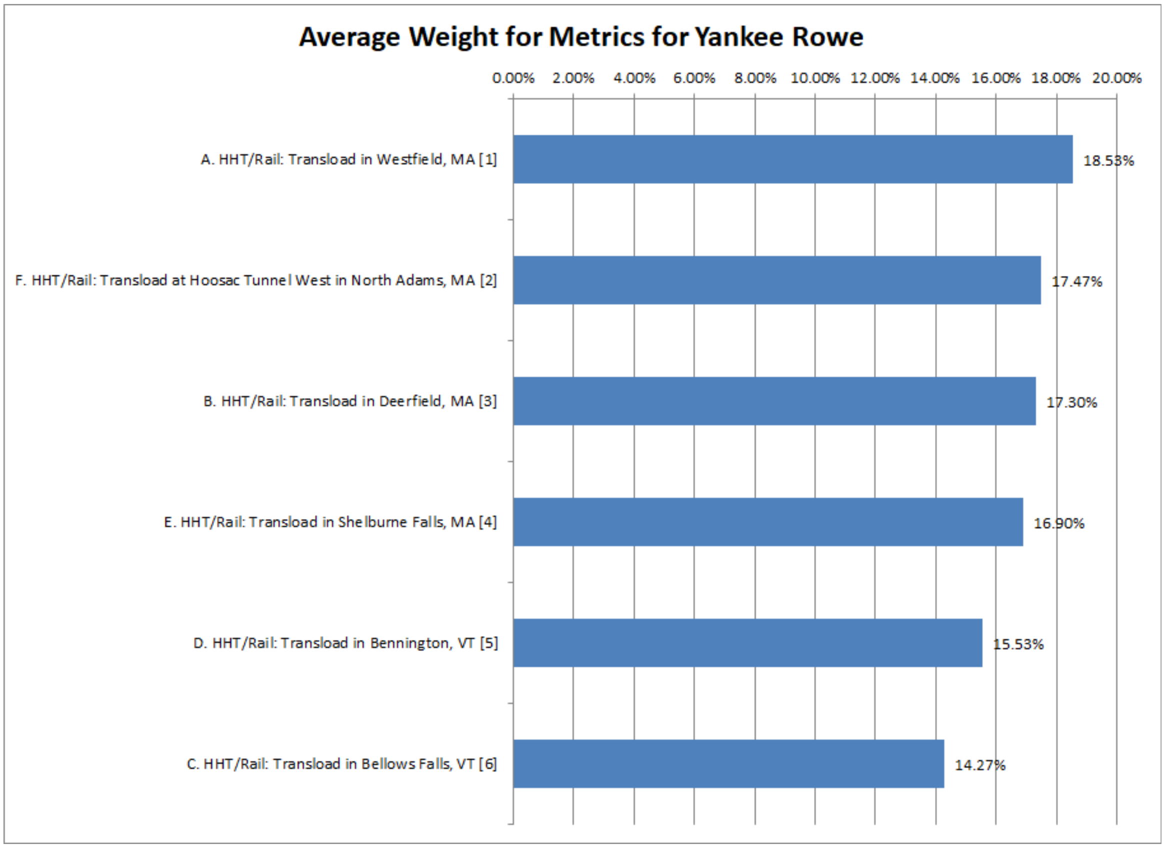


Figure 5-5 shows the impact each tangible metric had on the overall scoring of each route. There is no single dominant metric identified in this figure. However, this figure does show the most favored route received significantly greater contribution from the cost of rail transport metric, the public acceptability of route metric and the ease of access to transload site metric relative to the next favored route. Whereas the second ranked route received significant contributions from the following tangible metrics relative to the next favored routes: cumulative population dose along route, average accident frequency along route, and transit duration per conveyance and consist.

Since the safety metrics will be established by regulation to be acceptable, these metrics 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 5-8**, the route order changes when these metrics are removed from the assessment, except at the top of the ranking. Similarly, the removal of only the public acceptability metric also results in changes to the order of the routes, except for the top two routes. The removal of the public acceptability and safety metrics also results in changes to the order of the routes, except again at the top of the ranking. Additional analyses and sensitivity results were performed on these metrics to examine their impact on the rankings in **Section 5.5**.

Table 5-8 shows the sensitivity of the rankings 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 5-9**, **Table 5-10**, and **Table 5-11** 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 "Transit Duration per Conveyance and Consist" in **Table 5-11**, results are presented using a weight of 6.30% for the "Transit Duration per Conveyance and Consist" (instead of the 7.94% in **Table 5-3**) with the other metrics proportionally re-normalized. The results again indicate no change to the ranking of the routes. **Figure 5-6** summarizes the minimum, average, and maximum results presented in **Table 5-9**, **Table 5-10**, and **Table 5-11**, for the minimization of individual metrics. As can be seen from these results, Route A remains robustly ranked as the most favored route for the removal of the SNF from the YR ISFSI (at this time).

Table 5-12, **Table 5-13**, and **Table 5-14** 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 5-13**, results are presented using a weight of 13.0% for the "Public Acceptability of Route" (instead of the 9.31%), with the other metrics proportionally re-normalized. The results indicate that there is no change in the ranking of the routes. **Figure 5-7** summarizes the minimum, average, and maximum results presented in **Table 5-12**, **Table 5-13**, and **Table 5-14** for the maximization of individual metrics. As can be seen from these results, the order of the routes remains robustly the same for the removal of the SNF from the YR ISFSI, except for the Ease of Access to Transload Site which has the 2nd and 3rd ranked routes flip positions.

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 all but one individual who switched the 2nd and 3rd ranked routes, the ranked order of the routes remains the same, with Route A as the most favored route for the removal of the SNF from the YR ISFSI.

As a result of the MUA and its sensitivity analyses, the prioritized list of routes from the YR ISFSI is found in **Table 5-7**.

Table 5-7: Prioritized List of Routes from YR ISFSI

Rank	Prioritized Route
1	A. HHT/Rail: Transload in Westfield, MA
2	F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
3	B. HHT/Rail: Transload in Deerfield, MA
4	E. HHT/Rail: Transload in Shelburne Falls, MA
5	D. HHT/Rail: Transload in Bennington, VT
6	C. HHT/Rail: Transload in Bellows Falls, VT

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

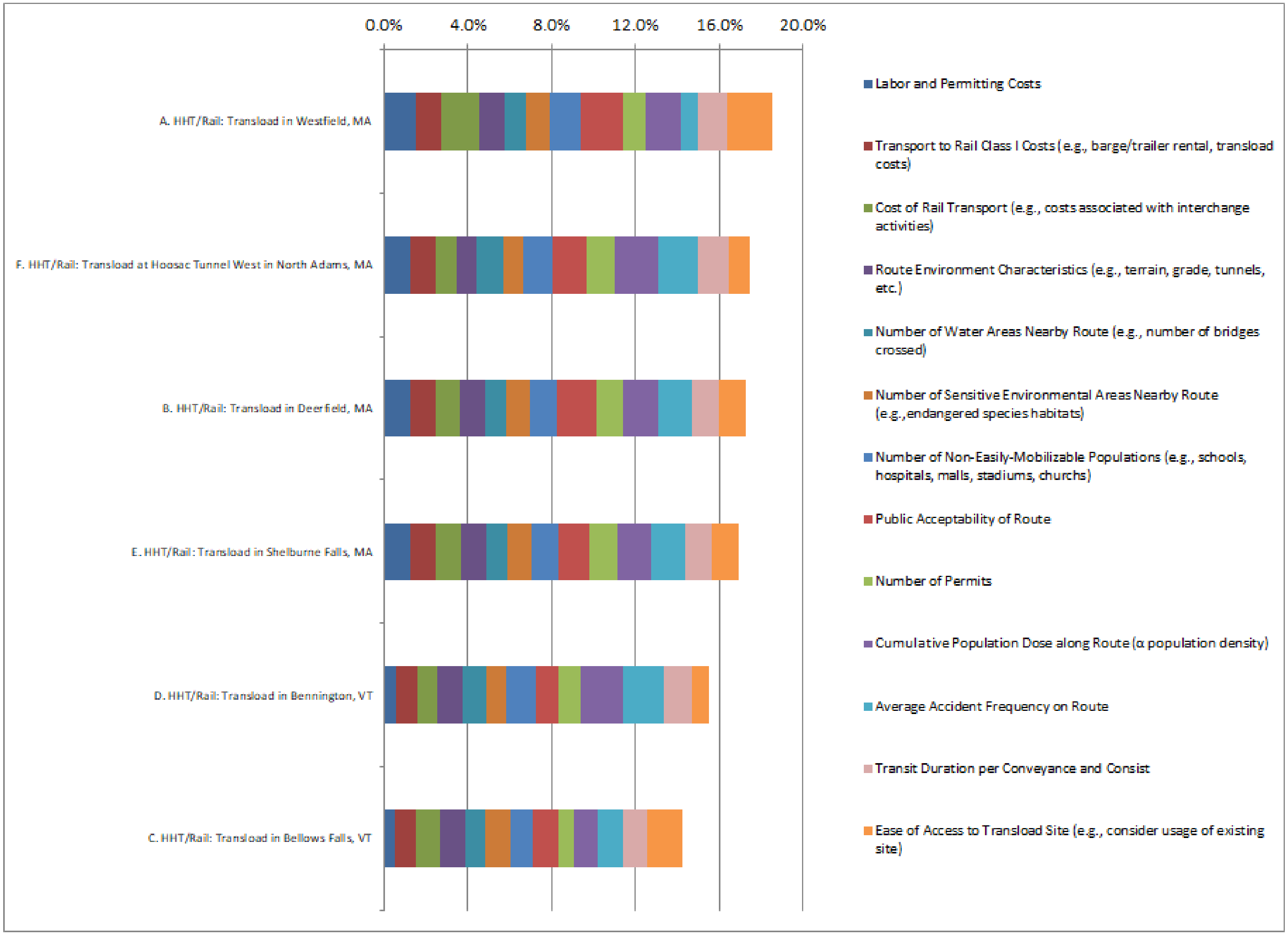


Table 5-8: Weighting of Routes

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. HHT/Rail: Transload in Westfield, MA	1	18.63%	1	18.53%	1	18.53%	1	19.85%	1	18.21%	1	19.61%
B. HHT/Rail: Transload in Deerfield, MA	3	17.31%	3	17.30%	3	17.30%	2	17.40%	4	16.96%	3	16.98%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.32%	6	14.27%	6	14.27%	5	14.77%	6	14.43%	5	15.03%
D. HHT/Rail: Transload in Bennington, VT	5	15.34%	5	15.53%	5	15.53%	6	14.34%	5	15.93%	6	14.69%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	17.01%	4	16.90%	4	16.90%	3	16.91%	3	16.99%	2	17.01%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.39%	2	17.47%	2	17.47%	4	16.74%	2	17.49%	4	16.67%

Table 5-9: Weighting of Routes at Minimum Metric Value (Part 1 of 3)

Metric Minimized:	Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Route Environmental Characteristics		Number of Water Areas Nearby Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. HHT/Rail: Transload in Westfield, MA	1	18.42%	1	18.54%	1	18.47%	1	18.54%	1	18.56%
B. HHT/Rail: Transload in Deerfield, MA	3	17.25%	3	17.29%	3	17.31%	3	17.30%	3	17.32%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.40%	6	14.27%	6	14.26%	6	14.25%	6	14.26%
D. HHT/Rail: Transload in Bennington, VT	5	15.66%	5	15.55%	5	15.55%	5	15.52%	5	15.50%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.85%	4	16.89%	4	16.91%	4	16.90%	4	16.91%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.42%	2	17.46%	2	17.50%	2	17.50%	2	17.44%

Table 5-10: Weighting of Routes at Minimum Metric Value (Part 2 of 3)

Metric Minimized:	Number of Sensitive Environmental Areas Nearby Route		Number of Non-Easily-Mobilizable Populations		Public Acceptability of Route		Number of Permits		Cumulative Population Dose along Route	
Route	Rank	Result	Rank	Result	Rank	Rank	Result	Rank	Result	Rank
A. HHT/Rail: Transload in Westfield, MA	1	18.54%	1	18.53%	1	18.43%	1	18.57%	1	18.61%
B. HHT/Rail: Transload in Deerfield, MA	3	17.29%	3	17.34%	3	17.20%	3	17.27%	3	17.34%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.21%	6	14.28%	6	14.32%	6	14.35%	6	14.36%
D. HHT/Rail: Transload in Bennington, VT	5	15.55%	5	15.45%	5	15.65%	5	15.54%	5	15.38%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.89%	4	16.94%	4	16.93%	4	16.85%	4	16.93%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.52%	2	17.44%	2	17.47%	2	17.42%	2	17.38%

Table 5-11: Weighting of Routes at Minimum Metric Value (Part 3 of 3)

Metric Minimized:	Average Accident Frequency on Route		Transit Duration per Conveyance and Consist		Ease of Access to Transload Site	
Route	Rank	Result	Rank	Result	Rank	Rank
A. HHT/Rail: Transload in Westfield, MA	1	18.71%	1	18.55%	1	18.37%
B. HHT/Rail: Transload in Deerfield, MA	3	17.29%	3	17.32%	3	17.32%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.30%	6	14.26%	6	14.15%
D. HHT/Rail: Transload in Bennington, VT	5	15.42%	5	15.50%	5	15.64%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.89%	4	16.92%	4	16.94%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.39%	2	17.45%	2	17.57%

Table 5-12: Weighting of Routes at Maximized Metric Value (Part 1 of 3)

Metric Minimized:	Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Route Environmental Characteristics		Number of Water Areas Nearby Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. HHT/Rail: Transload in Westfield, MA	1	18.63%	1	18.52%	1	18.60%	1	18.52%	1	18.50%
B. HHT/Rail: Transload in Deerfield, MA	3	17.34%	3	17.30%	3	17.28%	3	17.30%	3	17.28%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.16%	6	14.28%	6	14.29%	6	14.29%	6	14.29%
D. HHT/Rail: Transload in Bennington, VT	5	15.42%	5	15.51%	5	15.50%	5	15.54%	5	15.55%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.95%	4	16.92%	4	16.90%	4	16.91%	4	16.90%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.50%	2	17.47%	2	17.43%	2	17.44%	2	17.49%

Table 5-13: Weighting of Routes at Maximized Metric Value (Part 2 of 3)

Metric Minimized:	Number of Sensitive Environmental Areas Nearby Route		Number of Non-Easily-Mobilizable Populations		Public Acceptability of Route		Number of Permits		Cumulative Population Dose along Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. HHT/Rail: Transload in Westfield, MA	1	18.52%	1	18.52%	1	18.64%	1	18.51%	1	18.48%
B. HHT/Rail: Transload in Deerfield, MA	3	17.30%	3	17.25%	3	17.41%	3	17.31%	3	17.27%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.32%	6	14.26%	6	14.22%	6	14.24%	6	14.22%
D. HHT/Rail: Transload in Bennington, VT	5	15.52%	5	15.61%	5	15.39%	5	15.53%	5	15.62%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.92%	4	16.87%	4	16.88%	4	16.93%	4	16.89%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.42%	2	17.49%	2	17.46%	2	17.49%	2	17.52%

Table 5-14: Weighting of Routes at Maximized Metric Value (Part 3 of 3)

Metric Minimized:	Average Accident Frequency on Route		Transit Duration per Conveyance and Consist		Ease of Access to Transload Site	
Route	Rank	Result	Rank	Result	Rank	Result
A. HHT/Rail: Transload in Westfield, MA	1	18.32%	1	18.50%	1	18.94%
B. HHT/Rail: Transload in Deerfield, MA	3	17.31%	3	17.27%	2	17.23%
C. HHT/Rail: Transload in Bellows Falls, VT	6	14.24%	6	14.29%	6	14.62%
D. HHT/Rail: Transload in Bennington, VT	5	15.66%	5	15.57%	5	15.23%
E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.92%	4	16.89%	4	16.80%
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.55%	2	17.49%	3	17.18%

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

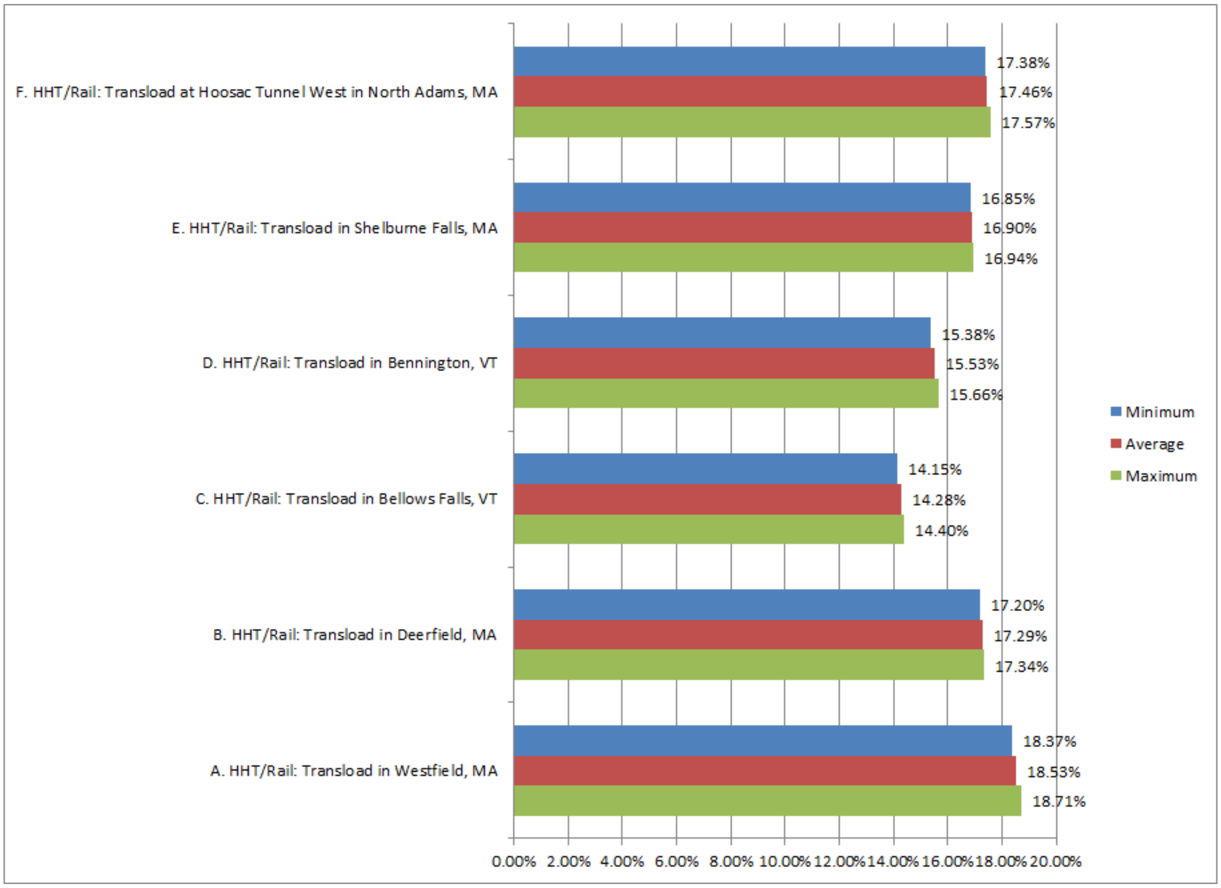
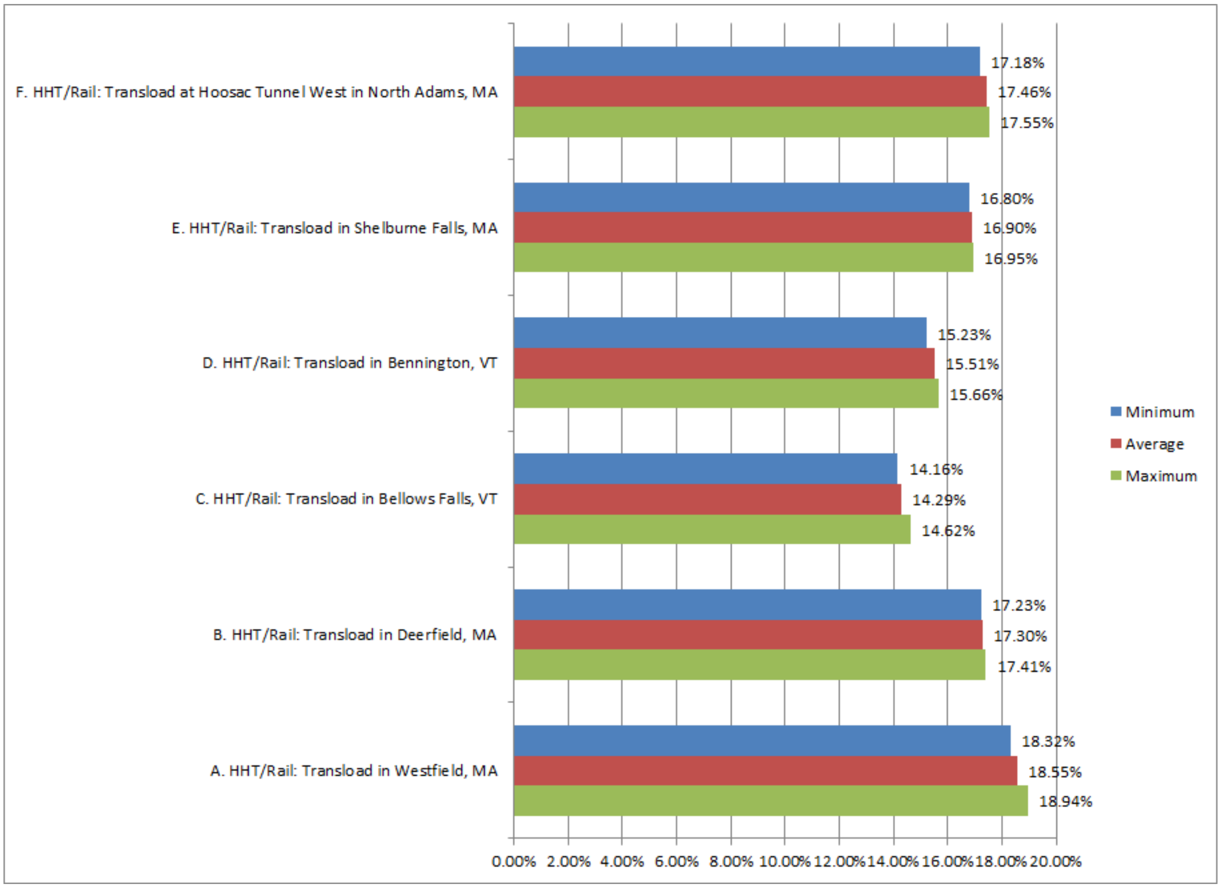


Figure 5-7: Minimum, Average, and Maximum Results from Sensitivity Analysis for Maximization of Each Metric



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 5-8**. 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 than may be necessary to distinguish between routes and may over emphasize the difference between routes. For example, as noted in **Section 5.3.3.10** 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 they could have spanned simply 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 5-8** are provided in this section for additional assessment.

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 could have been evaluated to be just slightly different 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 Population Dose along Route
- 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 5-8**, was examined. Since these two metrics were ranked, by average, in the top three metrics from the pairwise comparison by individual team members, the suppression of the span of the pairwise comparison could impact the route rankings.

Figure 5-8: Example of Suppression of Span for Cumulative Population Dose Along Each Route

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. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

(a) Before Suppression of Span

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. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

(b) After Suppression of Span

In **Figure 5-8**, 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 5-9 shows the modified rankings with the safety metrics evaluation range suppressed. **Figure 5-10** shows the contribution each tangible metric makes to the scoring for each route.

compares the results from the original assessment and the modified results using the suppressed span. These results show some change in the results between the 2nd, 3rd, and 4th ranked routes, with Route B and Route E becoming more favorable and Route F less favorable. However, the highest ranked route, Route A, and the lowest ranked routes, Routes D and C, maintain their rankings, which is consistent with the results identified by the other sensitivity analyses included in this report. Furthermore, the top ranked route actually has greater separation from the other ranked routes under this suppression case, indicating the metrics with more relevant differences between the routes support and actually enhance the high ranking of this route.

Figure 5-9: Resulting List of Prioritized Routes from the YR ISFSI for the Suppression of Span for Safety Metrics

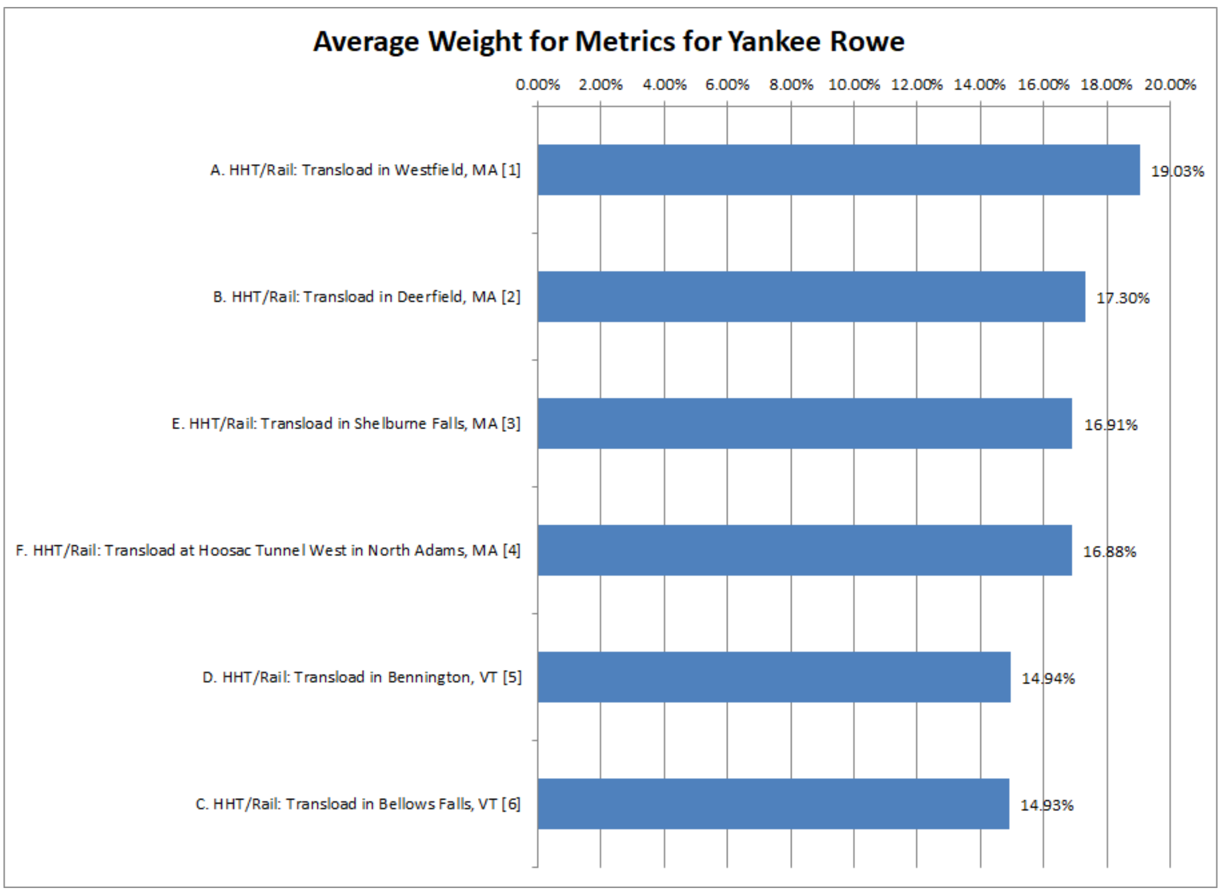


Figure 5-10: Impact of Each Tangible Metric on Each Route's Scoring for the Suppression of Span for Safety Metrics

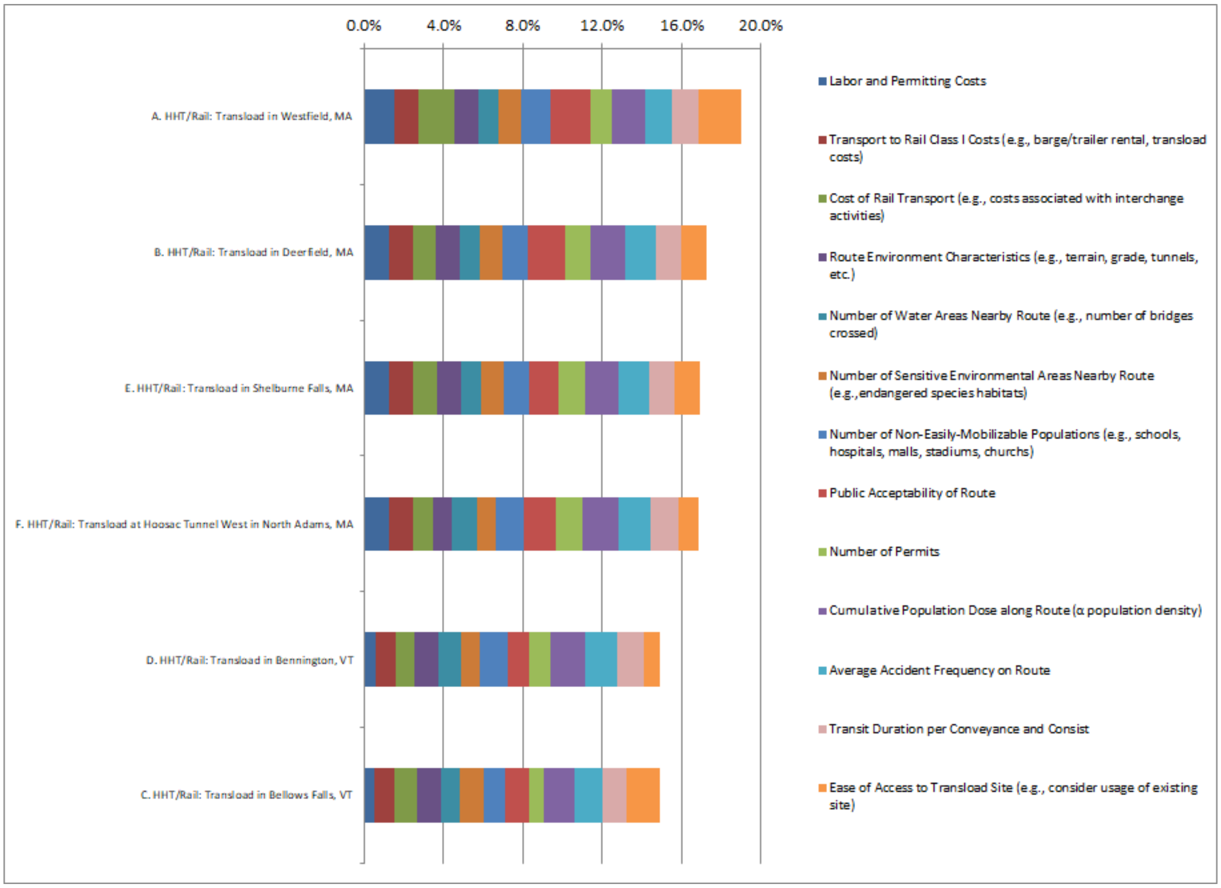


Table 5-15: Comparison of Original MUA Results to the Suppressed Span MUA Results

	Suppression Results		Original Results	
Rank	Avg	Results	Rank	Avg
1	19.03%	A. HHT/Rail: Transload in Westfield, MA	1	18.53%
2	17.30%	B. HHT/Rail: Transload in Deerfield, MA	3	17.30%
6	14.93%	C. HHT/Rail: Transload in Bellows Falls, VT	6	14.27%
5	14.94%	D. HHT/Rail: Transload in Bennington, VT	5	15.53%
3	16.91%	E. HHT/Rail: Transload in Shelburne Falls, MA	4	16.90%
4	16.88%	F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	2	17.47%

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 population dose along route metric
    - The average accident frequency on route metric
- The public acceptability metric
- The public acceptability and security metrics at the same time

Results shown in **Figure 5-11** and **Table 5-16** for the removal of the safety metrics show the top ranked route remains intact and in fact is over 2% separated from the other routes. However, the remaining routes all change in the ranking (e.g., Route F drops from 2nd in the original rankings to 4th overall without the safety metrics utilized). Results shown in **Figure 5-12** and **Table 5-17** for the removal of the public acceptability metric also shows no change for highest ranked route, however does show some change in the ranking of the mid-ranked routes. The final sensitivity analysis performed involved removing both the public acceptability and safety metrics at the same time. **Figure 5-13** and **Table 5-18** show the results of this assessment with again no change to the top ranked the route relative to the original ranking however, there again are differences between the lower ranked routes relative to the original ranking.

Overall, Route A from YR to GCUS performing the transload in Westfield, MA is consistently the highest-ranked route for transloading the transportation casks onto a Class I railroad. However, this site does require additional assessment prior to final selection and some of the particular issues requiring resolution include but are not limited to the rail line at the on-site transload site remaining viable for use and the rail routes meeting the required clearances.

Figure 5-11: Impact of Removing the Safety Metrics

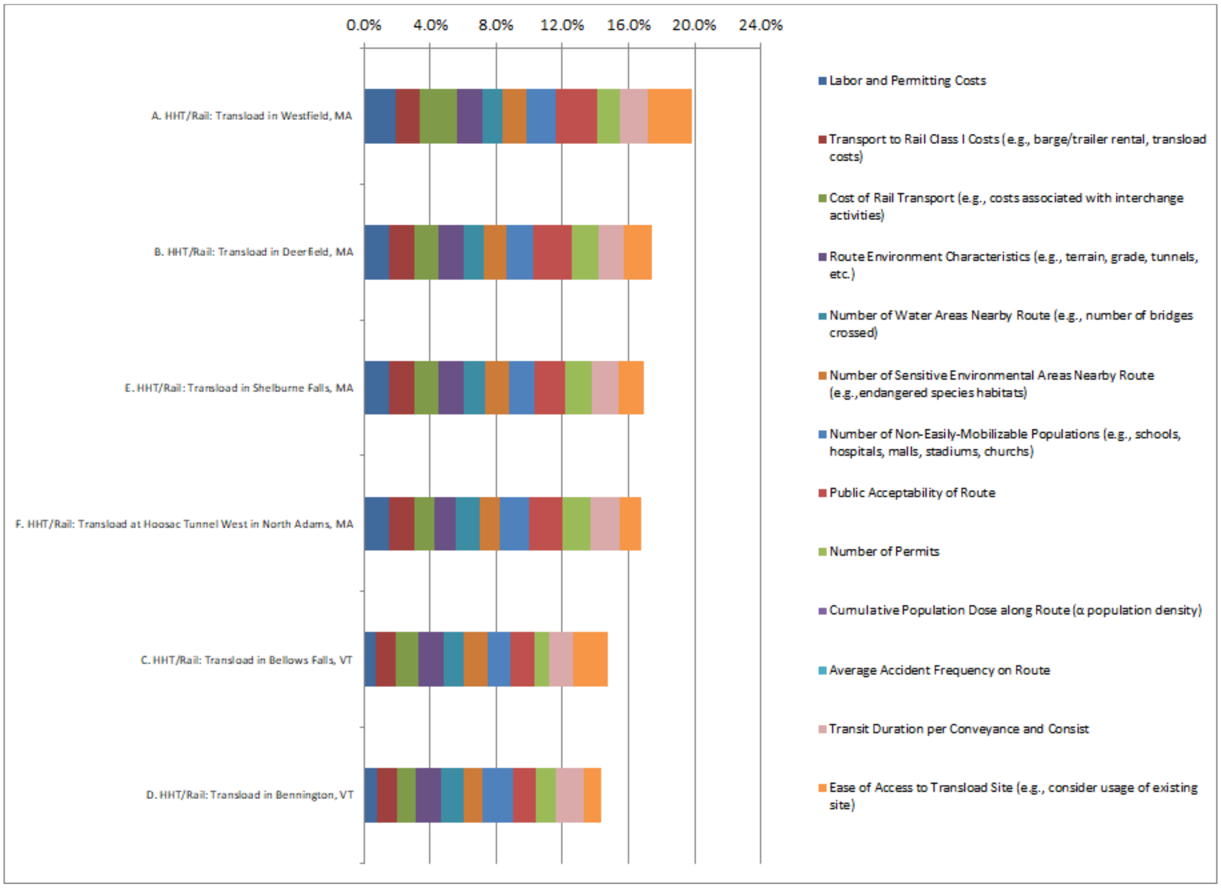


Table 5-16: Results from the Deletion of the Safety Metrics

Rank	Norm Points	Results
1	19.85%	A. HHT/Rail: Transload in Westfield, MA
2	17.40%	B. HHT/Rail: Transload in Deerfield, MA
3	16.91%	E. HHT/Rail: Transload in Shelburne Falls, MA
4	16.74%	F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
5	14.77%	C. HHT/Rail: Transload in Bellows Falls, VT
6	14.34%	D. HHT/Rail: Transload in Bennington, VT

Figure 5-12: Impact of Removing the Public Acceptability Metric

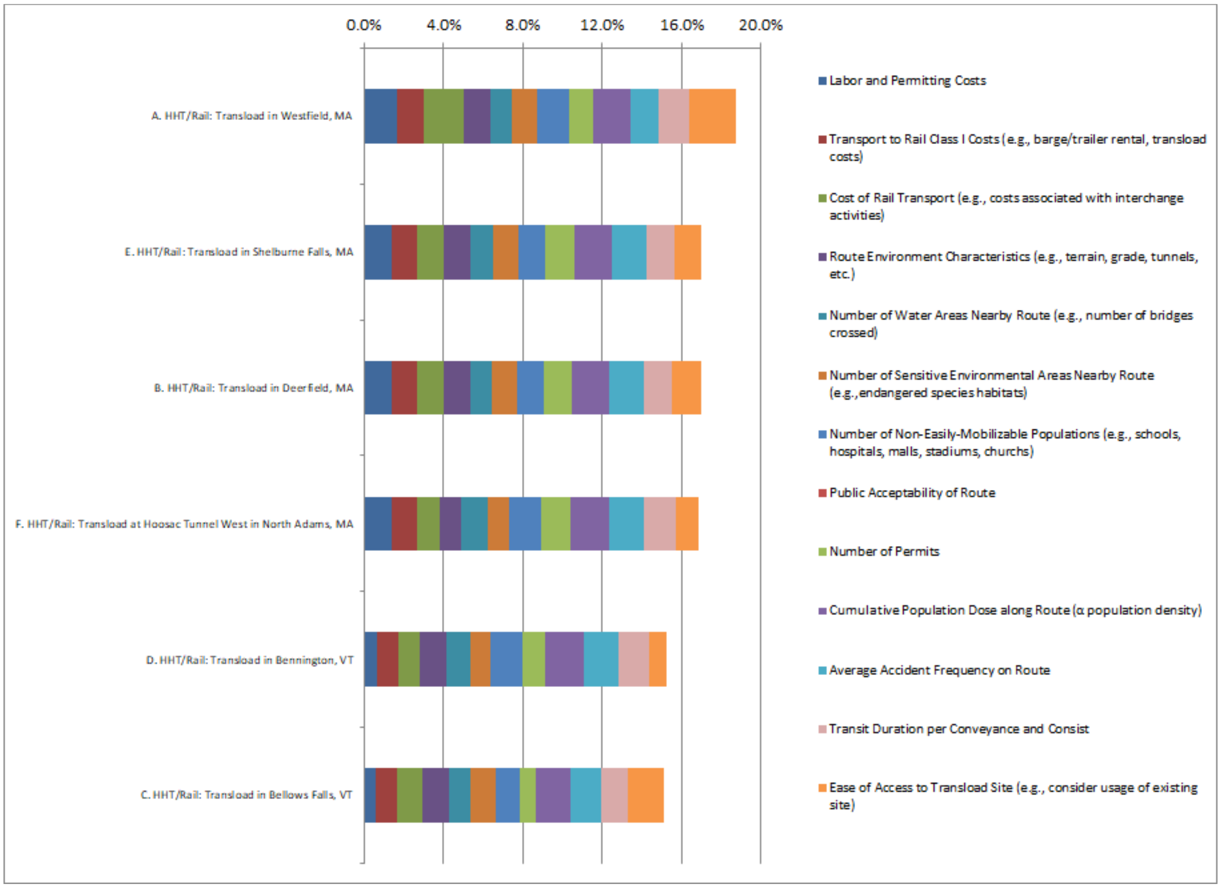


Table 5-17: Results from the Deletion of the Public Acceptability Metric

Rank	Norm Points	Results
1	18.76%	A. HHT/Rail: Transload in Westfield, MA
2	16.99%	E. HHT/Rail: Transload in Shelburne Falls, MA
3	16.97%	B. HHT/Rail: Transload in Deerfield, MA
4	16.84%	F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
5	15.28%	D. HHT/Rail: Transload in Bennington, VT
6	15.15%	C. HHT/Rail: Transload in Bellows Falls, VT

Figure 5-13: Impact of Removing Public Acceptability and Safety Metrics

Table 5-18: Results from the Deleteion of the Public Acceptability and Safety Metrics

Rank	Norm Points	Results
1	19.61%	A. HHT/Rail: Transload in Westfield, MA
2	17.01%	E. HHT/Rail: Transload in Shelburne Falls, MA
3	16.98%	B. HHT/Rail: Transload in Deerfield, MA
4	16.67%	F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
5	15.03%	C. HHT/Rail: Transload in Bellows Falls, VT
6	14.69%	D. HHT/Rail: Transload in Bennington, VT

6.0 CONCEPT OF OPERATIONS FOR RECOMMENDED APPROACH

6.1. Considerations regarding the transportation package selection

The operations associated with the de-inventory of fuel at YR would consist of lease or purchase of required auxiliary equipment and ancillary systems, identification and construction of a TSC Transfer Station pad, if required, mobilization of equipment and systems to the site, operating procedure development and YR approval, equipment set-up and functional testing, development/confirmation of training program materials, training of operating personnel and supervisors, facility operational readiness review, dry run operations, de-inventory activities, transportation operations, and demobilization of equipment from the site. Due to the complexity of these operations, the sequence of activities are divided into five groups: 1) mobilization operations (procurement/lease and delivery of required equipment to the site, and construction of the TSC Transfer Station pad and CHF); 2) operational readiness (operating procedure and training program development, operator training, dry run(s), and operational readiness review); 3) site operations (performance of TSC transfer operations from YR-MPC VCCs to NAC-STCs for offsite transports); 4) heavy haul road and rail transport operations; and 5) demobilization operations of equipment and personnel from the YR site.

Based on the number of YR-MPC TSCs to be loaded and shipped from the YR ISFSI site (i.e., 15 TSCs with SNF and 1 TSC with GTCC LLW), the plan is to load and ship 4 NAC-STCs for each offsite transport campaign by road and rail transport with a total of 4 NAC-STCs committed to the de-inventory shipping campaign.

The following assumptions were used in planning this YR-MPC TSC transfer, loading, and offsite shipment campaign:

1) A total of four complete NAC-STC Transport Systems, including transport cask, impact limiters, YR-MPC cavity spacers, intermodal transport cradles with integral tie-downs and personnel barrier, would be used for the de-inventory campaign located on a single special train system. A total of 4 four-cask transports for SNF and GTCC LLW contents would be required by dedicated train.
2) Off-site shipment of the NAC-STC to the rail intermodal transfer location would be by single NAC-STC package heavy haul trailer (HHT-example: goldhofer) road transport to the rail transload transfer location for assembly of the special train.
3) A new TSC Transfer Station pad may be required for off-loading of the TSC from the VCC into the YR TFR, and subsequent loading of the TSCs into the NAC-STC. The transfer and loading of the TSCs would be performed in a vertical orientation.
4) The TSC Transfer Station will need to incorporate a YR TFR restraint system to maintain the stability of the TFR during TSC removal from the VCC, and TSC loading into the NAC-STC. Alternatively, a single failure proof, seismically qualified gantry system incorporating an air or hydraulically operated chain hoist system for TSC lifting and lowering could be provided as discussed later in this section. To accommodate the CHF and TFR restraint system, and the weight of a loaded YR-MPC VCC, loaded YR TFR, and NAC-STC, a new TSC Transfer Station pad may be required to position and support the components. Estimated size to support two VCCs, the TFR, the NAC-STC, and the required auxiliary equipment, is approximately 25 feet wide x 35 feet, which could be

constructed in the current ISFSI site boundary as an extension of the current pad and adjacent roadway. This pad size would also provide sufficient space for placement of a mobile crane or gantry crane system mounted on temporary rails.

5) It is expected that the intermodal transport cradle mounted on the HHT/goldhofer or positioned on the pad surface could be used to upright the NAC-STCs using the NAC-STC vertical lift yoke. A horizontal lift beam or lifting sling system would be required to lift the loaded intermodal transport cradles off of and onto the HHT/goldhofer and railcar.
6) The NAC-STC intermodal transport cradle could also be used to upright and download the NAC-STC transport overpack with the cradle secured to the HHT.
7) The NAC-STC packages would be provided with certification of compliance with the US NRC CoC No. 71-9235 maintenance program as specified in **Table 6-2** "Maintenance Program Schedule" and Chapter 8.2 of the NAC-STC SAR.
8) New sets of inner and outer metallic O-ring seals will be required to be installed for the inner lid and inner lid vent and drain port coverplates. After replacement and re-installation following TSC loading, the inner lid and vent and drain port coverplates would require helium leakage testing to ANSI N14.5-2014 leak tight criteria using a helium MSLD. Additional sets of containment seals will be required in case of seal leakage test failure. Additional replacement seals would also be required for the non-containment closures provided by the outer lid, and pressure and interlid port covers. A future NAC-STC CoC amendment may delete the requirement for metallic O-rings for NAC-MPC canister shipments and authorize the use of reusable Viton O-ring containment seals.
9) All the required transfer and auxiliary equipment detailed in **Section 2.3** would be required to be procured and fabricated, and/or leased to support the loading and shipping campaign.
10) A mobile crane or gantry system would be required to lift the YR TFR, to remove the TSC from the VCC and load the TSC into the NAC-STC, to lift and load the NAC-STC on the intermodal transport cradle, and to lift and load the intermodal transport cradle to and from the off-site HHT and railcar. Mobile crane, gantry system and/or CHF are required to meet NAC-MPC CoC TS B3.5 requirements.
11) Site operations and contingency procedures would need to be prepared to meet the NAC-YR-MPC TSC system and NAC-STC system CoC and FSAR/SAR requirements.
12) Site operations, health physics, quality assurance (QA) and security personnel would require training in the procedures, FSAR/SAR/CoC requirements, and auxiliary equipment. Training would include on-the-job training (OJT), hands-on training of the equipment during equipment set-up and functional testing. Following completion of the training program, dry run(s) of the site operations, TSC transfer operations, transport operations, and intermodal transfer operations would be conducted to ensure personnel training is adequate, and that equipment and procedures are appropriate to perform the required operational sequences in a safe and efficient manner. The project activities required to be completed in preparation for the removal of SNF and GTCC LLW from the YR site are summarized in **Table 6-1**.

6.1.1. Package Permits / Requirements

In order to transport SNF and GTCC LLW from the YR ISFSI site in the NAC-STC, the package must meet a number of regulatory requirements. Those requirements are described in 10 CFR Part 71. Based on a preliminary review the YR-MPC TSC loaded contents and the NRC CoC for the NAC-STC (71-9235), the YR site-specific fuel in storage in the 15 fuel YR-MPC TSCs and the GTCC LLW in the 1 YR-MPC GTCC TSC meet the requirements of Paragraph 5(b)(1)(ii) for fuel and 5(b)(1)(iii) for GTCC for Type and Form of Material, and Paragraph 5(b)(2)(ii) for fuel and 5(b)(2)(iii) for GTCC for Maximum Quantity of Material per Package. In addition, CoC Condition 7 regarding hydrogen generation from organic materials contained in GTCC TSC, the contents are required to be analyzed to show that hydrogen generation will not exceed 4% by volume of the TSC. Based on previous analyses performed prior to loading the YR-MPC GTCC TSC it has been concluded that the loaded GTCC LLW canisters meet this condition. In addition, a comprehensive review of the fuel in its current storage system and against the NAC-STC CoC and SAR is recommended to be completed to verify the requirements for shipping have been met (refer to **Section 10.0**).

Table 6-1: Activities to Prepare for and Remove SNF and GTCC LLW from YR ISFSI

Task		Task Activity Description
Programmatic Activities to Prepare for Transport Operations from a Shutdown Site		
1	Assemble Project Organization	Assemble management teams; identify decommissioned site existing infrastructure, constraints, and transportation resource needs; and develop interface procedures.
2	Acquire NAC-STCs, Hardware, Railcars, Off-Site HHT, Rail Routing, 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, and intermodal transport cradles, NAC-STC Lift Yoke and Horizontal Lift Beam; revisions to NAC-STC Part 71 CoC and MPC Storage CoC, as required; procurement of AAR Standard S-2043 railcars; and procurement of offsite transportation services including rail and HHT services, as applicable.
3	Acquire/Lease Required Auxiliary Equipment Including Refurbished / New YR TFR, Transfer Adapter(s), Suitable HHT(s) and Prime Mover(s), and Remaining Required Auxiliary Equipment	The YR site does not have any major components, auxiliary systems, or standard tools available for performance of the required onsite operations necessary to move and unload YR-MPC TSCs from the 16 VCCs and transfer the TSCs to the NAC-STCs. Essentially all equipment will need to be acquired/refurbished/leased and shipped to site for set-up and checkout prior to start of the training program and performance of the dry run(s). In addition, there is limited staffing at the YR decommissioned site, so outside contractor crews will need to be assembled, trained, and evaluated to perform all transfer operations.

Task		Task Activity Description
4	Prepare, Design, and Construct Required CHF Transfer Station Base Mat and Equipment in Accordance with the Requirements of the MPC CoC TSs	There is limited free ISFSI pad space for the placement of the CHF and positioning of the required auxiliary equipment. A new or extended pad of sufficient strength and size to support the NAC-STC and YR TFR stack-up and the VCC and YR TFR stack-up would be required. In addition, the height of the pad will be required to be similar to the height of the YR ISFSI pad to allow movement of the empty and loaded VCCs off of and onto the pad, and onto and from the HHT using air pads. Alternatively, a qualified gantry crane system may be installed over the current ISFSI pad to allow the TFR to be positioned directly on the VCC for TSC removal without the need to move the VCC to a specific unloading position. This would eliminate the need for an extended pad for a TSC Transfer Station as the current pad has sufficient room for positioning a vertical NAC-STC transport cask for receipt of the YR-TSC.
5	Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport for decommissioned site.
6	Coordinate with Stakeholders	Coordinate with carriers and notifications to federal and state regulatory agencies. Obtain route approval from NRC and required state agencies.
7	Develop Campaign Plans (e.g., prepare, review, and approve all required site operating procedures for the TSC unloading from the VCCs and transfer/ loading into the NAC-STC, preparation and testing of the NAC-STC, and procedures for all the major and auxiliary components and systems)	Develop plans, policies, and procedures for onsite operational interfaces and acceptance, support operations, and in-transit security operations. Initial drafts of the VCC handling, TFR handling, VCC/TFR stack-up, and TSC unloading operations can be prepared from procedures initially prepared during the original loading campaign. Similar procedures will be required for the auxiliary equipment including HHT operations, transfer adapter hydraulic system operation, air pad and jack system operations, diesel powered air compressor, etc. New site procedures will be required for the handling of the NAC-STC, TSC Transfer Station operation, goldhofer HHT operation, proper tie-down and securing of the NAC-STC package to the railcar/intermodal transport cradle, evacuation, and backfilling of the NAC-STC cavity with helium, helium leakage testing of the NAC-STC containment boundary seals, etc. All approved procedures will require review and approval by YR Independent Safety Review (ISR).

Task		Task Activity Description
Operational Activities to Prepare, Accept, and Transport from a Shutdown Site		
8	Conduct Readiness Activities (e.g., In-Processing, Badging, Training, and Dry Run(s) of All Personnel, Procedures, and Equipment and Systems	Assemble and train onsite 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 QA/quality control (QC) personnel would need to be trained and qualified to perform the operating procedures in accordance with YR's Training Programs per TS A 5.2 of the NAC-MPC CoC. Training would require classroom, 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	Load for Offsite Transport	Unload storage systems and transfer YR-MPC TSCs to NAC-STCs, install loaded NAC-STCs onto intermodal transport cradles, installing impact limiters and personnel barrier, and lift onto offsite HHT trailer for offsite transportation to rail transloading facility. Prepare required shipping papers for shipment contents for exclusive use transport.
10	Accept Shipment for Offsite Transport	Accept loaded NAC-STC packages onto trailer/rail for offsite transportation and shipment to the final destination.

6.1.2. Operational Readiness

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 have been delivered, assembled, and proper operation verified. Required procedures and project instructions would have been 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 can be executed safely. It also ensures that the project team and procedures are in compliance with 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 YR ISFSI. The following subsection will discuss the operational readiness required to ensure operations at YR are ready to commence and can be performed in a safe and regulatory compliant manner.

A review of the NAC-MPC FSAR and NAC-STC SAR, and the applicable CoCs, would need to be performed. This would verify the contents of the YR-MPC TSCs met the required content conditions and quantities listed in the storage CoC No. 1025 TSs and Approved Contents and the CoC. The contents form and quantity of the YR-MPC TSCs (including the GTCC LLW) would require verification for compliance with the current revision of CoC 71-9235 for the NAC-STC system at the time of shipment.

Operations management would ensure readiness from a quality, safety, and operational perspective. Management assessments of these processes would determine readiness. This assessment would include verification of the roles and responsibilities between the different organizations involved with and performing the work. Communications between the stakeholders, review and approval of procedures, and interfacing with regulators must occur to ensure the processes to execute work have been reviewed and all agree on readiness to start work. Based on the preface for these reports, any DOE shipments would be subject to the same requirements as a commercial shipper of SNF, NRC would be involved in the initial routing approval and those approved routes would be in place and valid for 5 and 7 years as indicated and described above.[9] Once route approval is granted, advanced notification would be provided prior to each shipment since the campaign is longer in duration than one train movement.

As required by the NAC-MPC TSs, a training program would be required to be implemented for all project personnel with the extent of training required for each individual/project position. The training program would require a qualified trainer to oversee and conduct the training with NAC-MPC operationally qualified personnel to perform the OJT and TPE portions of the training program. The training program would include the following requirements and elements:

Classroom Training:

- Module 1 – NAC-MPC and NAC-STC Systems Overview
- Module 2 – YR TFR and Transfer Adapter Operations
- Module 3 – YR-MPC VCC Handling and Movement
- Module 4 – On-site HHT Operations (including prime mover, hydraulic jacks, air pad, air compressor, and telescope handler/vehicle operations)
- Module 5 – Off-site HHT (goldhofer) Operations including Prime Mover
- Module 6 –TSC Unloading Operations from VCC
- Module 7 – NAC-STC Handling and Loading Operations
- Module 8 - NAC-STC Intermodal Transport Cradle Tie-Down and Transloading Operations
- Module 9 – Preparation of NAC-STC for Transport
- Module 10 – NAC-STC Containment O-Ring Helium Leakage Testing
- Module 11 – Use of Measuring and Test Equipment (M&TE)
- Module 12 – Radiological Concerns and ALARA Planning
- Module 13 – Regulatory Requirements

[9] 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.

- Module 14 – Supervisor Training
- Module 15 – Contingency Procedures

OJT:

- OJT-1 – Perform Pre-Use Inspections (VCC, TFR, NAC-STC)
- OJT-2 – Perform Periodic Inspections (VCC, TFR, NAC-STC)
- OJT-3 – Prepare a VCC and TFR for Stack-up and TSC Transfer
- OJT-4 – Off-Load Empty NAC-STC from Intermodal Transport Cradle
- OJT-5 – Perform TFR Stack-up and TSC Unloading from VCC
- OJT-6 – Perform NAC-STC and TFR Stack-up for TSC Transfer
- OJT-7 – TSC Loading into NAC-STC
- OJT-8 – Movement of VCC to/from ISFSI/CHF
- OJT-9 – NAC-STC Inner Lid Installation and Torquing, and Cavity Evacuation, Backfill, and Helium Leakage Testing
- OJT-10 – NAC-STC Outer Lid and Pressure/Interlid Port Cover Installation and Leakage Testing
- OJT-10 – Perform Loaded NAC-STC Package Down-ending and Preparation for Transport
- OJT-11 – Onsite and Off-site HHT Operations
- OJT-12 – Operate Telescoping Handler and VCC Restraint
- OJT-13 – Operate Diesel Air Compressor, Hydraulic VCC Jacks, and Air Pad Systems
- OJT-14 – Onsite and Off-site Intermodal Transport Cradle Handling Operation

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

Operational dry runs with a TSC mock-up to perform the NAC-STC loading operation would be conducted at the YR site. Due to a lack of an empty VCC on site, it would be impractical to perform a full dry run of the TSC unloading from a VCC process. However, the actual equipment can be properly positioned and manipulated up to the point of actually withdrawing a TSC to confirm procedures, training, and equipment interfaces, fit-up and function.

Communication and interfacing with the applicable stakeholders would be needed to ensure readiness. This would include, but would not be limited to, YR and DOE, and State and local authorities. In addition, it is expected that NRC on-site and Region I inspectors would observe and provide regulatory oversight throughout the entire preparation, construction, and training/dry run program. Some entities would need to 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 would include reviewing procedures and possibly performing audits/assessments to ensure operational readiness. As an additional readiness verification, an independent team of dry cask storage and transport experts would 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 NAC-MPC CoC TSs and witnessed by DOE, NRC, and stakeholders. Additionally, and as applicable, these entities would be involved in event response planning and mitigation, including contingency event training, to ensure that, prior to the first shipment of the campaign, any foreseeable event would be well managed and mitigated. This would encompass approvals to start work, training, and interaction with state and local authorities. It is assumed that YR, NRC, and DOE would participate as observer/regulator for each shipment.

6.1.3. Site Operations

Each YR-MPC TSC transfer sequence encompasses the following major evolutions: loaded VCC retrieval and movement to the TSC Transfer Station; VCC/TFR stack-up and TSC extraction into the TFR; up-righting the NAC-STC from the transport cradle; movement and positioning of the vertical NAC-STC at the TSC Transfer Station; removal of the NAC-STC outer and inner lids and placement/verification of the YR-MPC transport cavity spacer; placement of the NAC-STC adapter ring and transfer adapter on the NAC-STC; lifting and movement of the loaded YR TFR from the VCC to the NAC-STC; transfer of the loaded TSC into the NAC-STC; removal of the TFR, transfer adapter and adapter ring from the NAC-STC; installation of the NAC-STC inner lid with new metallic O-ring seals and torquing of the inner lid bolts; evacuation and helium backfill of NAC-STC cavity; installation of vent and drain port covers with new metallic O-ring seals; performance of the inner lid and vent and drain port cover plate containment O-ring helium leakage tests; and movement and down-ending of the loaded NAC-STC on the intermodal transport cradle. Auxiliary equipment associated with the transfer would need to be staged, inspected, and prepared for the transfer operation. Based on review of the ISFSI at YR, additional room will be required to stage the equipment for the transfer operation and to place the equipment at the TSC Transfer Station.

As noted in **Section 2.1**, it is estimated that a TSC Transfer Station pad of approximately 25 x 35 feet elevated to approximately 27 inches will be required to be constructed within the ISFSI site perimeter. It is unknown if such a pad can be constructed within the current ISFSI site fenced boundary. The Transfer Station could optimally be located as an extension to the current ISFSI pad. At the TSC Transfer Station pad, a CHF will be required to meet the criteria specified in Section B 3.5 of the NAC-MPC TSCs, and any stationary or mobile crane utilized to lift and handle the loaded YR TFR and NAC-STC must meet the requirements of TS B 3.5.2.1.3 or B 3.5.2.2[21], respectively. In addition, if a stationary crane is not single-failure-proof, an impact limiter is required to ensure a TSC drop does not breach the canister (YR-MPC TSC).

An alternative to the location and use of mobile cranes for YR-MPC TSC transfer from the VCC into the TFR and loading into the NAC-STC would be to design and deploy a seismically qualified, single-failure-proof gantry system with lifting slings provided with an integral hydraulic or air-powered chain hoist system. This system would allow the direct movement of the loaded YR TFR from the top of the VCC to the top of NAC-STC cask for TSC transfer without the need to set down the TFR on the pad surface, with the TSC lowered by the chain hoist with the TFR maintained attached to the lift slings. A similar system is currently being deployed at the Taiwan Power Company's Kuosheng Nuclear Station in Taiwan for the loading of MAGNASTOR BWR VCCs, and a Secure Lift System (no gantry) with integral chain hoist was utilized successfully for

MAGNASTOR TSC transfer and loading operations at Dominion's Kewaunee Nuclear Station. Such a gantry and integrated chain hoist system would be able to be disassembled and moved to other sites for de-inventory operations. The system would also be adaptable to other storage and transport cask system designs. The use of the gantry and chain hoist system would meet the requirements of the NAC-MPC TS B 3.5[45] for a CHF.

Prior to the start of any YR-MPC TSC transfer operation or NAC-STC cask handling evolution, a pre-job brief with the operations staff will be conducted to review procedures, verify training of staff, discuss any safety/quality-related concerns and practices, Radiation Work Permit (RWP) requirements, dose and dose rate expectations, planned RP coverage, As Low As Reasonably Achievable (ALARA) practices, and to verify adequate personnel and equipment resources are available to successfully support and complete the planned evolution(s). 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. Operations management would verify that the NAC-STC has a certification of conformance with all required cask maintenance and testing as specified in **Table 6-2**.

Prior to commencing YR-MPC TSC transfer operations, the primary and auxiliary equipment and services would be configured and positioned as follows:

- Position the HHT adjacent to the VCC to be moved to the TSC Transfer Station with hydraulic jacks extended to raise level of HHT to pad, install aluminum channels under the main HHT beams fore and aft, and install wheel chocks. Install bridge plates between pad and HHT deck to facilitate air pad operation. (Note: This step and as follows may be modified if VCC can be moved directly for its' storage position to the TSC Transfer Station without the need to leave the ISFS pad. This movement would only require the use of the hydraulic jacking system, air pads and suitable tow/pushing vehicle). *Note: An alternative approach would be to utilize a qualified gantry crane system positioned over the ISFSI pad that would allow the TFR to be positioned on the VCCs in their current storage locations without the need to move them by air pads or by HHT to be in position adjacent to the NAC-STC cask. The gantry crane would move the loaded TFR into position over the NAC-STC cask for downloading of the YR-TSCs. Similar gantry systems are being developed for the proposed interim dry storage project.*
- Position the JCB or similar telescopic boom handler with VCC restraint adjacent to the HHT on the outward side away from the VCC.
- Extend the boom across the bed of the HHT and engage to the VCC.
- Install hydraulic jacks in the four VCC inlet vents ready to raise the VCC off the pad surface.
- Position the four sections of air pads around the VCC for insertion under the VCC when it is raised by the jacks.
- Position the primary mobile crane, if used in lieu of a stationary crane or qualified gantry system, to be located such that it would be able to reach the overpack down-ending area and the Heavy Haul Trailer (HHT [goldhofer]) /intermodal transport cradle.

- Locate the intermodal transport cradle, with securement straps removed, in the down-ending area either on the off-site HHT (goldhofer) or on the ground.
- Locate the secondary mobile crane intended to be used for lifting the transfer adapter, adapter ring, man-lift, VCC and cask lids, and shield plug adjacent to the transfer pad.
- Position the vacuum pump, leak test system and helium supply on the TSC Transfer Station pad. Also position temporary storage stands for the placement of the VCC lid, VCC shield plug, and NAC-STC outer and inner lids on the pad or directly adjacent to the pad.
- Equipment at the ISFSI pad would include the telescoping hauler and VCC restraint system, VCC jacks, air pads, and diesel air compressor. (*Note: a second air compressor would be required at the Transfer Station if station is not located at the ISFSI extended pad).*
- Once the transfer equipment is staged and ready, the onsite HHT (or air pads alone) would be used to move the first loaded VCC from the ISFSI pad to the TSC Transfer Station. Jacks would be used to lift the VCC off the pad, the air pads would be installed under the VCC baseplate, the VCC lowered onto the pads by the jacks, and the jacks removed. The telescoping hauler would be extended over the HHT and the VCC restraint system attached to the VCC, the air pads activated, and the telescoping hauler would pull the VCC from the pad onto the HHT. The air pads would be deflated and left in place and VCC restraint removed. The HHT and telescoping hauler would be driven to a position adjacent to the TSC Transfer Station, and the HHT would be prepared for off-loading of the VCC onto the pad. The telescoping hauler would be reattached to the VCC, the air pads re-inflated, and the VCC maneuvered onto the pad. The air pads would then be deflated, and the VCC restraints removed. The work platform(s) would be placed around the VCC, and the VCC lid bolts removed.

Table 6-2: Maintenance Program Schedule

Task	Frequency
Cavity Visual Inspection	Prior to Fuel Loading
Basket Visual Inspection	Prior to Fuel Loading
O-ring Visual Inspection	Prior to Fuel Loading
Outer Lid, Inner Lid and Port Coverplate Bolt Visual Inspection	Prior to installation during each use
Radial Neutron Shield Shell Visual Inspection	Prior to Fuel Loading
Cask Visual and Proper Function Inspections	Prior to each Shipment
Lifting and Rotation Trunnion Visual Inspection	Prior to each Shipment

Task	Frequency
Liquid Penetrant Inspection of surfaces and accessible welds	Annually during use
Maintenance Periodic Leakage Rate Test of Inner Lid and Port Coverplate O-rings	For Viton O-rings, annually or when replaced. For metallic O-rings, prior to each loaded transport.
Preshipment Leakage Rate Test	Prior to loaded transport for casks with Viton O-rings
Transport Impact Limiter Visual Inspection	Prior to each shipment
Quick-disconnect Inspection for Proper Function	During each Cask Loading/Unloading Operation
Quick-disconnect Replacement	Every two years during transport operations
Metallic O-ring Replacement	Prior to installation for a loaded transport
Viton O-ring Replacement	Annually, or more often, based on inspections during use or leakage test results
Inner and Outer Lid Bolt Replacement	Every 240 bolting cycles (Every 20 years at 12 cycles per year)
PTFE O-ring Replacement	Every two years during transport operations or as required by inspection
Periodic Leakage Rate Test	Performed within 12 months prior to each shipment for containment boundary Viton O-rings. No testing needed for out-of-service packaging or for casks provided with containment boundary metallic seals as metallic seals are replaced and maintenance leakage tested during each loading operation.
Post-Fabrication Thermal Test	Performed after a cask experiences an adverse event such as fire, drops or impacts that result in obvious damage to the neutron shield. The cask shall pass the pre-fabrication thermal test prior to being used in a subsequent fuel transport.

The next operational sequence would be to off-load an empty NAC-STC from the off-site HHT (goldhofer), if not planned for later in the operational sequence. First, the empty cask would be visually inspected for any transport or handling damage and then surveyed to determine if there is any radiation/contamination. The personnel barrier would be removed and stored using the secondary mobile crane. Next, the front and rear impact limiters would be unbolted, removed, and stored in a protected area to prevent any damage to the stainless-steel shells. The cask front tie-downs would be removed and stored. A visual inspection of the primary lifting trunnions would be performed to inspect for any damage or galling. Any road dirt and previous labels would be removed from the cask's surfaces. The primary mobile crane would then be connected to the NAC-STC lift yoke and the lift yoke engaged to the two primary NAC-STC lifting trunnions. The crane and lift yoke would then upend the NAC-STC by lifting from the front to rear while maintaining the center of gravity of the cask under the crane lift point while rotating the cask on its rear trunnions.

Alternatively, at the discretion of site operations management and handling equipment available, the horizontal lift beam would be used to off-load the NAC-STC on the intermodal transport cradle with the impact limiters and tie-downs still installed. Once positioned on the ground, the detailed up-righting operations described above will be performed to prepare and upright the NAC-STC in preparation for movement to the Transfer Station pad. Once in a vertical orientation, the NAC-STC would be lifted from the intermodal transport cradle and placed in position at the Transfer Station adjacent to the loaded VCC.

Once the NAC-STC is in position on the TSC Transfer Station pad, a complete visual inspection of the cask surfaces and components would be performed to verify the correct assembly of the cask. Using the man-lift and/or work platforms, personnel would access the top of the cask to inspect the outer lid, outer lid bolts, pressure and interlid port covers, bolting, and leak test port plugs. The outer lid bolts are then removed, inspected for thread damage, and stored, and the outer lid alignment pins installed. The four-point lifting sling is then installed to the outer lid lifting threaded holes and the outer lid is lifted and removed. The outer lid is stored to protect the O-ring which is inspected for damage, and the outer lid alignment pins removed. This non-containment O-ring is replaced if required.

The vent port coverplate bolts (captured) and coverplate would be removed to access the cask cavity and a pressure and gas sampling system connected to measure cask cavity pressure and cavity gas radioactivity levels (as determined by site). The cask cavity would then be vented to atmosphere through a HEPA filter set (also used during evacuation of the cask cavity following TSC loading connected to the exhaust of the vacuum pump). The vent port coverplate and bolts would be inspected for damage, corrective actions taken as required, and then they would be stored to prevent loss or damage. Prior to re-installation, new metallic O-rings would be installed in the vent port coverplate. The inner lid bolts would then be de-torqued in the numbered sequence of the bolts as stamped on the cask lid, and the two inner lid alignment pins installed in the bolt holes identified as guides. The inner lid bolts would be inspected for any damage and damaged bolts replaced with authorized spares and stored to prevent loss or damage. The inner lid lifting rig set would then be attached to the four lift designated holes using swivel hoist rings connected to the secondary mobile crane. The inner lid is lifted, removed, and stored in a location to protect the O-ring grooves. Prior to inner lid re-installation, the two inner lid metallic O-ring seals will be replaced. Following the inner lid removal, an inspection of the inner lid containment boundary seating surface is performed. Finally, prior to insertion of a YR-MPC TSC, the installation of the YR-MPC lower cavity spacer will be performed. A lower and upper cavity spacer will be required for all YR-MPC TSC loading operations. Prior to the empty return shipment, the YR-MPC cavity spacers will be removed during off-loading of the TSC and returned to YR in an IP-1 package and re-installed in the NAC-STC cavity prior to loading the next YR-MPC TSC. After the spacer installation, the cask adapter ring is lifted, installed in the inner lid seating surface, and bolted in place. The adapter is provided to interface with the TFR transfer adapter plate and to provide additional shielding during the loading of the TSC into the NAC-STC.

The secondary mobile crane would be placed into position for removal of the VCC lid followed by the removal of the shield plug. The secondary mobile crane would then be used to lift and place the transfer adapter on the top of the VCC. Once the shield plug is removed, the radiation dose from the TSC and the VCC/TSC annulus would increase significantly. After this point in the operation and through the extraction of the TSC from the VCC, radiation streaming is to be expected and may be significant. ALARA considerations will need to be accounted for during these operations, and radiation levels monitored and controlled. The TSC lift rigging sets would be installed in the six lifting threaded holes on the TSC structural lid (or the TSC Lift Adapter Plate bolted to the TSC structural lid to connect to the Secure Lift Yoke Chain Hoist System). If installed, threaded hole plugs would be removed. The primary mobile crane or CHF crane with a YR TFR Lift Yoke (or seismically qualified Gantry System Secure Lift Yoke and Integral Chain Hoist System) would then be used to lift and place the empty YR TFR with retaining ring installed in position on the transfer adapter positioned on the top of the VCC. Prior to removal of the lift yoke from the TFR trunnions, the TFR restraint system would be installed or attached depending on the restraint system design, if required. (Note: A TFR restraint system and a CHF or primary crane would not be required if a seismic gantry/secure lift yoke/chain hoist system. In addition, the lift yoke/slings would not be required to be disconnected from the YR TFR trunnions).

The system would now be ready for removal of the shield door lock pins, opening of the shield doors using the auxiliary hydraulic unit for the retrieval of the TSC redundant lifting sling sets and connection to the crane hook using long reach tools and tag lines with personnel access provided to the top of the YR TFR by use of the man-lift.

The next operational sequence is the lifting of the YR-MPC TSC from the VCC using the crane system into the YR TFR until the top of the YR-MPC TSC is lifted to just below (< 1 inch) the retaining ring. The retaining ring is designed to prevent the unauthorized extraction of a loaded TSC from the TFR and the retaining ring is structurally designed to take the entire weight of the loaded YR-MPC TSC and YR TFR without failure. However, caution should be used to ensure that the top of the TSC does not engage the retaining ring. Once the YR-MPC TSC is in the YR TFR, the auxiliary hydraulic system is used to close the shield doors and the YR-MPC TSC is lowered to rest on the doors. During the TSC transfer operation, radiation dose rates are expected to be high at the TFR to adapter plate interface and through gaps in the shield door to YR TFR openings. Also, once the YR-MPC TSC is in the YR TFR dose rates on the YR TFR surface will be higher than the dose rates from a loaded VCC. It should be noted that there may be residual removable contamination on the exterior surfaces of the YR-MPC TSC as allowed by NAC-MPC TS Limiting Condition of Operation (LCO) A.3.2.1, which allows up to 10,000 dpm/100 cm^2 from beta and gamma sources, and 100 dpm/100 cm^2 from alpha sources. The residual removable contamination is a result of use of filtered SFP water in the annulus flush water during in-pool SNF loading operations. Although the TS establishes maximum limits, a significant majority of the YR-MPC TSCs had less than 2,500 dpm/100 cm^2 beta/gamma contamination in surveys performed during TSC closure and transfer to VCC for storage. Few if any had contamination > 5,000 dpm/100 cm^2. It is expected that weathering will have significantly reduced the residual contamination prior to the de-inventory project. However, contamination control practices will be required to be observed during YR-MPC TSC handling and transfer operations to the NAC-STC transport cask. It is expected that interior surfaces of the NAC-STC and YR TFR may potentially pick up minimal contamination during the YR-MPC TSC transfer and loading operations. The potential contamination of the interior of the NAC-STC cavity would not exceed the allowable contamination limits specified for an empty radioactive return shipment per 49 CFR 173.428.

Once the shield doors are closed and the door lock pins installed, the lifting slings would be detached from the crane hook and lowered to rest on top of the YR-MPC TSC. The crane would then be used to retrieve the YR TFR lift yoke, which would then be engaged to the YR TFR lifting trunnions to lift and remove the YR TFR from the top of the VCC and be placed in a temporary storage area after removing the TFR restraint system. The secondary crane would then be used to remove the transfer adapter. It is recommended that a second transfer adapter be utilized to allow the immediate movement of the loaded YR TFR from the top of the VCC to the NAC-STC without the need to set the YR TFR down on the pad. At an appropriate point in the operations evolution, the empty VCC movement to the designated ISFSI position would be performed using the air pads and/or HHT, and telescoping handler to return the empty for future decommissioning. Due to limited area of the ISFSI pad for retrieval of loaded VCCs, it may be appropriate to consider moving the empty to a separate temporary pad for temporary storage prior to decommissioning. This pad may be located outside of the security fence as the VCC will now be empty and not under the security conditions of 10 CFR Part 72.

As an operational alternative sequence, with the use of a seismically qualified gantry system, the VCC and NAC-STC could both be positioned adjacent to each other with access to raise or lower the YR-MPC TSC provided by the gantry system incorporating a chain hoist system. In this operating scenario, two transfer adapters are required so that the YR TFR containing the TSC can be moved directly from the top of the VCC to the top of the NAC-STC without the need to place the loaded YR TFR on the pad surface. A single hydraulic operating system with separate sets of hoses connecting to the two transfer adapter operating cylinders would be used to operate the YR TFR shield doors. The seismically designed gantry system would also eliminate the need to provide a separate CHF YR TFR restraint system, as the YR TFR and YR-MPC TSC would always be under the control of the gantry. A separate air-operated or hydraulic100-ton chain hoist suspended from the gantry would be used to lift and lower the YR-MPC TSC from the VCC and to the NAC-STC, respectively.

In preparation for the YR-MPC TSC loading into the NAC-STC, the primary mobile or CHF crane or gantry system is then used to lift and install the loaded YR TFR on top of the NAC-STC/transfer adapter ensuring the adapter's female connectors engage with the male connectors of the shield door. The auxiliary hydraulic system would then be connected to the adapter hydraulic cylinders. Prior to disengaging the YR TFR lift yoke, the CHF YR TFR restraint system would be installed and/or positioned to restrain the YR TFR under seismic events. The primary mobile crane is then connected to the TSC redundant lifting sling sets by manually retrieving the sling set from the top of the TSC and installing the master link to the crane hook with access to the top of the YR TFR using a man-lift. The sling set is then used to raise the YR-MPC TSC approximately ½ - 1 inch off the shield doors. The shield door lock pins are removed, and the shield doors opened. The primary mobile, CHF crane, or gantry system is then used to slowly lower the YR-MPC TSC into the NAC-STC cask cavity. During the YR-MPC TSC transfer operation, radiation dose rates are expected to be high at the YR TFR to adapter plate interface and through gaps in the shield door to YR TFR openings. Once the TSC is fully down in the NAC-STC cavity resting on the YR transport spacer, the sling set would be removed from the crane hook and lowered through the YR TFR annulus to rest on top of the YR-MPC TSC. The YR TFR shield doors are then closed, and the door locks installed, and the crane and YR TFR lift yoke would be engaged to the YR TFR trunnions for the lifting and removal of the YR TFR from the NAC-STC. The YR TFR is then lifted off the NAC-STC and set down and staged for the next YR-MPC TSC unloading sequence from the next loaded VCC.

Operators would then access the top of the NAC-STC to remove the TSC lifting slings and hoist rings from the six lifting threaded holes (or the TSC Lift Adapter and bolting) and the four bolts attaching the transfer adapter to the cask adapter ring. Then, using the transfer adapter sling set and the secondary crane, they would remove the transfer adapter and TSC sling set and place them in storage for the next VCC unloading sequence. The operator needs to ensure that the YR-MPC TSC structural lid plugs are not re-installed in the six holes, as their installation in the TSC structural lid are not authorized for transport. To complete the YR-MPC loading for transport, the upper cavity spacer is installed on top of the TSC's structural lid.

Next, the cask adapter ring is unbolted and attached to slings and removed using the secondary crane. A visual inspection of the cask seal seating surface is performed, and any dirt or debris is removed using a soft cloth. The inner lid alignment pins are installed in the designated holes and the cask inner lid provided with new metallic O-ring seals is lifted using the secondary crane and inner lid sling set and installed in the lid recess using the alignment pins to appropriately align the lid to the lid bolt holes. Once the lid is fully seated, the operator must remove the alignment pins and install the 42 lid bolts lubricated with Never-Seez or equivalent and using the bolt torquing device, torque the lid bolts in the indicated numbered sequence stamped on the lid in complete three passes to a final torque of 2,540 ± 200 ft-lbs (e.g., 825 ft-lbs, 1,650 ft-lbs, 2,540 ft-lbs).

After the inner lid is secured, a vacuum pumping and helium backfill system would be connected to the vent port and the cask cavity evacuated to a vacuum pressure of ≤ 3 torr. Without breaking the connection to the vent port, the cask cavity is then backfilled with high-purity helium (≥ 99.9%) to 1 atm (absolute) pressure. The vacuum pumping and helium backfill system is then disconnected from the vent port quick disconnect fitting. The vent port sealing surface is then inspected and cleaned, as necessary, and the vent port coverplate installed with new metallic O-ring seals. The four coverplate bolts lubricated with Never-Seez or equivalent are then torqued to a final torque of 300 ± 20 in-lb. If the current test and O-ring status of the drain port coverplate is unknown, it is recommended in the latest NRC guidance on ANSI N14.5 practices[46] that the port coverplate be removed, the O-ring grooves and mating seating surfaces inspected and cleaned, and the port coverplate re-installed and torqued to a final torque of 300 ± 20 in-lb.

Final helium leakage testing of the three inner lid cask containment boundaries (e.g., inner lid seals, and vent and drain port coverplate seals) will then be performed using a helium MSLD system to confirm that each containment boundary closure is leak-tight in accordance with ANSI N14.5-2014[46] to a leakage rate of ≤ 2 x 10^{-7} cm^3/s, helium with a minimum sensitivity of 1 x 10^{-7} cm^3/s, helium. Following successful leakage testing, the MSLD will be removed from each component and the leak test port plug will be re-installed with a new O-ring seal and tightened to the designated torque (e.g., inner lid test port plug to 30 ± 3 ft-lbs, port coverplate test port plug to 70 ± 5 in-lbs.).

The next operational sequence to prepare the NAC-STC cask is to install the outer lid alignment pins and install the outer lid with a new metallic O-ring seal to the cask's upper forging. Remove the two alignment pins and install the 36 outer lid bolts lubricated with Never-Seez or equivalent and torqued to a final torque of 550 ± 50 ft-lbs. Attach a supply of air, nitrogen, or helium to the interlid port quick-disconnect and backfill the interlid volume to 15 (+2, -0) psig air, nitrogen, or helium and hold for 10 minutes. No loss of pressure is permitted during the 10-minute test period. Disconnect air, nitrogen, or helium supply. Detach pressure drop test equipment and reinstall the interlid port cover and torque the bolts to 140 ± 10 in-lbs. Remove the interlid port cover test plug and pressurize the interlid port cover O-rings to 15 (+2, -0) psig air, nitrogen, or helium and hold for 10 minutes. No loss of pressure is permitted during the 10-minute test period. Remove the pressure drop test equipment, vent off the test gas, re-install test plug, and tighten the port plug to 70 ± 0.5 in-lbs.

The NAC-STC containment boundary provided by the inner lid closures and secondary boundary provided by the outer lid and port covers is now verified as properly closed and leakage tested.

Following final leakage testing, decontamination of the cask external surfaces would be performed. A visual inspection of the primary trunnion and rotation trunnion recess bushings for general condition and lubrication would be performed, with corrective actions as required. Using the primary mobile crane connected to the NAC-STC Lift Yoke, the NAC-STC primary trunnions would be engaged and the loaded cask removed from the CHF. The cask would need to be moved over to the off-site goldhofer HHT provided with an intermodal transport cradle (or the intermodal transport cradle positioned on the ground) and the NAC-STC lowered until the rear trunnion recesses are seated into the cradle's rear rotation trunnions and fully engaged. Taking precaution to maintain the cask's center of gravity over the centerline of the cranes load path, the NAC-STC would be slowly lowered and rotated into a horizontal position on the intermodal transport cradle. (Note that the rear trunnion recesses are off-set from the cask centerline to assist in correct down-ending). If the cask is loaded on the intermodal transport cradle located on the ground or at the Transfer Station pad, a specially designed horizontal lift beam can be used to horizontally lift the loaded NAC-STC/intermodal transport cradle and place it on the off-site HHT. The NAC-STC lift yoke would be disengaged and placed in a protected storage area in preparation for the next NAC-STC handling sequence.

Once the cask is in the horizontal position, final removable contamination surveys can be taken for areas to be covered by the front and rear impact limiters. The cask tie-down assembly is installed between the top neutron shield plate and the trunnions and engaged to restrain the cask in a vertical orientation. Using the secondary mobile crane and the impact limiter sling set, the front/upper impact limiter is lifted and installed to the lid end of the cask. While maintaining the impact limiter weight on the crane, the 16 impact limiter retaining rods are installed and torqued to 75 ± 5 ft-lb. The 16 impact limiter nuts are installed and torqued to 35 ± 2 ft-lb followed by the impact limiter jam nuts torqued to 75 ± 5 ft-lb. The crane and sling set are then disengaged from the front impact limiter and the impact limiter installation operation would then be repeated for the rear/lower impact limiter. To provide evidence of tampering during transport, security seal wire and tamper indicating devices can be installed between the front impact limiter and the primary trunnion or intermodal transport cradle. The intermodal transport cradle horizontal lift beam is also used to lift and place the loaded intermodal transport cradle containing the assembled NAC-STC package on the railcar at the transload site.

Final radiation surveys are then performed with dose rates taken at the cask surface, 1 meter from the cask surface and 2 meters from the vertical plane of the transport conveyance. The maximum dose rate at 1 meter from the cask is defined as the transport index. All dose rates and contamination surveys must comply with applicable DOT and NRC regulations. The appropriate Criticality Safety Index assigned to the package contents should be determined in accordance with the CoC and indicated on the Fissile Material labels applied to the package. The personnel barrier is then installed and bolted to the transport cradle and the barrier access port is padlocked closed. Appropriate placards are applied to the transport vehicle in accordance with DOT regulations. The final shipping documentation is then completed by the transport specialist including instructions to the carrier regarding the required Exclusive Use Shipment.

6.1.4. Transport Operations

The following permits for transporting the loaded transportation casks from the YR ISFSI to the recommended rail transload location in Westfield, MA must be obtained by the shipper:

- A formal clearance submission would be made to the originating Class I rail carrier. For the purposes of this project, the goal is to deliver the overpacks from the YR to the Class I rail carrier, CSX Transportation, which would clear the entire route with all participating railroads.
- State DOT permits would be required for movement of the HHT from YR to the rail transload facility in Westfield, MA. This would include State and local jurisdictions through which the HHT will travel. State Police escorts will be required in compliance with DOT regulations for movement of dimensional cargo on HHT. These escorts are in addition to those required for security of the cargo.

For the purposes of this report, it is assumed that DOE would be the shipper and that the shipments would be conducted by commercial carriers like comparable commercial shipments. Although typically not required for DOE shipments, for purposes of this report, it is assumed that DOE would file an application with the NRC for an approved rail and HHT routes from the YR to the rail transload and GCUS and the corresponding final destination. DOE Order 460.2B[41] provides information on the management of DOE materials transportation and packaging.

Note: a formal clearance submission to the originating railroad is required for all dimensional shipments[10] on all railroads involved in the full route. With loading at the recommended track location, the clearance will be submitted to CSX Transportation for the rail movement to clear the entire route to the final destination, in this case to the GCUS, including the short line PVRR, which serves the recommended Westfield, MA site.

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

[10] In the rail industry a dimensional load is an oversized or overweight load (for the car on which it is loaded and travels). The definition varies by railroad, but in general any cargo that is (a) greater than 17'0" in height (including the railcar), (b) wider than 11' 0", (c) overhangs the sills or ends of the rail car, (d) is shorter than 18' long, (e) is greater than 60' long or (f) heavier than 220,000 lbs. is considered dimensional. A dimensional load requires an approved clearance granting permission to move the car in a particular load configuration on a specific rail car over a defined route. The eastern U.S. railroads (NS, CSX) have tighter tolerances versus the western railroads (UP, BNSF) due to physical constraints on the infrastructure.

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).[11]
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. These should also include:
    a) A diagram of offsets, ballasts, or any other loading configuration specifics important to the railcar.
    b) Center of gravity measurements and total weight of the unit plus the railcar.
4) A diagram of the unit with 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 railroads 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 railroad 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.

Furthermore, it is recommended that more than 6 months are allotted for the railroad clearance submission process in the event the intended routes have not been approved for previous shipments and the approval process takes longer than anticipated. This recommendation is based on extensive experience in obtaining super-load permits for movements of similar weight and dimensions and HAZMAT (Class 7) shipments. Once the railroad cleared route is approved by NRC, it would be valid and effective for 7 years for rail routes. The NRC would approve routes for a period of 5 years for combination routes (truck-to-rail siding, transloading, and rail to destination). The minimum amount of time to submit cleared routes to the NRC for approval is 90 days; however, it would prefer 6 months.

Once the rail route is cleared by all involved railroads, the clearance is valid for 6 months for railroad purposes and should the campaign 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 any impediment. It is required to be resubmitted after 6 months to ensure no changes have taken place on the rail

[11] Note: Although DOT regulations in 49CFR172.820 require the railroad to determine the routes it can use for transporting highway route controlled quantities of radioactive materials, the first screening will be determined by the clearance because this is a dimensional shipment. The shipper is allowed and is encouraged to select a desired route for the movement. Once the clearance is issued the railroads in the route will confirm the cleared route is acceptable to move HRCQ materials. In addition, chain of custody rules will influence manned interchanges between railroads and if required, needed or desired based on the clearance, new interchanges may be established.

route that would affect the ability for the dimensional load to pass the route safely without impact (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 in the opposite direction.

Once the selected rail route is approved by all carriers in the route, the shipper will submit the route to the NRC for approval. NRC approval of routes is 5 years and 7 years depending on if the route is a rail direct or transload route.

Any time a route condition changes or needs to be altered on an approved route, the shipper must notify the NRC and submit an amendment.

Road permits would be required for movement of the cranes and other equipment to YR to be used for lifting or transloading the transportation casks onto the HHT at the ISFSI. 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 of the equipment to be used in the on-site operations. These escorts are separate than those required by the regulations for LLEA for safety and security purposes.

In addition to the equipment moving to YR for the transload, any oversized equipment like cranes would require road permits from the leasing location to travel over the road to Westfield for use in the rail transload facility. Depending on the size of the crane, private escorts and State Police escorts likely will be required in accordance with the road permits for the State and jurisdictions the trucks will travel through to reach the Westfield.

Coordination with Mode of Transport

This section provides a description of activities necessary to coordinate with the site owners in preparation for the transport activities. The actions necessary to prepare for and remove the SNF from YR are listed as tasks in **Table 6-3**. These identified actions are based on the assumption that DOE, or another management and disposal organization would be responsible for shipping to and operating the 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.

Table 6-3: Transport Related Activities to Prepare and Remove SNF and GTCC LLW from YR ISFSI

Task		Task Activity Description
Programmatic Activities to Prepare for Transport Operations from a Shutdown Site		
1	Assemble Project Organization	Assemble management teams, identify shutdown site existing infrastructure, constraints, and transportation resource needs and develop interface procedures.
2	Acquire Casks, Railcars, Ancillary Equipment and Transport Services	Develop specifications, solicit bids, issue contracts, and initiate preparations for shipping campaigns. Includes procurement of transportation casks and revisions to CoC as may be needed, procurement

Task		Task Activity Description
		of AAR Standard S-2043 railcars, and procurement of off-site transportation services.
3	Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport for shutdown site.
4	Coordinate with Stakeholders	Assess and select routes and modes of transport and support training of transportation emergency response personnel.
5	Develop Campaign Plans	Develop plans, policies, and procedures for at-site operational interfaces and acceptance, support operations, and in-transit security operations.
Operational Activities to Prepare, Accept, and Transport from a Shutdown Site		
6	Conduct Readiness Activities	Assemble and train on-site operations interface team and shutdown site workers. Includes readiness reviews, tabletop exercises and dry run operations.
7	Load for Transport from ISFSI to off-site Transload Track for Loading Rail Cars	Load and prepare casks and place on HHT for the off-site transportation to the recommended rail transload facility in Westfield, MA
8	Transmit DSC load reports and transportation related documents	Assemble DSC load reports and the applicable transportation documents and transmit to the rail transload facility.
9	Accept for Onsite Transport	Accept loaded casks on HHT for off site transportation to rail transload site.
10	Transport	Ship shutdown site casks.

Description of activities necessary to coordinate with heavy-haul providers:

- All diagrams, including dimensions, center of gravity and weights must be collected, preferably in CAD format.
- Any lift diagrams or transport diagrams should be collected.
- Anything out of the ordinary on the anticipated route or in the geographical area should be communicated to the trucking company for consideration and inclusion in the road route survey.For example, schools along the route may impact hours of operation in that jurisdiction, if known. Otherwise the route survey will identify these factors.
- Route surveys will be conducted by the trucking company to identify any encumbrances along the routes and develop any alternate routes and contingencies, including safe havens as required by regulation. Overhead wires, bridges, overpasses, etc. will be measured and noted for engineering checks for weight restrictions, spanning, etc. Trucking companies

charge for conducting route surveys and this charge generally includes obtaining initial permits for the movement. This would include an engineering review or new assessment of the spillway bridge and the dam to make sure the HHT can safely cross those structures without causing damage to them.

- The information gathered by the trucking company will be used to develop accurate engineering drawings of the cask and skid on the specific piece of equipment being used for the movement and the resulting diagrams will be part of the submission for HHT truck permits.

- Securement information, including weights of the components in transport configuration plus the weights of the trailers, will be used to determine and verify vehicle axle weights to meet permitting requirements for the roads being traversed.

- The transporter and project personnel must coordinate with state and local authorities to determine the routing (similar to a railroad clearance)

- The local utilities must be brought into the work plan for overhead and underground clearances.

- The approve route survey, including the DOT inspections, securements, routing issues (obstructions, bridge reinforcement, etc.), document checks, notifications, and briefings will become part of the Transportation Plan.

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 plan. 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 company. This information will be used for plan development, including crane selection.
- Crane company/riggers would physically survey the items to be lifted, 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 would ensure all aspects of the lift and securement plan are considered and planned.
- A timeline would be established for mobilization of all required equipment including all standard rigging tools, forklifts, etc., to make sure all equipment is in place and tested prior to the start of the operation and test lift.

Description of Activities Necessary to Coordinate with Transload Site:

The private rail siding at the recommended loading location is in Westfield, MA. It is directly rail served by a short line, the PVRR. This location is unique due to several factors including: the commodity currently being manufactured at this industrial site; the 24/7 security including guards on site; the entire complex is fenced and lighted and, the rail infrastructure is currently being expanded within this secure area to allow for independent loading on a separate track which would not interfere with current and projected transload operations for the site.

Since this is an active business, some coordination will be required between the operating plant and the on-site Rail Transload Area to ensure cask loading operations, release of the loaded train and placement of the empty train will not interfere with normal plant operations. The PVRR conducts some transload operations on site and is expanding the track and adding an additional switch. The railroad is eager to expand the operation and allow an independent company to lease the new track and conduct transload operations on site for a shipping campaign. Arrangements must be reconfirmed, and rates negotiated for the use of the rail and property required for the transload at the time the campaign is to commence. Permission of the owner of the site would also be required.

Meeting with the railroad 6 months prior to beginning the loading operation would allow for coordinating and planning with the railroad to set expectations for service level requirements and crew staffing for the additional rail service required to meet the desired shipping schedule and to plan coordination activities to avoid congestion with any planned inbound or outbound cars being delivered to or shipped from the site. Special considerations and possibly budget concerns would need to be addressed by the railroad to ensure it has the available crews to run a dedicated train and is willing to do so. Knowing how many trains will be handled and with what frequency will be important to the railroad. Other items to discuss would be security requirements for the crew entering the site, describing the intended loading operations, planning for the placement of the empty train, inspection of the loaded train to ensure compliance with the approved clearance, and all other operations including establishing the mechanics for pulling the released train from the site and planning and coordinating the interchange with the Class I railroad. This interchange is already an established interchange point between these carriers which takes place at a yard 1.5 miles from the recommended Rail Transload Facility

Due to the nature of the product being manufactured today on the Westfield site, it may already be designated as a Rail Secure Area. Conversations with the owner of the site would be required to determine if this designation is already in place. If so, the SNF transload operation may fall under the site designation and the plan may only need to be revised.

- If the designation is not in place or it is not practical to make additions to the site plan, shipper would develop a Security Plan for the rail transload site and notify the serving rail carrier, PVRR, of the existence of the plan and provide a contact name and number for the transload site operations. Provide proper notification that the transload site will be designated as a "rail secure area", which is based on the HAZMAT category of the commodity being loaded. The railroad does not need to approve the plan, but it must be notified it is in place and there is an identified contact available at the transload site.
  - 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 railroad of the level of preparation and operations planning for the campaign.

  - Again, this would require communication and coordination with the site owner.

- Determine if railroad police will be present during the manned interchanges and any other stops along the route on the way to the destination. This includes the entire route. They 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. At this time, the PVRR does not have a railroad police force. Railroad management personnel and the Class I railroad police will be present during the manned interchange between PVRR and CSX at Westfield
- Hold initial meetings with the Class I carrier, CSX Transportation, to explain the movement, provide estimated number of trains to ship, discuss the dedicated train requirement, manned interchange requirement and begin rate negotiations for the trains.
- Mention current safety and security measures for the site to PVRR to ensure the railroad is aware of special considerations and operating procedures in case it has no familiarity with these requirements as it does not currently serve other customers where these procedures are in place:
  - Note and discuss safety features that will be added to the site: fence, lights, defined perimeter, etc.
  - Discuss requirements of crew entry into the site (Transportation Worker Identification Credential (TWIC) cards, training, etc.).
  - Discuss manned interchanges with the railroad and record keeping requirements.
  - Discuss normal times of operation for the established plant and any extensions in hours the plant has granted to the shipper for the transload campaign. Coordinating operations hours and access to the plant is important for planning release of the loaded train and consideration of the current rail operations on the division and normal operating parameters at the plant.
  - Open communication with all rail carriers in the route to ensure a smooth transition at any interchange point. In this case, only one Class I railroad is involved in the route to the GCUS.
  - Hold initial meetings with the local trainmaster and safety manager to discuss intended operations and parameters for operations, even though the transload is taking place inside a private and secure site.
  - Communicate that all requirements have been exceeded for the intended site and operations.

Transportation-related Operational Readiness Items

Equipment readiness is determined through review of the:

- Insurance requirements of the contract are in place.

- Transportation equipment certifications are current and would be for the duration of the transportation cycle.
- All vehicles have required registrations (as applicable).
- All vehicles have current inspections.
- Radiological packaging meets all current requirements.
- Packages are correctly identified; all required markings and placards are properly displayed and are available at the site prior to beginning the operation.
- Inspections for equipment to be utilized to handle and transport the loaded transportation casks to the on-site rail siding have been conducted and copies provided.

Transportation Personnel Readiness:

- Identify key personnel and their qualifications.
- Ensure required background checks are current and requirements of coverage of drug and alcohol programs are met.
- Provide copies of the training materials and ensure required trainings are current for all employees involved.
- Provide copies and ensure that all personnel are in possession of and working from the correct procedures and RWP.
- Ensure all private security personnel have required weapons certifications to cover the transportation cycle.
- Ensure the transportation personnel would be monitored for radiological exposure, if required.
- Ensure proper equipment and personnel are available to monitor workers for contamination, if required.

Transportation Readiness Notifications:

- Provide copies and ensure proper notifications have been made to the applicable Tribes, NRC, State and local governments, DOT, USCG, and DOE as applicable.
- In compliance with the regulations, the security team must be on the site once the transportation casks begin to arrive.
- Provide copies of and ensure all required permits to transport SNF are prepared and/or in place. This includes all HHT road permits.
- Ensure proper notification requirements are being met for the disposal/storage facility as well as all other Advance Notification requirements.
- Identify scheduled meetings and briefings that would be conducted for all phases of the shipments.

Off-Site Movement to the Transload Facility

Once the transportation cask is loaded onto the HHT (goldhofer) at the YR ISFSI and the cask leak testing completed, it would be secured by the site operations personnel. The State DOT inspection is ordered and conducted in preparation for the off-site movement to the rail transload site. In accordance with the issued road permits for the dimensional movement, State Police escorts and private escorts are required for the off-site road transport. The security team may be in addition to the State Police escorts. The HHT would proceed to the exit at the designated time stated in the road permit and would leave the site with the escorts traveling on the approved permitted route to Westfield, MA.

The hours of operation [12]for the transport will be listed on the issued truck permits, which dictate the number of casks that may travel in one day along the specific route. For purposes of this report, the assumption is that one cask per day will move from the ISFSI to the rail transload site (one to move every three days). Local law enforcement personnel or the private security team would provide the physical protection of the load during the 68-mile transport to the rail transload site in Westfield, as applicable.

Prior to any transportation operations from the ISFSI to the rail transload site a pre-job briefing with the operations staff would be provided. This briefing would be conducted to review procedures, 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. Once the briefings have been completed, the transportation team would be assembled and staged as directed by the transportation supervisor.

The HHT will exit the YR ISFSI gates and proceed along the approved permitted route moving into place parallel to the crane which will be positioned next to the rail track. No stops are anticipated during the short 68-mile transit. [13]

Shipment speed, route, and duration would be monitored and controlled as dictated by road permits and procedure and managed by the transportation supervisor.

Performing the Off-Site Transload from HHT (example: goldhofer) to the Railcars

The loaded HHT would meet the crane at the rail transloading track where the empty train is already staged. The HHT will park parallel to the crane, which is positioned along the rail track, and the tie-downs of the intermodal transport cradle are released from the HHT. The crane will lift

[12] Multiple types of equipment and various configurations are available in this area and are acceptable for movement of these casks over this terrain. Specific equipment will be determined at the time of the physical survey; however, it is a general assumption of these studies that for road hauls a 12-line 2-file wide Goldhofer THP/SL with ADDrive hydraulic platform trailer will be used. If amenable to the operation, *more than one could be planned for* and they would move in tandem. Actual permit investigation revealed that four casks could be moved in two days if two were to move in tandem to the Westfield rail transload location. Additionally, this saves cost on equipment mobilization. Anticipated actual transit time from the permit investigation is movement from YR to Westfield in 6-8 hours, for this equipment.

[13] In the trucking industry any movement under 150-250 miles is considered a short-haul movement, especially for dimensional or oversized cargo. FMCSA defines a short-haul driver as one who travels 100-150 miles/day. A long-haul driver is a driver traveling 250+ miles/day.

the intermodal transport cradle containing the loaded package including impact limiters using the horizontal lift rig and set it in the identified position on the railcar deck. The intermodal transport cradle will then be secured to the railcar deck in preparation for transport in accordance with the AAR OTLR restraint requirements. The fixture placement on the railcars will be carefully measured to ensure the center of gravity of the unit rests exactly on the centerline of the railcar for maximum stability and to conform with the approved clearance window for the rail shipment.

The HHT will then be loaded with an empty cask contained on an intermodal transport cradle from a rail car and returned to the YR ISFSI and the cycle will be repeated until all four casks are delivered to the rail siding. For purposes of this study, a second HHT will be planned for the campaign and will be loaded at the YR ISFSI while the first transportation cask is being transferred to the railcar at the transload site.

Performance of a visual inspection of the installed transportation casks, intermodal skid, impact limiters, and personnel barrier assures that it is assembled correctly and in an unimpaired physical condition. The visual inspection includes checking for cracks on the intermodal skid main beam web-to-flange-welds, the beam webs, plus checking the tie-down structure for any signs of distortion or failure.

Once the transportation cask is secured to the railcar and external inspections of the transportation cask and the loaded train is completed, the Rail Transload Facility Supervisor would request the railroad inspection. Once the inspector measures and approves the cars for shipment, the Rail Transload crew would air test the train if air brakes were on the train and perform a visual inspection of the train's safety devices. The appropriate party would issue the electronic bill of lading (BOL) to the serving railroad, the PVRR, prior to the train being released which is required for rail movement of HAZMAT cars and trains.

The crew would 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 would also record any impacts (from switching, etc.) that occur at more than 4 miles/hour. Impact recorders are not required by regulation or the railroads 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 railroad.

Once 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 railroad, PVRR, notifies the rail transload facility of the intended switch time, the train will be prepared for movement from the private loading track. Upon arrival of the PVRR train crew, 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 CSX train crew. The chocks would be removed, and the locomotive(s) would attach to the loaded train and pull it 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.

The railroad and Transload Facility Manager would document the manned interchange in writing.

The PVRR train will leave the facility with the loaded train and proceed to the interchange point with the Class I carrier, also located in Westfield, MA, 1.20 miles from the rail transload site. CSX Transportation crew and railroad police will await the arrival of the PVRR train to conduct the manned interchange. The anticipated travel time from the rail transload site to the interchange point is 20 minutes. No stops will take place from the time the train leaves the transload facility until it reaches the interchange with the Class I carrier. Upon arrival at the interchange, the PVRR 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(s). The Class I carrier will provide advance notification to the GCUS location to coordinate the arrival and manned delivery to the GCUS. It will proceed to the GCUS with only stops for refueling and crew changes at which time railroad police will guard the train during these minimal stops. An estimated transit schedule would 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 GCUS, the CSX Transportation train crew will document the manned interchange, deliver the loaded train to the designated track and receiving railroad then disengage its locomotive(s).

6.1.5. Demobilization

Once the TSC de-inventory project operations have been completed, demobilization would commence. This is the process of removing all the equipment and materials used during the operation at the YR ISFSI site and returning it to its proper owner in accordance with rental or 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 TSC exterior surfaces are potentially contaminated as discussed earlier, large components, such as the TFR, transfer adapter, lift yokes, etcetera would be decontaminated, approved for free release, and returned to the owner(s) for storage. Specialized equipment, e.g., the VDS, leak test systems, air pads, jacking systems, would be decontaminated, returned to the owner, and placed into storage.

The train with empty fixtured transportation skids (for some casks) would be returned intact to its storage location (or directly shipped to the next loading location) from the disposal site at the completion of the shipping campaign, in accordance with the release criteria established by DOE. It would likely move in regular train service, which may take a few weeks depending on the distance and route dictated for the movement. The option to reposition or demobilize the train equipment via special train is always available to the shipper. For other casks, the transport packaging, transport cradles/skids, lift yokes, and other equipment the like would be decontaminated, placed in an assembled condition, and returned to DOE for storage and maintenance.

The CHF would be disassembled, decontaminated, and crated for storage for next use on another site.

Demobilization of ancillary equipment from each site would be accomplished in the same manner as it was mobilized. Trailers used to transport the VCCs would be surveyed for contamination, broken down, and loaded onto flatbed trailers when required for return to its owner. Forklifts, man lifts, 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 in accordance with the road permits to reach the next job 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 lessor.

The empty VCCs would remain on site for disposition by YR as potentially contaminated and activated materials. In addition, the ISFSI site would be decommissioned in accordance with NRC and site regulatory requirements.

6.2. Resource Requirements / Staffing

Personnel required at the YR site:

- Operations Manager (OM)
- Cask Operations Shift Supervisor (COSS)
- 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
- Cask Operations Technicians/Mechanics
- Tractor / JCB Driver and Equipment Operators
- QA/QC Specialist
- Security Personnel

6.3. List of Ancillary Equipment

Additional ancillary equipment that will be needed through-out the de-inventory process are given in **Table 6-4**, **Table 6-5**, **Table 6-6**, and **Table 6-7**.

Table 6-4: Additional Equipment for YR Site Transfer

Additional Equipment for YR Site Transfer	
Primary Mobile Crane (375-ton)	Required for vertical lifting and movement of the YR TFR, the vertical lifting and movement of the NAC-STC, the upending and down-ending of the NAC-STC from and to the intermodal transport cradle/frame located on the railcar or HHT, or on the ground and subsequently lifted horizontally and loaded onto the railcar and/or HHT.
Secondary Mobile Crane (150-ton)	Required for lifting ancillary items, such as the VCC shield plug, VCC lid, transfer adapter, NAC-STC inner and outer lids, transport impact limiters, and personnel barrier
Man basket/ lift	Capable of accessing the top of the YR TFR when in stack-up position on the VCC or NAC-STC will be required for retrieval of the TSC lifting slings
Lifting Rigs	See **Section 2.3** for details
Standard rigging and supplies	See **Section 2.3** for details
Lifting Jacks / Air Pad Rig Set / Diesel-Powered Air Compressor	See **Section 2.3** for details
Standard tools	These include personal protective equipment (PPE), communications equipment, wrenches, etc.
Telescoping Hauler / Forklift	Used to assist handling of VCC with air pad system

*Note: the listing and description of all equipment and systems required to safely transfer the YR-MPC TSCs from onsite storage VCCs to NAC-STCs are provided in **Section 2.3** of this report.*

Table 6-5: Off-Site HHT Transport

Off-Site HHT Transport	
1 Goldhofer or equivalent heavy haul trailer	Final size to be determined by the road survey, assuming use of 12 lines for this activity.
1 Truck Cab- Prime Mover	To provide motive force to goldhofer
Pusher	Depending on HHT equipment and the selected road route, an assist vehicle may be required for steep grades
Standard tools	These include PPE, communications equipment, wrenches, etc.

Table 6-6: Equipment for the Transload Facility

Equipment for the Transload Facility	
Crane: 350-ton mobile crane	Crane would be used to conduct lift operations removing the NAC-STC package and intermodal transport cradle combination from the trailer and placing it onto the railcar.
Large forklift	Used to move heavy equipment and welding machines on site, pick up and relocate heavy objects, and reposition train if required.
Man basket	Used to inspect and measure the loaded rail cars to ensure compliance with the clearance window and to safely extend reach of humans for any required reason.
Welding machines	Use 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.
Standard tools	These include PPE, communications equipment, wrenches, etc.

Table 6-7: Rail Equipment (per Consist)

Rail Equipment (per consist)	
Locomotive(s)	Dedicated for the train movement and at least two to be AAR S-2043. compliant.
Buffer cars	Used to provide buffer between loaded overpack cars and all other cars.
Overpack cars	Heavy duty flat cars.
Escort car	Houses the armed security team and will meet the portion of AAR S-2043 applicable to escort cars.
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 overpack 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 railroad 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**.

For the onsite loading sequence, it is estimated that 3 x 10-hour days per TSC will be required to move the VCC, off-load the NAC-STC transport cask, retrieve the TSC from the VCC into the YR TFR, load the TSC into the NAC-STC, close and prepare the NAC-STC for transport (e.g., evacuation, helium backfill, leakage testing), placement of the loaded NAC-STC on the transport vehicle/horizontal transport cradle, release for transport, and move the empty VCC back to the ISFSI pad, plus 2 days for HHT transport to the transload facility, transfer and securing the loaded NAC-STC to the rail car, loading an empty NAC-STC transport cask/cradle onto the transport vehicle, and returning to the site. Therefore, for a 4-cask train, approximately 20 days (3 weeks) will be required per shipment.

Prior to the start of site operations, new site procedures or current site procedures would be required to be prepared or revised and approved by YR ISR as follows:

- Pre-Use and Periodic Inspection Instructions for YR TFR, VCC, NAC-STC, YR TFR Lift Yoke, NAC-STC Lift Yoke, and Horizontal Lift Beam
- De-inventory Project Conduct of Operations Procedure
- VCC Movement Operations

- TSC Unloading Operations from VCC
- TSC Loading Operations into NAC-STC
- NAC-STC Leakage Testing Operations
- NAC-STC Lifting, Handling, and Preparation for Transport Operations
- CHF Operations
- TSC, VCC, TFR, and NAC-STC Dose and Removable Contamination Survey Procedure
- Contingency Procedures
- Training Course Description for YR De-inventory Project
- TSC Transfer and Loading Job and Task List
- NAC-MPC / NAC-STC General Cleaning Procedure
- Control and Calibration of M&TE
- FME Procedure
- Document Control and Records Retention Procedure
- OJT and Evaluation Procedure
- Site Materials Control Procedure

The sequence of operation timeline, **Figure 6-1**, outlines the operations associated with the facility at the YR site, the short on-site heavy-haul transportation operations and off-site heavy-haul transportation services to the recommended off-site rail transload facility in Westfield, the transloading operations at the at the off-site railcar loading facility, and the manned interchanges between the Class III and I railroads. Note that some operations could be completed concurrently (equipment staging and some inspections) to reduce time, but this was not considered in the development of this timeline. Transfer operations at the YR site would include the overpack handling operations to transfer the overpacks and preparation for shipment. The transit times listed in **Figure 6-1** are provisional and may change as route details and operations are better defined. The on-site transfer and loading of the TSC from the VCC to the NAC-STC and transport vehicle is estimated to take approximately three 10-hour days per NAC-STC. Transport of the NAC-STC packages from the YR site to the off-site rail siding, conducting the transload from the HHT to the rail cars, and securing the NAC-STC package/intermodal transport cradles to the railcars and returning an empty NAC-STC to the site will take approximately 2 additional days per cask for 20 days (3 weeks) total per consist. The total evolution from the initial transfer of a TSC from a VCC to a NAC-STC to the return of the empty NAC-STCs to the YR ISFSI takes approximately 40 days.

For the resources estimate, the timeline of the operations can be broken down into 4 shipments of 4 packages over a period of approximately 5-½ weeks per complete turnaround as shown in **Figure 6-1** and staffing requirements per **Table 6-8**. An additional 8-9 weeks of planning and preparation is added before the start of the first campaign.

Figure 6-1: Sequence of Operations

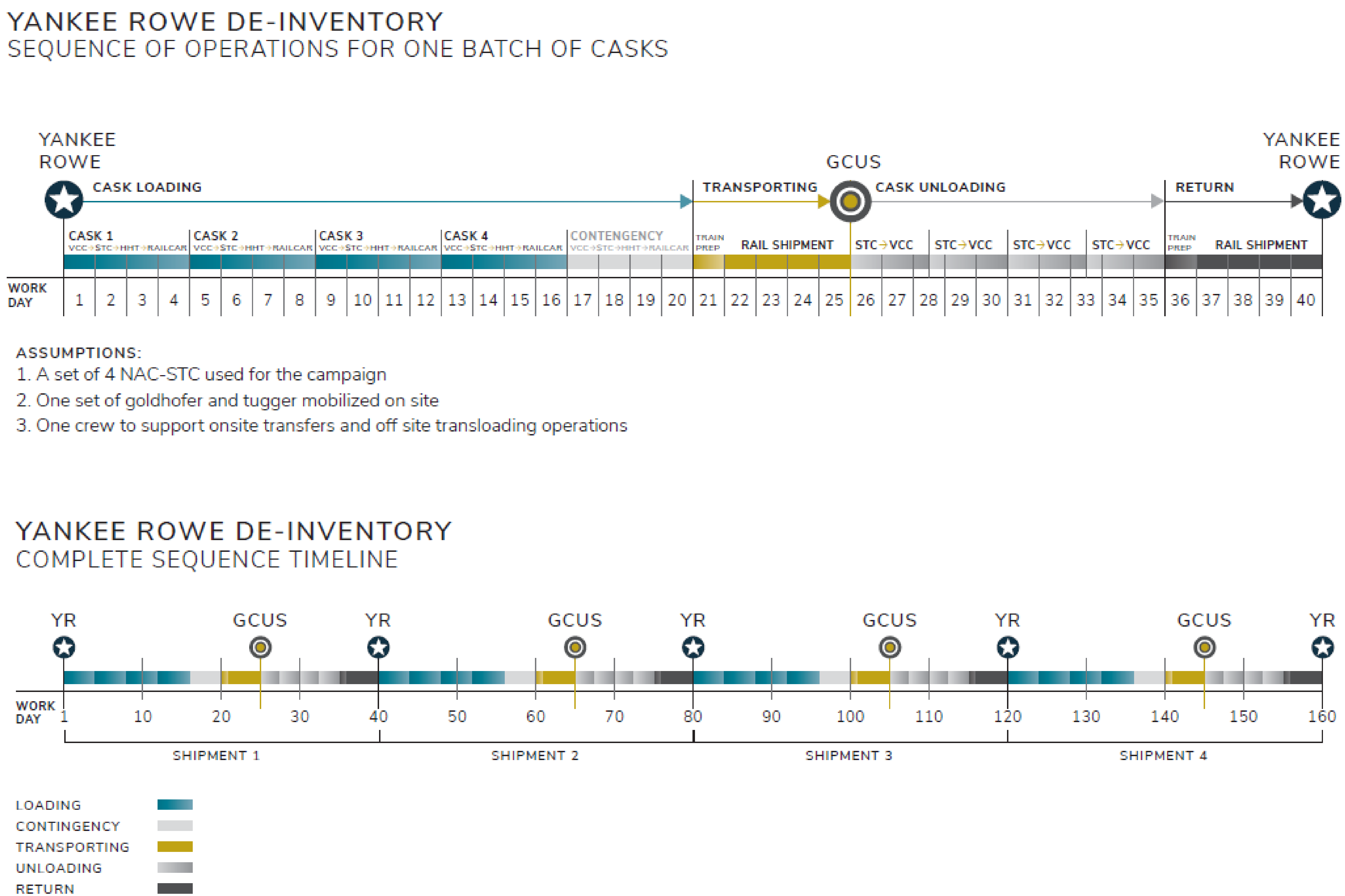


Table 6-8: Operations Timeline with Required Resources

	Major steps for a 16 TSC campaign	Resources required [in full-time equivalent]*											Estimated Duration (in days)
		OM	COSS	TS	PW	RP	TC	CO	RM	EO	QS	SP	
1	Detail planning of the operations, preparation of the campaign, mobilization of the equipment, procedure preparation and approval, training program, and pre-loading review(s) and dry run(s)	1	2	1	2	2	1	2	6	2	1	3	65 days (8-9 weeks) prior to start 1st campaign
2	Onsite transfer of the SNF and GTCC canisters and preparation of the 5 packages, HHT transport to a transload facility for loading on rail cars and release for transport	1	2	1	1	2	1	2	6	2	1	3	20 days per 4 cask campaign
3	Shipment to destination	0.5			1		2						5 days per 4 cask campaign
4	Unloading	0.5	1		1	1	2						10 days per 4 cask campaign
5	Return transport of empty casks	0.5			1		2						5 days per 4 cask campaign

***Key:**

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

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 measures 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 work site that involves handling and loading operations would be considerable. Stranded sites that are no longer fully 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
- 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 Part 20 and 10 CFR Part 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 two RCTs per shift)
- Sufficient quantity of radiation control equipment and consumable supplies on hand to support the planned work activities (PPE, signage for posting, radwaste 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
- 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 Program (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.

Fabrication of important safety components and support equipment for the NAC-MPC 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[48] and NUREG/CR-6407[49] 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 YR campaign organized over 32 calendar weeks is $9.0 million. 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 at the time the data was gathered for this report (2022). This section provides a breakdown of the estimated campaign costs of the de-inventory of the YR 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.

Assumptions:

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

1) A fleet of NAC-STC is considered in the report as suggested in **Section 6.1**.
2) A set of 4 NAC-STC transport casks, 4 pairs of impact limiters, 4 personnel barriers, 4 transport cradles are provided by the cask vendor. Ancillary equipment to prepare the transport cask for transportation (tooling, lifting yoke, spreader bar, leak test equipment, VDS, etc.) will be supplied by the cask vendor. No estimate is provided here.
3) The cask railcars, escort car, buffer cars, locomotives, etc. are provided by DOE. No estimate is provided here.
4) 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.
5) It is assumed that no covered building would be used at the designed transload location. No cost for a new building construction is considered here.
6) Train delivery to the final destination and return shipment of the empties by train are not included. For scheduling purpose, the destination is considered to be GCUS. Only the cost of the loaded casks transports from the origin site to the Class I railroad is included.
7) Assumptions are made based on the current status of the origin site and current understanding of the operation. Some pieces of equipment are not designed yet, and no reasonable assumptions can be made at this point.
8) No additional onsite fencing and lighting is considered.
9) A total of 4 iterations of 5-½ calendar 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 5-½ weeks duration.
10) Pre-loading canisters inspection activities are not included in the cost estimates
11) Does not account for potential impact of additional specific local regulatory requirements, if applicable, and assumed labor performed by vendor-approved specialists.

12) The YR-TFR to be mobilized for this effort already exists at an affiliated site. Component costs are thus considered to be negligible and only mobilization and demobilization costs are factored here. These mobilization and demobilization costs will be minor when compared to the rest of the mobilization scope.

7.1. Fees and Permits

An estimated trucking permit fee of $5,000 per move for the loaded casks is included here. The permit may cover the dimensional aspects that may apply at the time of the transport. Additional permits may be required for the mobilization of the transfer equipment and are already included in the mobilization cost.

A physical road survey would be required which will likely include engineering costs to confirm structural capacity and soundness of the bridges and dam. The cost for this road survey is not included here and would have to be assessed when the transport is scheduled.

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.

The State where the HHT is required to reach the rail transload site will require truck permits from YR to the identified transload sites. The State will require State Police escorts for the dimensional portion of the load, as well as private escorts in accordance with the individual state heavy haul requirements.

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 32-week campaign is $0.6 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, operators for 32 weeks at the shipper site, one large forklift, two-man baskets, three welding machines, miscellaneous supplies, air pads and compressor, a telescopic handler and the mobilization/demobilization of the equipment would be approximately $2.1 million for the duration of the campaign.

Additional equipment is also necessary for the transfer of the TFR, including the YR-TFR system. No lease cost is included here as it is assumed here that this equipment would be borrowed from another site. The mobilization and demobilization costs of this equipment is estimated to be $0.9M.

No cost for a new building is considered here.

7.4. Site modifications

The design and construction of a new TSC transfer pad to support the operation as described in **Section 6.0** is estimated $1.0M.

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 at $500,000 for the movement to the Class I railroad for the campaign and the security at the transload location. 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 railroad clearance and inspection fees are also included.[14]

A HHT and tugger, 350-ton crane, a large forklift, and a man basket (detailed in **Section 6.0**) will have to be mobilized and leased for the duration of the campaign. HHT transportation costs and security team costs are included for the truck movements from YR to Westfield, MA. In addition, the rail transport from the transload location to the Class I railroad is included here.

The estimated costs for the cask transportation services are $2.2 million for the entire campaign.

7.7. Onsite Operations

The shipping site operations would be composed of the crew listed in **Section 6.2**. The estimate for the whole crew for the onsite operation is $1.7 million for the entire campaign.

7.8. Breakdown of the Costs by Activity

This section provides a breakdown of the estimated $9.0 million cost to de-inventory the YR site, by activity, and to the extent cost information is currently available.

- Equipment (e.g., transportation casks, railcars, cranes, movers, etc.): >$3.0 million (cost of casks and railcars is currently unknown)
- Transportation services and security: $2.7 million
- Management and labor: $2.3 million
- Infrastructure: $1.0 million.

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 and include: 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 is based on costs in the current quarter of the calendar year (2nd quarter of 2022), 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 NAC-STC) and are similar to one another.
- The maintenance activities projected for the railcars are representative of DOE's in-progress 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 YR ISFSI and the portion of the facility and communication equipment needed to support the shipments from the YR 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 Class I movement of a single rail consist from the nearest class I site to the GCUS site, which is a point-to-point distance of approximately 1,052 railroad miles, costs were developed to be comparable to current market rates for radioactive materials rail shipments and include:

- Freight Costs per Special Train Consist
- Current Fuel Surcharge Costs
- Total Estimated Costs.

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 trainings.
- 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 (railroads, trucking companies, etc.), the 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 documentations.
- 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 safeguards information, and appropriate training. Additional emergency training such as Federal Emergency Management Agency training would also be useful.

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, four cask cars, and one escort car and dedicated to the de-inventory of the YR ISFSI, as opposed to costs associated with maintaining a fleet of rail cars 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 railroads 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.
- Cask car (12 axles) maintenance costs.
- Escort car (4 axles) maintenance costs.
- Costs associated with administering a fleet maintenance program are not included.

The above costs associated with the maintenance of a fleet of rail cars 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 included in the above costs. However, these costs are estimated to only cover the cars in use for the de-inventory of the YR ISFSI, rather than the costs associated with establishing and maintaining a facility and fleet for the larger inventory of rail cars 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 rail cars considering:

- Administrative costs.
- 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 railroad and a portion is covered in freight rates. 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. 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 and locomotives.

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 with 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.

8.0 SECURITY PLAN AND PROCEDURES

The purpose of a Security Plan is to provide an overview of the direction and control for the safe and secure transportation of HAZMAT.

A Security Plan would encompass strategies and procedures in compliance with 49 CFR Part 172. It ensures the safety and security of the material, employees, and the public during loading, truck transportation from the ISFSI, transloading activities, and rail movement associated with the transportation of the SNF and GTCC LLW from the YR site to the final destination and the security of this shipment.

The transportation activities covered by the plan would include the shipment, by HHT/transport trailer of the transportation casks from the YR ISFSI site approximately 68 miles to the designated rail transload site located in Westfield, MA at a secure site. This is the location where the train will be loaded and shipped by rail to the hypothetical destination of the GCUS.

The basic statute regulating HAZMAT transportation 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.

The entities with jurisdiction over commercial transport of SNF in the U.S. include: the NRC and the DOT. The DOT's PHSMA issues the Hazardous Materials Regulations in 49 CFR Parts 171-180 and represents the DOT in international organizations. Another organization that would be involved in the transportation of overpacks from the YR ISFSI site only in the event of a transload on a water served facility (port location like Albany Port), would be the USCG. Barge is not the recommended mode of transportation for this shipping campaign; however, in the event of selecting a water movement (barge or vessel), or utilizing a water-served or water adjacent site (including one on a navigable waterway), the USCG would be involved. The relevant regulations addressing the security of SNF during transportation include 49 CFR Parts 172-177; 10 CFR 73.20, 73.37 and 73.72 (advance notification); and 49 CFR Part 172, Subpart I.

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: PHMSA, Federal Motor Carrier Safety Administration (FMCSA), FRA, Federal Aviation Administration, TSA, 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. The Maritime Transportation Security Act of 2002 (MTSA) is assumed to govern any water-served site, including a transload location located on the water, even though the recommended mode of transportation may be direct rail from the ISFSI (non-water served) site to GCUS. Any site, whether private or public, that is on or adjacent to water will be governed by the USCG regulations and it is assumed that MTSA provisions apply. The local Captain of the Port (COTP) may designate the area a Safety Zone during loading operations as a means of providing an additional layer of security to the sites during transload operations.

Given the geographic location of the site, which is far removed from any water access, MTSA will not apply to shipments from YR unless a water served[15] transload facility is utilized. Only in that event would additional security precautions be implemented for the transload site to ensure a secure maritime area for the transload. In consultation with the USCG, a facility security plan should be developed as described in the MTSA for the transload site or port.

For the rail-served transload site located on the private PVRR served site, the railroad will be notified the site is being declared a “rail secure area” because of the transload operation, as required by regulation. Considering the fact owner of the Westfield facility is manufacturing weapons and a rail siding already is on site, it is likely the location is already established as a " rail secure area" site. There is 24/7 security in place due to the commodity being handled on the property.

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, supplemented by training to its contents. 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 highway route controlled quantities (HRCQ) of radioactive materials, and must address the identified risks including security while the material is en 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 to any water served or water adjacent facility, which does not include the YR facility, although is it located on a dam, or the recommended transload facility location in Westfield, MA; nonetheless, the following information is provided as there is potential for an applicable transload site to be assessed in the future. 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:

- 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 covered by the Security Plan or transport conveyances being prepared for transportation of the HAZMAT covered by the Security Plan.

[15] Whenever “water-served” is mentioned in this report, it encompasses the definition of both a site being located on a waterway, accessible by a waterway or adjacent to a navigable waterway.

- En-route security – measures to address the assessed security risks of shipments of HAZMAT covered by the Security Plan en 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 responsible for implementing any portion of the plan and the process of notifying employees when specific elements of the Security Plan must be implemented.
- Training: A Training Plan for HAZMAT employees in accordance with 49 CFR 172.704 (a)(4) and (a)(5).
- Risk Assessment with details addressing:
    - An assessment of transportation security risks for shipments of the specific HAZMAT listed in 49 CFR 172.800 (includes radioactive materials) and selected mode of transportation.
    - 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. 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.

Each person required to develop and implement a Security Plan in accordance with this subpart 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).

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 the security and risk analysis from point of origin (YR) 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 locations of each pick-up site are determined and the destination for the delivery of the SNF and GTCC LLW is determined, the contractor should then contact all the 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.
- 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. Select the Rail/Truck Transload Site to be Used

The following aspects should be considered when the shipper is initially evaluating potential sites for selecting, establishing or utilizing an existing transload site:

- If an existing site is identified, the preference is that it be a fully enclosed and secure commercial installation or lends itself to be secured; if it is established, these measures must be considered to enclose the site in an effort to create a secure perimeter around the loading location. This will include fencing and lighting the perimeter of the property, installing security cameras and modifying 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. If the USCG has jurisdiction over the site and/or transload locations MTSA is assumed to have jurisdiction and TWIC identification cards would be mandatory for workers.
- 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.

Note these activities take place before the railroad cleared route is submitted to NRC for approval because the dimensional characteristics may limit the routes available for movement.

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 activities to be performed by the RSAT:

- 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.
- The RSAT will be comprised of security and risk professionals from licensee, security contractor, and any Federal and State agency that wishes to participate.
- A security risk assessment of the surrounding transportation infrastructure will be conducted. This includes, but is not limited to, bridges, tunnels, overpasses, proximity to population centers or landmarks, direct route access to the installation, identifying potential bottlenecks, narrow roads, interstate highways, and proximity to hospitals, schools, civic centers, shipping channels, and highly populated areas.
    - The assessment should include a 10-mile area from each side of the center of the proposed transportation route.
    - Contingency routes should also 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:

- Utilize the existing Security Plans of the railroads and trucking companies and rail/truck transfer sites and develop a concise hand off of security responsibilities at each transfer.

- 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" [38] and the Enhancing Security of Hazardous Materials Shipments Against Acts of Terrorism or Sabotage[39].
- Existing site Security Plans (transload locations) will be incorporated into the Security Plan for this campaign/project.
- 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 [39].

8.8. Develop Security and Communication Protocols

Security and communication protocols will be developed as follows:

- All personnel identified above will have background checks completed prior to being included in any communications.
- Administrative Team will determine 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.
- Administrative Team will determine what type of communications can and cannot be used during the entire project.
- Administrative Team will determine what level of distribution will be allowed and how that will be administered and monitored.
- Administrative Team will develop and approve all distribution lists and approved contacts.

8.9. 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[40] and are still in effect. The materials subject to these rules include explosive, TIH, 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
    - 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
    - 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 railroad 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 railroad until the transfer has been completed and appropriately documented by both the shipper and railroad.
- 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[37] (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 railroad may refuse to perform switching services at the facility until the requirements are met.
    - 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 railroad for review or approval, but the shipper must inform the serving railroad that the plan exists.
- All of the above will apply to the SNF rail transload facility.

8.10. 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)[43]:

- Transportation vehicles must be accompanied by at least individuals
    - One serving as an armed escort
    - A second armed member of the LLEA in a mobile unit 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.

- All armed escort are equipped with a minimum of two weapons (as permitted by law); however, 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 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.
    - Escorts must have the ability to call for assistance when necessary
    - Escorts must be provided with a way to quickly develop new LLEA contacts and obtain new route information when unexpected detours become necessary
    - Escorts must be provided a way to coordinate the movement of transport and escort vehicles when more than one transport vehicle is used in the shipment
    - Escorts must be able to reach the emergency phone number provided on the approved route
- 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 a MCC.

The MCC shall:

- Provide positive confirmation of the location, status and control over the shipment, and
- Implement preplanned procedures in response to deviations from the authorized routes,
- 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.

8.11. Provisions for Protection of In-Transit Rail Shipments

The following provisions are required 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).
- Each armed escort shall be equipped with a minimum of two weapons (as permitted by law, but does not apply to LLEA personnel performing guard 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 railroad 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.

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 an HHT or rail 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 [44][53].

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))[44].

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 away 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[53].

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 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.
- 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. Shipper must make sure to provide CHEMTREC with current information on the material before it is offered for transportation.

As noted above, the purpose of the ERP is to establish notification and response guidance in the event of a reportable transportation incident involving an HHT or rail shipment that is transporting HAZMAT material. The plan would include information in compliance with 49 CFR 172.600 to 172.606 (i.e., Subpart G) and other Federal, State, Tribal, 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 YR, on-site HHT/transfer trailer transport beginning with all transfer operations conducted at YR to transfer the overpacks from the ISFSI to the HTT for movement to the off-site rail transload siding in Westfield, MA and, 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 the site to the GCUS or 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. YR Site-Specific Considerations for the Emergency Response Plan

The MUA identified the highest ranked means for transporting the SNF and GTCC LLW from YR by HHT transport to a secure 24/7 rail served site, where loading the rail cars would be conducted at the private facility on its private rail track. The facility is located 68 miles from the YR ISFSI. Even though the secure rail transload site is not located on or adjacent to a U.S. waterway, it may be assumed that MTSA security 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 campaign.

Since the secure rail transload facility is an active private, fenced, lighted and guarded plant with a contained rail siding, there may be additional security measures the private company would impose. Those additional security requirements are expected to be identified at the time the site is being vetted. Because the MUA recommended route does not include a water-served site or transload facility, or mode of transportation, the USCG does not have a role in the security or ERP for these shipments.

The required notification will be given in writing to the serving railroad, PVRR, stating that the rail transload area meets the requirements of a "rail secure area" and contact information will be supplied to the railroad. There is no requirement, as stated earlier, for the railroad to approve the Security plan.

Compliance with MTSA is recommended at this time as a conservative approach to a multi-tiered security plan.

The site Security Plan for YR is as required by 10 CFR Part 73 and is comprehensive and encompasses various protection measures for the vital areas of the site, including the ISFSI. The site Security Plan should be updated to include the on-site ISFSI loading operations to HHT and preparation for the offsite movement to the rail transload facility to ensure compliance with the regulations concerning RSSM.

In October 1992 the NRC approved the proposed changes to the security and ER plans and YAEC implemented Yankee Nuclear Power Station Defueled Emergency Plan. In November 1992 the NRC also approve the proposed changes to the security plan for the site and granted exemptions from certain requirements of 10 CFR 73.55. Although future changes to the defueled security plan may be made under 10 CFR 50.50 without prior NRC approval both plans should be reviewed to see if additional considerations should be made to accommodate for the increase activity at the YR ISFSI while conducting transfer operations and preparing casks for the outbound HHT movement from the site.

Additional considerations for the Emergency Response Plan and the Security Plan should be weather forecasting conditions which impact the ability of safe HHT during heavy snow and ice conditions during the winter months. Depending on the outcome of the road surveys, special attention may be required to travel over the mountainous local roads during these weather events. Additional equipment such as prime movers or pushers may be required to compensate for the grade and condition of the local roads.

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. Conduct an engineering survey of the onsite road from the ISFSI to the end of the off-site transport route and evaluate the need for improvements to ensure acceptable conditions of transport exist. Consider the extent of the concrete roadway needed to be added/upgraded at the site to handle anticipated transportation activities, as well as grading improvements needed on steep grades and if any improvements are necessary due to weight and clearance limitations.
2. Prepare a listing of all miscellaneous equipment and services required to safely and efficiently perform the YR-TSC transfers into the NAC-STC transport cask and prepare the casks for off-site transport. Such equipment would include required measuring and test equipment (MT&E) and calibration services, radiological instrumentation and services, radioactive material control supplies, additional lighting to support operations, standard tooling, hydraulic torquing equipment, etc. The listing should also include identification of responsible party for procurement and maintenance of identified equipment and materials.
3. The content conditions of the YR-MPC TSCs and NAC-STCs 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 requirements and verification that the canister integrity has been maintained. It is recommended to allocate 2-3 years for this activity, which could involve a need to revise the CoC. 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 CoC holder prior to transportation of each canister to be offered for transport.
4. Establish planned shipment date from the YR ISFSI and verify:
    a. The CoC for the NAC STC package is still valid. NAC has confirmed that it fully intends to submit a timely renewal application for the NAC-STC 10 CFR Part 71 CoC, as required to maintain certification.
    b. The contents in the YR-MPC TSCs, as loaded in the NAC-STC, are compliant to the applicable NAC-STC CoC requirements (e.g., content, dose and thermal transport limits are satisfied).
    c. Ability for permitting the transportation activities along the selected route(s).
5. Establish equipment needs for transportation:
    a. Procurement of the appropriate number of NAC-STCs, associated impact limiters, cavity spacers, intermodal transport cradles, personnel barriers, and YR TFR and NAC-STC vertical lifting yokes, and horizontal lift beam.
    b. Regarding the procurement of the four required NAC-STCs, and associated impact limiters, cavity spacers, transport cradles, personnel barriers, and vertical lifting

yoke and horizontal lift beam, the following delivery times are estimated based on imposition of the 'Buy American' clause:

i. If all NAC-STCs casks are purchased from one US fabricator at one time and have not been previously procured for other de-inventory projects):

1. First two casks, 24 months after receipt of order.
2. Next two casks, 32 months after receipt of order.

These cask dates bound the supply dates for impact limiters, lifting equipment, auxiliary equipment, etc.

ii. If foreign fabricators were allowed to be considered, dates would be shortened by at least 2 months for each delivery.

c. Design, procure and construct additional equipment and auxiliaries including TSC Transfer Station pad, Canister Handling Facility (CHF), or Gantry Crane and Chain Hoist System (as described in d. below), YR TFR lift yoke, vacuum, leak test and helium backfill system, pressure drop test system, etc. Limiting schedule delivery date would be for the design and construction of the gantry crane and chain hoist system at 24 months, with CHT at 18 months, and Transfer Station pad design and construction at 12 months.

d. In lieu of requiring a CHF at the TSC Transfer Station pad, a seismically qualified gantry crane and chain hoist system can be designed to perform the YR-TSC removal from the VCC into the YR TFR, movement to the TSC Transfer Station and loading of the YR-TSC into the NAC-STC transport cask. The system would be rail mounted with new crane rails installed on both sides of the ISFSI pad to allow the gantry crane to access any of the VCCs without requiring the VCCs to be moved. A similar system has been designed and fabricated for VCC loading operations at Taiwan Power's Kuoshang Nuclear Station in Taiwan. NAC is also proposing a similar system for licensing to support operations at the proposed Interim Storage Partners (ISP) WCS Consolidated Interim Storage Facility in Andrews County Texas. NAC has submitted licensing documentation to support use of a seismically qualified gantry crane and chain hoist system as meeting the requirements for a Canister Transfer Facility specified in the NAC-MPC, NAC-UMS and NAC MAGNASTOR CoCs.

6. Establish YR ISFSI site operations related details, including electrical power requirements for performing operations and verify availability at YR ISFSI.

7. Determine the maximum height a loaded NAC-STC transport cask can be lifted without impact limiters. Lifts of the loaded NAC-STC without impact limiters will be required to be performed to load the cask on the HHT (goldhofer) at the ISFSI/TSC Transfer Station pad. The approximate lift height off the surface of approximately 6 feet is expected to be required to position the cask's trunnion recesses in the mating rear rotation trunnions on the intermodal transfer cradle positioned on the HHT. A lower lift would be required with the intermodal transport cradle positioned on the ground. The vertical lifting height for the loaded YR-TFR during TSC transfer operations will also need to be evaluated. However, it is expected that the use of single-failure-proof lifting and handling equipment in accordance with ANSI N14.6[22] and NUREG-0612[47] for lifting the NAC-STC and

YR-TFR then there should not be an issue regarding lifting heights without requiring a drop analysis. The seismically qualified gantry crane system would satisfy these requirements.

8. Establish if the TSC Transfer Station pad can be placed on or adjacent to the current ISFSI pad to minimize expansion of the security fencing of the ISFSI.
9. Establish the most efficient location for the upending and down-ending of the NAC-STC transport cask from the intermodal transport cradle (e.g., on the HHT [goldhofer] or with the intermodal transport cradle positioned on the ground adjacent to the TSC Transfer Station pad).
10. Examine potential for optimizing (time, exposure, cost. etc.) the design of the transfer activities through the use of a gantry crane and chain hoist system.
11. Evaluate the potential for designing and provision of a protective enclosure over the TSC Transfer Station pad to allow TSC transfer operations in inclement weather.
12. Consult with appropriate regulatory authorities on the applicability of the MTSA and its requirements for YR ISFSI.
13. Due to the potential significant impacts of the conditions and assumptions used to determine 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 given in **Section 7.0**, 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.

11.0 REFERENCES

[1] Abkowitz, M., "Stakeholder Tool for Assessing Radioactive Transportation (START): Version 3.2 User Manual," FCRD-NST-2014-000092, Rev. 5, North Wind Services, LLC, June 2017.

[2] Enclosure 2 – Annual Radiological Environmental Operating Report January-December 2018, April 30, 2019. (ML19121A422)

[3] Yankee Rowe Independent Spent Fuel Storage Installation – Revision 4 to Shutdown Decommissioning Activities Report, February 21, 2017. (ML17062A412)

[4] State of MA, Dept. of Environmental Protection, Review of Final Phase II – Comprehensive Site Assessment Report for Environmental Assessment of Yankee Nuclear Power Station in Rowe. (ML083240377)

[5] 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.

[6] Google Maps (2017), August 2019.

[7] Yankee Nuclear Power Station Site Closure Project Amended Phase III – Remedial Action Plan/Phase IV – Remedy Implementation Plan, June 17, 2005. (ML071660105)

[8] NAC Calculation EC455-5304, Yankee Rowe Cask Loading Pattern Determination.

[9] Yankee Atomic Electric Company Adoption of NAC-MPC® System, Amendment 8 Certificate of Compliance and Canister Registration, April 18,2022. (ML22119A211)

[10] Facility Interface Data Sheet – Yankee Rowe.

[11] Yankee Atomic Electric Company, Drawing ISFSI-FY-007, Plan-ISFSI Storage Casks, Rev. 2, October 29, 2013.

[12] Near-Site Transportation Infrastructure Project Report and Assessment, NAC Report No. C-89108OO, Revised February 1992.

[13] Yankee Rowe Atomic Power Station, Site and Facility Waste Transportation Services Planning Document, Completed by The Transportation Operations Project Office, Oak Ridge, TN, September 1993.

[14] NAC Drawing 455-863, MPC-Yankee Vertical Concrete Cask Lid.

[15] NAC Drawing 455-862, MPC-Yankee Loaded Vertical Concrete Cask.

[16] NAC Drawing 455-864, MPC-Yankee Vertical Concrete Cask Shield Plug.

[17] NAC Drawing 455-871, MPC-Yankee Canister Details.

[18] NAC Drawing 455-860, MPC-Yankee Transfer Cask Assembly.

[19] NAC-STC Storable Transport Cask (STC) Safety Analysis Report (SAR), Revision 20, 2019.

[20] NAC Drawing 455-895, Fuel Basket Assembly.

[21] NRC CoC 71-9235 Rev. 22 for NAC-STC.

[22] ANSI N14.6, Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 lbs (4500 kg) or More.

[23] ASME B30.9, Slings.

[24] Yankee Rowe Atomic Power Station, Yankee Atomic Electric Company, Site and Facility Waste Transportation Services Planning Document, The Transportation Operations Project Office, Oak Ridge, TN, Sept 1993, page 8.

[25] www.yankeerowe.com/decommissioning_removal.html.

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

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

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

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

[30] AREVA Federal Services LLC Report RPT-3016128-000, September 28, 2016, Initial Site-Specific De-Inventory Report for Trojan.

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

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

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

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

[35] 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.

[36] 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.

[37] 49CFR1508.

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

[39] 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.

[40] National Archives and Records Administration, Office of Federal Register, “Code of Federal Regulations 73FR 72173”, Title 49CFR1580, 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 49CFR1580 – Rail Transportation Security, November 26, 2008.

[41] Department of Energy, “Departmental Materials Transportation and Packaging Management,” DOE Order 460.2B, June 2022.

[42] Not used.

[43] 10CFR73.37(c)(4), December 31, 2015.

[44] 49CFR172, Subpart G, Section 172.600, "Emergency Response Information: Applicability and general requirements." June 2016.

[45] NRC CoC 72-1025 Amendment 8 for NAC-MPC Storage System.

[46] ANSI N14.5-2014, “Radioactive Materials – Leakage Tests on Packages for Shipment.”

[47] NUREG-0612, “Control of Heavy Loads at Nuclear Plants”, 1980.

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

[49] 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.

[50] NAC-MPC Final Safety Analysis Report (FSAR), Revision 12, 2019.

[51] Arthur Brodeur, personal picture, June 2016.

[52] NRC CoC 71-9235 Revision 23 for NAC-STC Transportation Package. (ML19318G677)

[53] 49CFR172, Subpart G, Section 172.602, "Emergency response information." June 2016.

[54] E-mail from Yankee Rowe, 2/21/23, with two attachments: ISFSI Engineering & Fuel Procedure EF-3, Rev. 5 – Page 25 of 25; and Memorandum Yankee Nuclear Power Station – Fuel Transfer Oversight FTOD 03-068 Rev. 2 dated June 16, 2003.

Attachment A: Full Pairwise Comparison for the Tangible Metrics

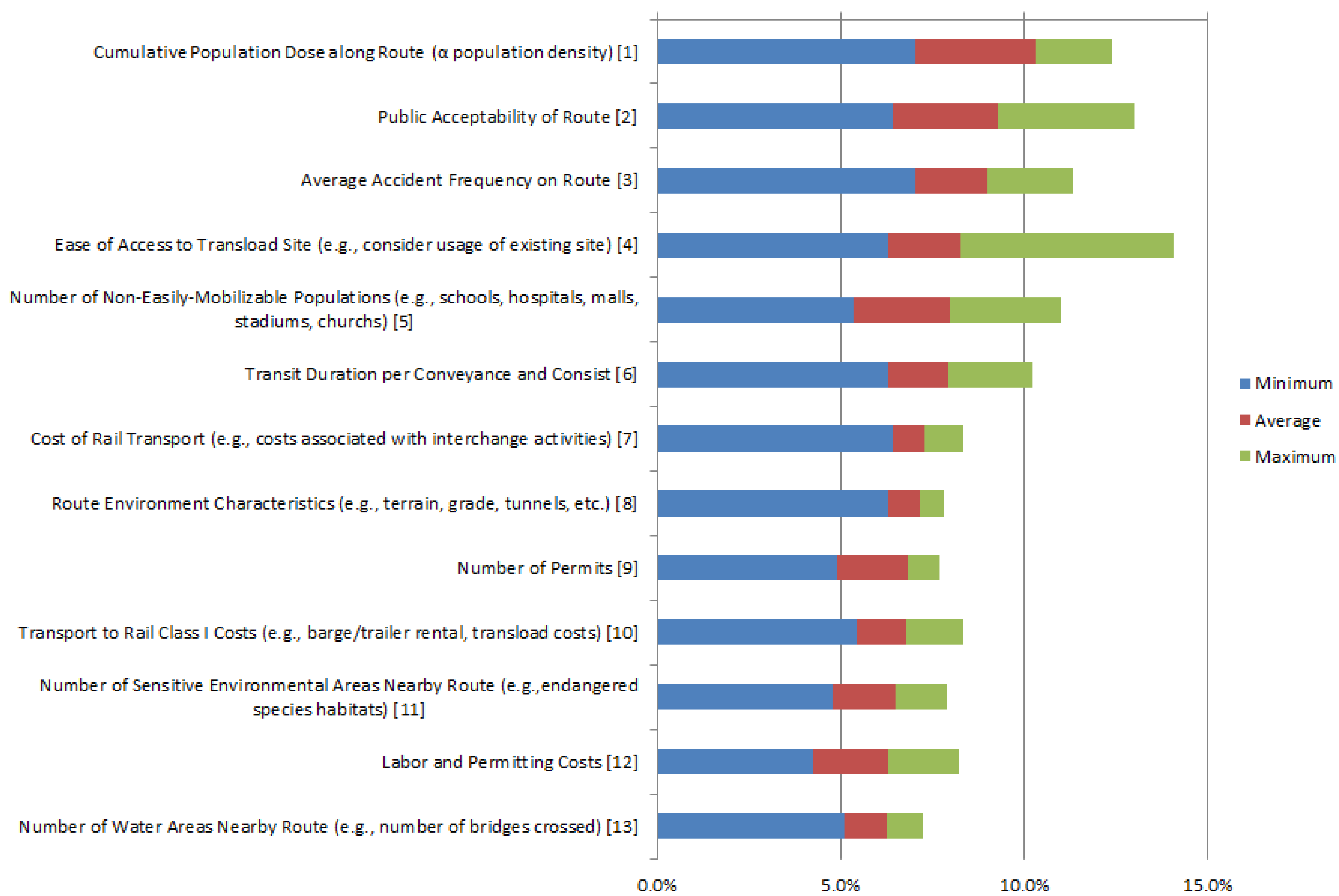
Place a single "X" per line where you believe the importance of the metric in column A falls against the metric in column B.

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
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 interchange activities)
Labor and Permitting Costs								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
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								Number of Permits
Labor and Permitting Costs								Cumulative Population Dose along Route (α population density)
Labor and Permitting Costs								Average Accident Frequency on Route
Labor and Permitting Costs								Transit Duration per Conveyance and Consist
Labor and Permitting Costs								Ease of Access to Transload Site (e.g., consider usage of existing site)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cost of Rail Transport (e.g., costs associated with interchange activities)
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)								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)								Number of Permits
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)								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)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Public Acceptability of Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Permits
Cost of Rail Transport (e.g., costs associated with interchange activities)								Cumulative Population Dose along Route (α population density)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Average Accident Frequency on Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Transit Duration per Conveyance and Consist
Cost of Rail Transport (e.g., costs associated with interchange activities)								Ease of Access to Transload Site (e.g., consider usage of existing site)
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.)								Number of Permits
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.)								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.)								Ease of Access to Transload Site (e.g., consider usage of existing site)
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)								Number of Permits
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)								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)								Ease of Access to Transload Site (e.g., consider usage of existing site)
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)								Number of Permits
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)								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)								Ease of Access to Transload Site (e.g., consider usage of existing site)
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)								Number of Permits
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)								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)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Public Acceptability of Route								Number of Permits
Public Acceptability of Route								Cumulative Population Dose along Route (α population density)
Public Acceptability of Route								Average Accident Frequency on Route
Public Acceptability of Route								Transit Duration per Conveyance and Consist
Public Acceptability of Route								Ease of Access to Transload Site (e.g., consider usage of existing site)
Number of Permits								Cumulative Population Dose along Route (α population density)
Number of Permits								Average Accident Frequency on Route
Number of Permits								Transit Duration per Conveyance and Consist
Number of Permits								Ease of Access to Transload Site (e.g., consider usage of existing site)
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)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Average Accident Frequency on Route								Transit Duration per Conveyance and Consist
Average Accident Frequency on Route								Ease of Access to Transload Site (e.g., consider usage of existing site)
Transit Duration per Conveyance and Consist								Ease of Access to Transload Site (e.g., consider usage of existing site)

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

Metric	Rater																											Metric
	1		2		3		4		5		6		7		8		9		10		11		12		Average			
	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	Average	
Labor and Permitting Costs	6.41%	10	5.66%	12	4.27%	13	6.94%	10	5.88%	11	6.20%	13	5.88%	13	8.01%	5	7.48%	5	4.27%	13	6.52%	12	8.23%	4	6.3%	12	10.1	Labor and Permitting Costs
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	6.62%	8	6.94%	7	5.45%	12	6.94%	10	7.26%	8	6.84%	11	6.62%	10	7.16%	7	7.05%	7	5.45%	12	6.73%	10	8.33%	2	6.8%	10	8.7	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Cost of Rail Transport (e.g., costs associated with interchange activities)	6.41%	10	6.73%	8	8.01%	5	6.94%	10	6.84%	9	8.33%	2	6.52%	11	7.05%	9	7.05%	7	8.01%	5	7.16%	7	8.33%	2	7.3%	7	7.1	Cost of Rail Transport (e.g., costs associated with interchange activities)
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)	7.59%	6	7.69%	6	6.30%	8	7.80%	6	7.69%	7	7.48%	3	7.26%	7	6.41%	13	7.05%	7	6.30%	8	7.26%	6	7.05%	6	7.2%	8	6.9	Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)	5.13%	12	5.98%	10	5.77%	10	7.05%	8	5.34%	12	7.05%	8	7.26%	7	6.84%	10	5.34%	12	5.77%	10	6.73%	10	7.05%	6	6.3%	13	9.6	Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)	6.62%	8	5.88%	11	5.77%	10	7.91%	5	4.81%	13	7.05%	8	7.59%	5	7.16%	7	6.20%	11	5.77%	10	6.52%	12	7.05%	6	6.5%	11	8.8	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)	9.19%	4	11.00%	2	8.44%	4	8.65%	1	8.97%	4	7.26%	5	7.91%	4	6.73%	11	5.34%	12	8.44%	4	6.94%	9	7.05%	6	8.0%	5	5.5	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Public Acceptability of Route	9.62%	3	9.94%	3	13.03%	1	8.65%	1	10.04%	2	7.16%	7	7.05%	9	10.79%	1	6.41%	10	13.03%	1	8.97%	4	7.05%	6	9.3%	2	4.0	Public Acceptability of Route
Number of Permits	4.91%	13	5.45%	13	7.59%	7	7.05%	8	6.41%	10	7.48%	3	6.20%	12	7.69%	6	7.48%	5	7.59%	7	7.05%	8	7.05%	6	6.8%	9	8.2	Number of Permits
Cumulative Population Dose along Route (α population density)	11.54%	1	11.54%	1	12.39%	2	8.65%	1	10.58%	1	7.05%	8	10.90%	1	8.44%	3	9.40%	4	12.39%	2	9.29%	2	11.54%	1	10.3%	1	2.3	Cumulative Population Dose along Route (α population density)
Average Accident Frequency on Route	11.32%	2	8.65%	4	7.91%	6	8.65%	1	9.51%	3	7.26%	5	10.90%	1	8.65%	2	10.68%	1	7.91%	6	9.40%	1	7.05%	6	9.0%	3	3.2	Average Accident Frequency on Route
Transit Duration per Conveyance and Consist	7.69%	5	6.30%	9	8.76%	3	6.94%	10	8.55%	5	6.73%	12	7.59%	5	8.44%	3	10.26%	2	8.76%	3	8.12%	5	7.16%	5	7.9%	6	5.6	Transit Duration per Conveyance and Consist
Ease of Access to Transload Site (e.g., consider usage of existing site)	6.94%	7	8.23%	5	6.30%	8	7.80%	6	8.12%	6	14.10%	1	8.33%	3	6.62%	12	10.26%	2	6.30%	8	9.29%	2	7.05%	6	8.3%	4	5.5	Ease of Access to Transload Site (e.g., consider usage of existing site)

Purple	lowest ranked
Red	highest ranked


Cumulative Population Dose along Route (α population density) [1]
Public Acceptability of Route [2]
Average Accident Frequency on Route [3]
Ease of Access to Transload Site (e.g., consider usage of existing site) [4]
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs) [5]
Transit Duration per Conveyance and Consist [6]
Cost of Rail Transport (e.g., costs associated with interchange activities) [7]
Route Environment Characteristics (e.g., terrain, grade, tunnels, etc.) [8]
Number of Permits [9]
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs) [10]
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats) [11]
Labor and Permitting Costs [12]
Number of Water Areas Nearby Route (e.g., number of bridges crossed) [13]
0.0%
5.0%
10.0%
15.0%
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
Labor and Permitting Costs	A. HHT/Rail: Transload in Westfield, MA			x					B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA	x							C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA	x							D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA		x						D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT						x		E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT						x		E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT				x				D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Cost of Rail Transport (e.g., costs associated with interchange activities)	A. HHT/Rail: Transload in Westfield, MA		x						B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA		x						D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA		x						E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA		x						F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

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 Environmental Characteristics (e.g., terrain, grade, tunnels, etc.)	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT				x				D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Number of Water Areas Nearby Route (e.g., number of bridges crossed)	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

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. HHT/Rail: Transload in Westfield, MA			x					B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Public Acceptability of Route	A. HHT/Rail: Transload in Westfield, MA			x					B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA		x						D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA		x						D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT			x					D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Number of Permits	A. HHT/Rail: Transload in Westfield, MA					x			B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT						x		E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

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. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Average Accident Frequency on Route	A. HHT/Rail: Transload in Westfield, MA						x		B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA					x			C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA						x		D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA						x		E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA					x			D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT					x			E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT						x		F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
Transit Duration per Conveyance and Consist	A. HHT/Rail: Transload in Westfield, MA				x				B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA			x					C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA				x				C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT				x				E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA					x			F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

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
Ease of Access to Transload Site (e.g., consider usage of existing site)	A. HHT/Rail: Transload in Westfield, MA		x						B. HHT/Rail: Transload in Deerfield, MA
	A. HHT/Rail: Transload in Westfield, MA		x						C. HHT/Rail: Transload in Bellows Falls, VT
	A. HHT/Rail: Transload in Westfield, MA	x							D. HHT/Rail: Transload in Bennington, VT
	A. HHT/Rail: Transload in Westfield, MA		x						E. HHT/Rail: Transload in Shelburne Falls, MA
	A. HHT/Rail: Transload in Westfield, MA		x						F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	B. HHT/Rail: Transload in Deerfield, MA					x			C. HHT/Rail: Transload in Bellows Falls, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					D. HHT/Rail: Transload in Bennington, VT
	B. HHT/Rail: Transload in Deerfield, MA			x					E. HHT/Rail: Transload in Shelburne Falls, MA
	B. HHT/Rail: Transload in Deerfield, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	C. HHT/Rail: Transload in Bellows Falls, VT		x						D. HHT/Rail: Transload in Bennington, VT
	C. HHT/Rail: Transload in Bellows Falls, VT		x						E. HHT/Rail: Transload in Shelburne Falls, MA
	C. HHT/Rail: Transload in Bellows Falls, VT		x						F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	D. HHT/Rail: Transload in Bennington, VT						x		E. HHT/Rail: Transload in Shelburne Falls, MA
	D. HHT/Rail: Transload in Bennington, VT				x				F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA
	E. HHT/Rail: Transload in Shelburne Falls, MA			x					F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA

Attachment D: Route Information from START for YR NPS

Route	HHT Distance (mi.)	Barge Distance (mi.)	Rail Distance (mi.)
A. HHT/Rail: Transload in Westfield, MA	68	0	1084
B. HHT/Rail: Transload in Deerfield, MA	32	0	1123
C. HHT/Rail: Transload in Bellows Falls, VT	62	0	1190
D. HHT/Rail: Transload in Bennington, VT	30	0	1025
E. HHT/Rail: Transload in Shelburne Falls, MA	21	0	1139
F. HHT/Rail: Transload at Hoosac Tunnel West in North Adams, MA	18	0	1038

Parameter	Route > Metric V	A. HHT/Rail: Westfield, MA	B. HHT/Rail: Deerfield, MA	C. HHT/Rail: Bellows Falls, VT	D. HHT/Rail: Bennington, VT	E. HHT/Rail: Shelburne Falls, MA	F. HHT/Rail: Hoosac Tunnel West
Total Dist. (mi)		1152	1155	1252	1056	1160	1055
Travel Time (hr/min)	Duration	32 hrs. 1891 min	33 hrs. 1971 min	35 hrs. 2088 min.	31 hrs. 1836 min	33 hrs. 1997 min	30 hrs. 1827 min
Accident Likelihood (per mi^2)	Accidents	0.018	0.010	0.013	0.008	0.009	0.008
Water Crossings	Acceptability	204	207	220	175	206	168
Average Track Class		3.6	3.5	3.5	3.5	3.5	3.4
Average Rail Traffic Density		4.7	4.6	4.5	4.6	4.6	4.5
Average Pop Density (/ mi^2)		826	853	822	872	849	877
Total Population	Pop Dose	559.931	571,752	595,552	532,138	571,825	536,857
Mass Gathering Places	Pop Dose	628	649	671	621	646	626
Tribal Lands (per mi^2)	Acceptability	1.10	1.14	1.21	1.04	1.16	1.17

Parameter	**Route > Metric** \/	A. HHT/Rail: Westfield, MA	B. HHT/Rail: Deerfield, MA	C. HHT/Rail: Bellows Falls, VT	D. HHT/Rail: Bennington, VT	E. HHT/Rail: Shelburne Falls, MA	F. HHT/Rail: Hoosac Tunnel West
Sensitive Environ. Area (/ mi^2)	Acceptability	6.28	7.07	8.37	11.37	7.17	11.81
Locks		N/A	N/A	N/A	N/A	N/A	N/A
Tunnels		6	6	6	5	6	5
Emergency Response Capability (/ mi^2)		0.27	0.27	0.26	0.27	0.27	0.27
Fire Departments (per mi^2)		0.15	0.15	0.15	0.16	0.15	0.16
Police (per mi^2)		0.11	0.11	0.12	0.10	0.11	0.10
Hospitals (per mi^2)		0.01	0.01	0.01	0.01	0.01	0.01
Educational Institutions (total)		256	274	280	237	271	232
Grammar Schools		242	260	263	225	258	220

Parameter	**Route > Metric** \/	A. HHT/Rail: Westfield, MA	B. HHT/Rail: Deerfield, MA	C. HHT/Rail: Bellows Falls, VT	D. HHT/Rail: Bennington, VT	E. HHT/Rail: Shelburne Falls, MA	F. HHT/Rail: Hoosac Tunnel West
Higher Education		14	14	17	12	13	12
Special Age Groups (total)		286	310	335	270	312	256
Day Care		206	231	253	188	232	184
Nursing Homes		80	79	82	82	80	72
Railroad Crossings (total at grade)		1259	1276	1327	1253	1280	1252
Signs		22	22	25	25	22	26
Signals		201	203	219	205	203	205
No signs or signals		0	0	0	0	0	0
Both signs / signals		0	0	0	0	0	0

Parameter	**Route > Metric** V	A. HHT/Rail: Westfield, MA	B. HHT/Rail: Deerfield, MA	C. HHT/Rail: Bellows Falls, VT	D. HHT/Rail: Bennington, VT	E. HHT/Rail: Shelburne Falls, MA	F. HHT/Rail: Hoosac Tunnel West
Unknown signs/signal		1036	1051	1083	1023	1055	1021