Initial Site-Specific De-Inventory Report for Kewaunee

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Prepared by: AREVA Federal Services LLC

REVISION LOG

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DISCLAIMER

This is a technical report which reflects concepts which could support future decision-making by the Department of Energy (DOE). No inferences should be drawn from this paper regarding future actions by DOE. To the extent the discussions or recommendations in this report conflict with the provisions of the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract), 10 C.F.R. Part 961, the Standard Contract provisions prevail.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAR	Association of American Railroads
AFS	AREVA Federal Services
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
BOL	Bill of Lading
BPAA	Burnable Poison Absorber Assembly
BPRA	Burnable Poison Rod Assembly
BW	Babcock and Wilcox
BWR	Boiling Water Reactor
CAD	Computer Aided Drawing
CAM	Continuous Air Monitor
CARL	Computer Assisted Remote Lifting
CC	Control Component
CE	Combustion Engineering
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CHA	Chain Hoist Assembly
CHF	Canister Handling Facility
Ci	Curie
CO	Crane Operator
CoC	Certificate of Compliance
COSS	Cask Operations Shift Supervisor
COTP	Captain of the Port
CPRS	Canadian Pacific Railway
CRCPD	Conference of Radiation Control Program Directors, Inc.
CSI	Criticality Safety Index
CSSC	Chicago Sanitary & Ship Canal
DEK	Dominion Energy Kewaunee, Inc.
DF	Damaged Fuel

DFC	Damaged Fuel Can
DHS	Department of Homeland Security
DOE	Department of Energy
DOT	Department of Transportation
DSC	Dry Storage Canister
ELSS	Escanaba & Lake Superior Railroad
EO	Tractor/JCB Driver and Equipment Operator
EPDM	Ethylene Propylene Diene Monomer
ERP	Emergency Response Plan
FA	Fuel Assembly
FAA	Federal Aviation Administration
FCF	Framatome Cogema Fuels
FMCSA	Federal Motor Carrier Safety Administration
FME	Foreign Material Exclusion
FRA	Federal Railroad Administration
FSAR	Final Safety Analysis Report
FSL	Fuel Spacer Long
FSO	Facility Security Officer
FSP	Facility Security Plan
FSS	Fuel Spacer Short
FTE	Full-Time Equivalent
GCUS	Geographical Center of the 48 Contiguous United States
GPS	Global Positioning System
GTCC	Greater Than Class C
GTPD	Guide Tube Plug Device
GWd	GigaWatt-day
HAZMAT	Hazardous Material
HBU	High Burnup Fuel
HFRA	Hafnium Absorber Assembly
HHT	Heavy Haul Truck/Trailer
HLW	High-Level Radioactive Waste
HMR	Hazardous Materials Regulations
HRCQ	Highway Route Controlled Quantity

HSM	Horizontal Storage Module
HTUA	High Threat Urban Areas
IL	Illinois
ISFSI	Independent Spent Fuel Storage Installation
ISR	Independent Safety Review
KPS	Kewaunee Power Station
kW	kiloWatt
LCO	Limiting Condition of Operation
LLC	Limited Liability Corporation
LLEA	Local Law Enforcement Agency
LLW	Low Level Radioactive Waste
M&TE	Measuring and Test Equipment
MCC	Movement Control Center
MCL	Maximum Critical Lift
mph	miles per hour
MSDS	Material Safety Data Sheet
MSLD	Mass Spectrometer Leak Detection
MTC	MAGNASTOR Transfer Cask
MTHM	Metric Tons Heavy Metal
MTSA	Maritime Transportation Security Act
MUA	Multi-Attribute Utility Analysis
MWe	Megawatt (electric)
NRC	U.S. Nuclear Regulatory Commission
NS	Neutron Source
NS	Norfolk Southern
NSA	Neutron Source Assembly
NSSS	Nuclear Steam Supply System
NWPA	Nuclear Waste Policy Act
OJT	On the Job Training
OM	Operations Manager
OSHA	Occupational Safety and Health Administration
OTR	Open Top Rules
PHMSA	Pipeline and Hazardous Materials Safety Administration

PIH	Poisonous Inhalation Hazard
PPE	Personal Protective Equipment
PT	Penetrent Testing
PW	Procedure Writer
PWR	Pressurized Water Reactor
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
QS	QA/QC Specialist
RCC	Reactor Control Component
RCCA	Reactor Core Control Assembly
RCT	Radiation Control Technician
RM	Rigger/Cask Operations Technician/Mechanic
RO/RO	Roll On/Roll Off
RP	Radiation Protection
RSAT	Risk and Security Assessment Team
RSSM	Rail Security Sensitive Materials
RTL	Rail Transload
RWC	Radioactive Waste Container
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SAT	Systematic Approach to Training
SGLA	Steam Generator Lower Assembly
SME	Subject Matter Expert
SNF	Spent Nuclear Fuel
SP	Security Personnel
SPC	Siemens Power Corporation
SS	Stainless Steel
START	Stakeholder Tool for Assessing Radioactive Transportation
TC	Transport and Waste Management Coordinator
TFR	Transfer Cask
TI	Transport Index
TID	Tamper Indication Device

TIH	Toxic Inhalation Hazards
TLD	Thermoluminescent Dosimeter
TN	Tennessee
TN	TransNuclear
TP	Thimble Plug
TPE	Training Program Evaluation
TS	Technical Specification
TS	Training Specialist
TSA	Transportation Safety Administration
TSC	Transportable Storage Canister
TWIC	Transportation Worker Identification Credential
U.S.	United States
USCG	U.S. Coast Guard
VCC	Vertical Concrete Cask
VCT	Vertical Cask Transporter
VDS	Vacuum Drying System
VSO	Vessel Security Officer
VSP	Vessel Security Plan
WE	Westinghouse
WI	Wisconsin
WSOR	Wisconsin and Southern Railroad

EXECUTIVE SUMMARY

This report has been developed to satisfy the Statement of Work for Task Order #3 for the Department of Energy (DOE) – Office of Nuclear Energy under contract number DE-NE0008491 issued to AREVA Federal Services (AFS).

The purpose of this report is to assist the United States (U.S.) 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 Kewaunee Power Station (KPS) independent spent fuel storage installation (ISFSI) site located in the town of Carlton, WI (but with a Kewaunee mailing address), approximately 30 miles southeast of Green Bay, WI and 90 miles north of Milwaukee, WI. 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 planned GTCC LLW were considered as part of this report (i.e., heavy haul truck (HHT), rail, and barge). Both barge-to-rail and HHT-to-rail were evaluated as viable modes of transport by this assessment (there is no direct rail access at KPS). 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 planned GTCC LLW from KPS to a Class I railroad.

The results from the MUA identified a ranking of routes from the KPS site, with the highest ranked route identified as using an HHT from the site to a rail transload site in Green Bay, WI, and then traveling by rail on the Canadian National Railway over the Fox River, south along the Fox River toward Chicago, IL, and then to the hypothetical destination near the geographical center of the 48 contiguous United States (GCUS). This route was favored over four other routes, which included (in descending rank): barge from the KPS ISFSI along Lake Michigan to transload in Milwaukee, WI and rail to GCUS on Union Pacific Railroad; HHT from the KPS ISFSI to transload in Kohler, WI and rail to GCUS on Union Pacific Railroad; HHT from the KPS ISFSI to transload in Milwaukee, WI and rail to GCUS on Union Pacific Railroad; and HHT from the KPS ISFSI to transload onto barge at the Port of Kewaunee, WI and then barge along Lake Michigan to transload in Milwaukee, WI and rail to GCUS on Union Pacific Railroad.

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, for the most part, rankings of the routes fairly consistent with the results noted above. However, there were four sensitivity analyses where the results changed, indicating no single route clearly stood out in this assessment and multiple route options from the KPS ISFSI could be used. For example, if the public acceptability metric was removed from the MUA (with the weights for the remaining metrics renormalized), then the barge route from the KPS ISFSI to Milwaukee, WI would rise to the highest ranking, exchanging places with the HHT to Green Bay, WI. If the security and safety metrics were removed from the MUA, then the HHT directly to Milwaukee, WI would rise to the highest ranking, followed by the HHTs to Green Bay, WI and Kohler, WI, then the barge to

Milwaukee, WI and finally the HHT to the Port of Kewaunee, WI which consistently ranked lowest of these routes.

Using the primary MUA result, a concept of operations and recommended budget and spending plan are detailed for the removal of existing SNF and pending GTCC LLW from the KPS site using the shipment route by HHT to Green Bay, WI and then by rail over the Fox River, south along the Fox River toward Chicago, IL to GCUS. The total estimated budget for the whole KPS campaign organized over 56 weeks is $19.3M (2017). Also documented in this assessment are a security plan and procedures, as well as an Emergency Response and Preparedness Plan for the prospective shipments. Finally, the recommended next steps are identified for the process of initiating the removal of the existing SNF and pending GTCC LLW from the KPS site.

1.0 INTRODUCTION

This report provides an assessment of the tasks, equipment, and interfaces necessary to remove the SNF and GTCC LLW from the KPS ISFSI located in Carlton, WI (but with a Kewaunee mailing address), approximately 30 miles southeast of Green Bay, WI and 90 miles north of Milwaukee, WI. The objective of this removal activity is to transport the existing SNF and pending GTCC LLW to a Class I railroad, where it can be transported to either a consolidated interim storage facility or a 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 consolidated interim storage facility, a geological repository, or a transportation hub; but its selection was necessary because it impacts both the scheduling and costing activities included 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 planned GTCC LLW contained within the KPS ISFSI using AREVA's and our teaming partners' experiences in the shipping of like and similar materials. For the purposes of this assessment, the shipments are assumed to be regulated by the U.S. Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT); the DOE would be the shipper of record.

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 potential GTCC LLW to be shipped from the site, and a description of both the TN Americas, LLC Standardized NUHOMS System and NAC International MAGNASTOR system used to store this material onsite and their respective transportation systems: the TN MP197HB and NAC MAGNATRAN. 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 a transfer cask) to facilitate the shipment of the MP197HBs and MAGNATRANs from the KPS ISFSI. Although accessing the site was not within the scope of this activity, sufficient sources of information existed for an informed assessment of the site to be performed, but ultimately a formal inspection would be necessary to verify assumed site criteria. Identification of the characteristics of the existing SNF and, to the extent possible, the pending GTCC LLW at the KPS ISFSI provide the information necessary to verify compliance with the transportation licenses via their NRC Certificates of Compliance (CoCs). Similarly, the description of the TN MP197HBs and the NAC MAGNATRANs to be shipped are also verified to be compliant with their CoCs, allowing, if necessary, either provisions to be designated to bring a TN MP197HB or a NAC MAGNATRAN into compliance or identification of exemptions requiring approval from the regulator.

After the pertinent site information was assessed, a transportation route analysis was performed, as described in Section 3.0, identifying transportation routes from the KPS 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 pending GTCC LLW were considered (i.e., HHT, rail, and barge). From the KPS ISFSI site itself, HHT-to-rail and barge-to-rail transload sites were evaluated to be viable options for shipment of the existing SNF and pending GTCC LLW. **Figure 1-1** depicts the major steps of HHT-to-rail transfer and the barge-to-rail transfer scenarios. As shown in this figure, the HHT-to-rail scenario appears to be the least complicated approach, with the minimum number of times the TN MP197HB and the NAC MAGNATRAN are handled, whereas the barge scenario appears to be more complicated, with additional handling activities. The result of the assessment of the transportation routes is a listing of multiple viable routes with various attributes, both pro and con, that would require evaluation to identify the optimal and/or favored route to ship the existing SNF and pending GTCC LLW from the KPS site.

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 would be burdensome, so initial screening criteria were established to allow for less attractive routes to be screened from further consideration based on attributes associated with a particular mode of transport (i.e., screening is performed only between routes associated with a particular mode of transport). These screening criteria were applied in Section 3.0 to reduce the number of identified routes from greater than 20 to a manageable number of five. After the participating entities were identified in Section 4.0, these five routes (using two different modes from the site: HHT and barge) were evaluated using the MUA to rank the routes for shipping the existing SNF and pending GTCC LLW from KPS to the hypothetical destination of GCUS by Class I rail in Section 5.0. **Figure 1-2** identifies the routes evaluated in the MUA.

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

FIGURE 1-1: POTENTIAL FLOW OF OPERATIONS ASSESSED FOR LOADING A CONSIST PER MODE OF TRANSPORT FROM KPS ISFSI

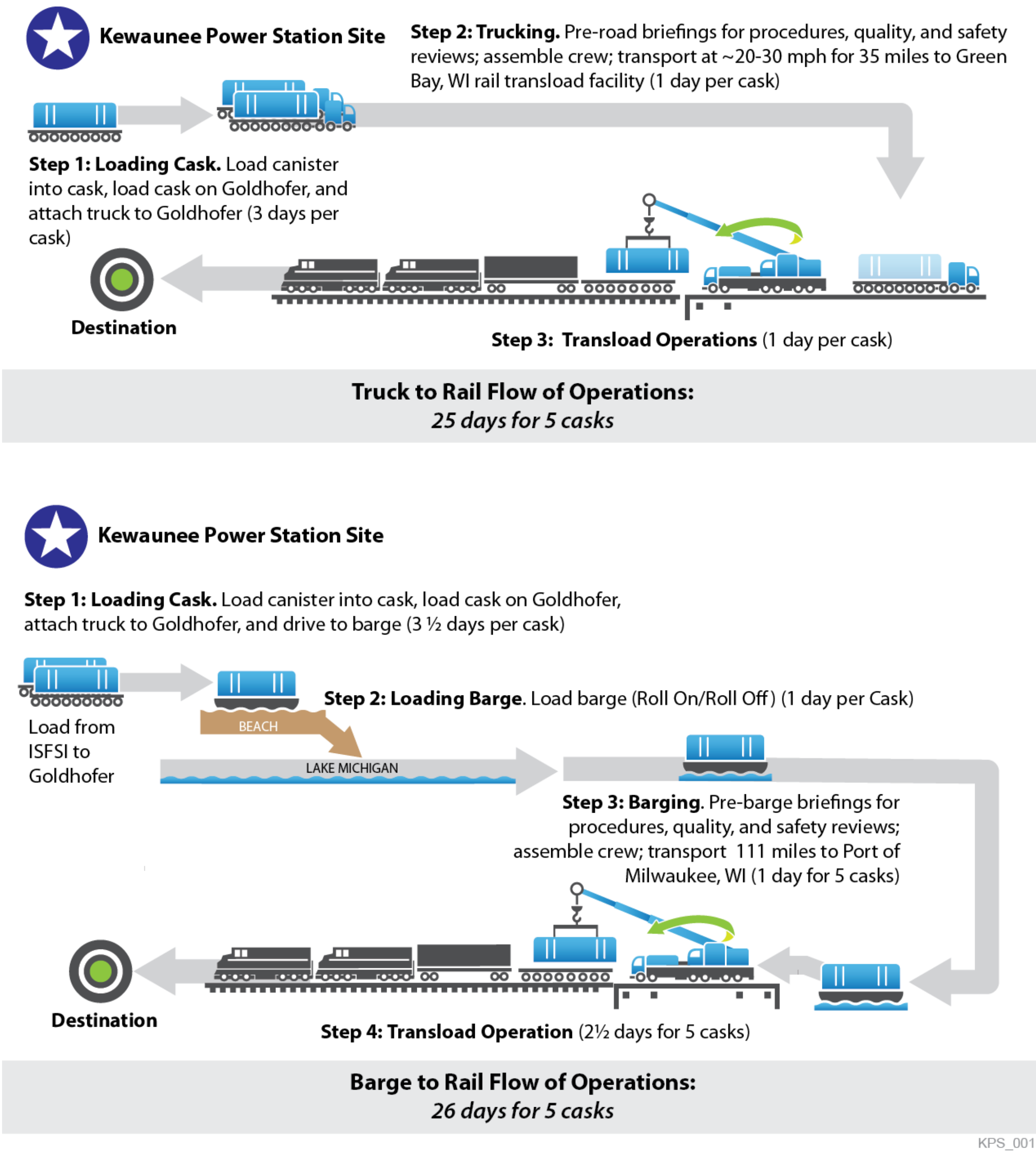
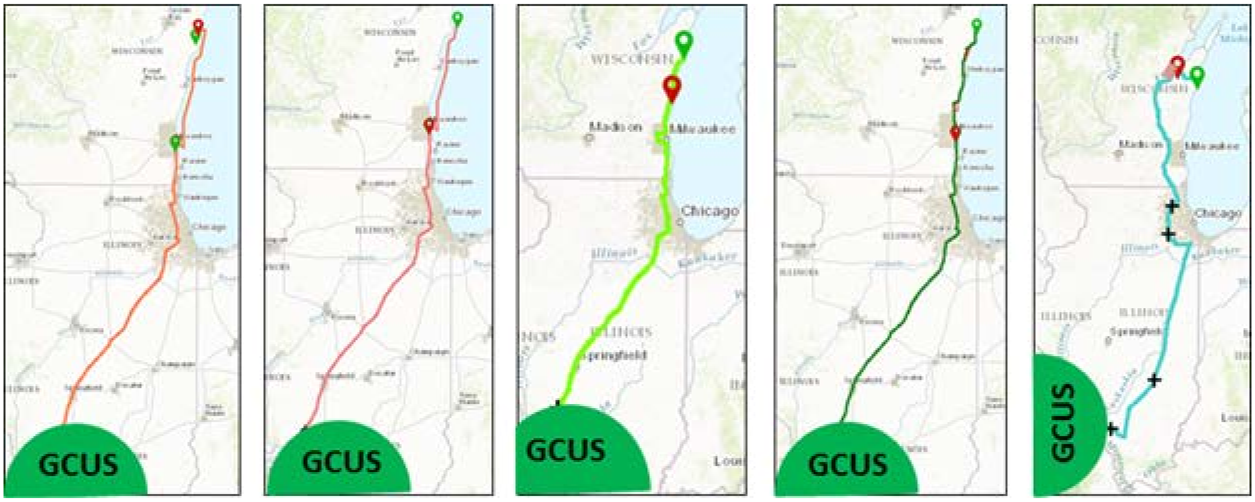


FIGURE 1-2: ROUTES EVALUATED BY THE MUA FOR SHIPMENT OF SNF AND GTCC LLW FROM KPS ISFSI



(a) (b) (c) (d) (e)

Note: Routes are described in detail in Section 3.0. These figures were produced by START[1]. The green and red pointers indicate transload locations (e.g., barge-to-rail in Milwaukee, WI), and the colored lines indicate the routes analyzed by the MUA with: (a) the orange line representing the HHT to the Port of Kewaunee, barge to the Port of Milwaukee, WI, and rail on the Union Pacific Railroad to GCUS; (b) the red line representing the barge from KPS to the Port of Milwaukee, WI and rail on the Union Pacific Railroad to GCUS; (c) the light green line representing the HHT to Kohler, WI and rail on the Union Pacific Railroad to GCUS; (d) the dark green line representing the HHT to Milwaukee, WI and rail on the Union Pacific Railroad to GCUS; and (e) the blue line representing the HHT to Green Bay, WI and rail on the Canadian National Railway to GCUS. Note: route lies near Oneida (WI) Reservation outside of Green Bay.

2.0 PERTINENT SITE INFORMATION

2.1 Description of Site/Characteristics

The KPS site, operated by Dominion Energy Kewaunee, Inc. (DEK), is in Carlton, WI (but has a Kewaunee mailing address), approximately 30 miles southeast of Green Bay, WI and 90 miles north of Milwaukee, WI. As shown in **Figure 2-1**, the site is on the western shore of Lake Michigan and is about 200 miles south of the international border with Canada [2].

The KPS site has a two-loop Westinghouse Pressurized Water Reactor (PWR) nuclear power plant, rated for 590 megawatt (electric) (MWe). The plant began commercial operation on June 16, 1974 and ceased operations on May 7, 2013. All the fuel was removed from the reactor vessel by May 14, 2013, and the plant is now undergoing decommissioning activities under the SAFSTOR method [2]. On May 14, 2013 DEK submitted the certification of permanent removal of fuel from the reactor vessel to the NRC, which in turn modified the KPS operating license DPR-043 (Docket 50-305) to no longer authorize reactor operations [3].

The site boundary for KPS is depicted in **Figure 2-2** and encompasses 908 acres. The cemetery and highways that fall within the site boundary are not owned by DEK. The areas surrounding KPS are almost exclusively devoted to agriculture, with the nearest occupied residence located at least 0.8 mile from the plant. The Point Beach Nuclear Plant, owned by NextEra Energy, Inc., is located 4.5 miles south of KPS [4].

FIGURE 2-1: KEWAUNEE SITE LOCATION [5]

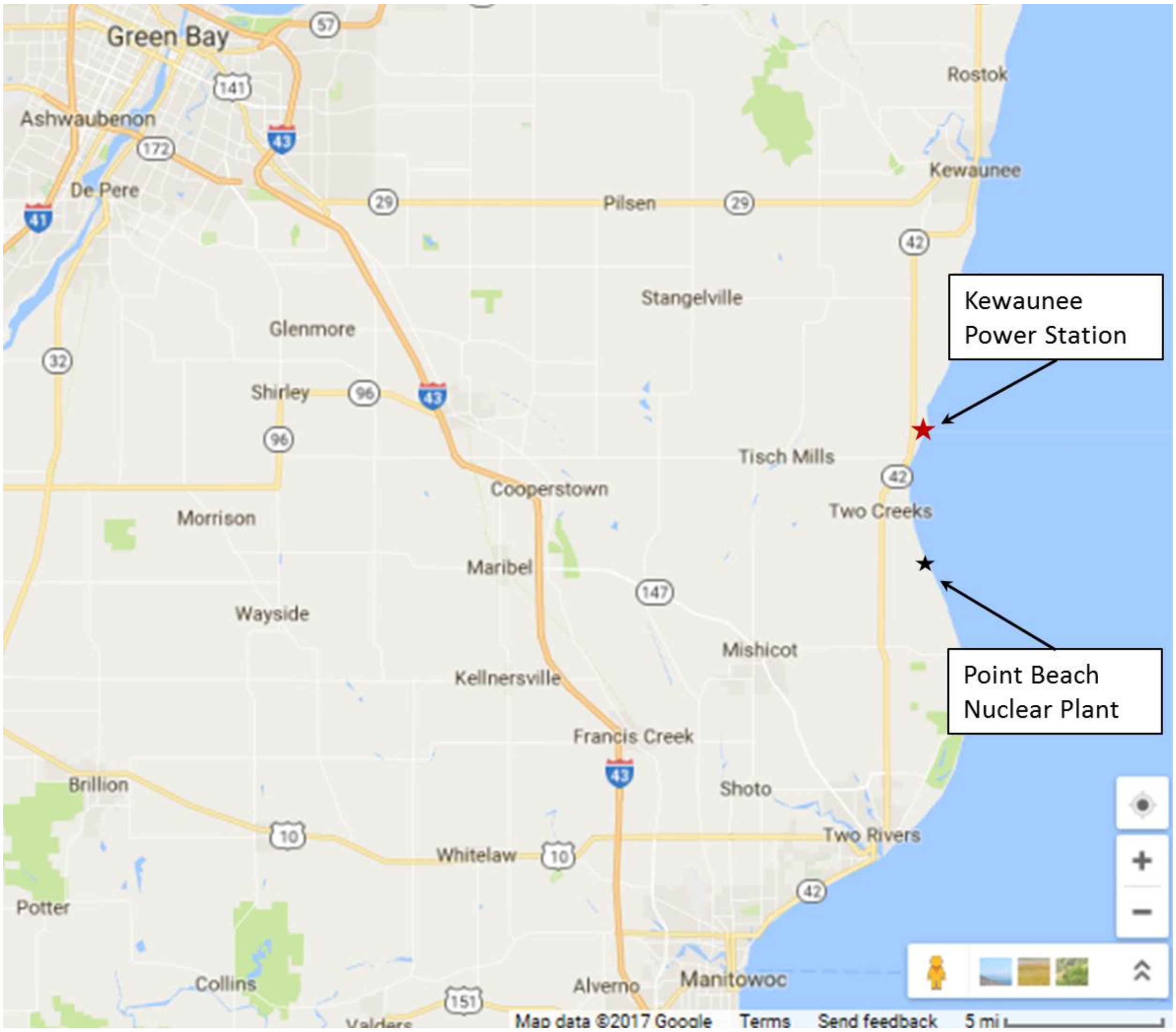
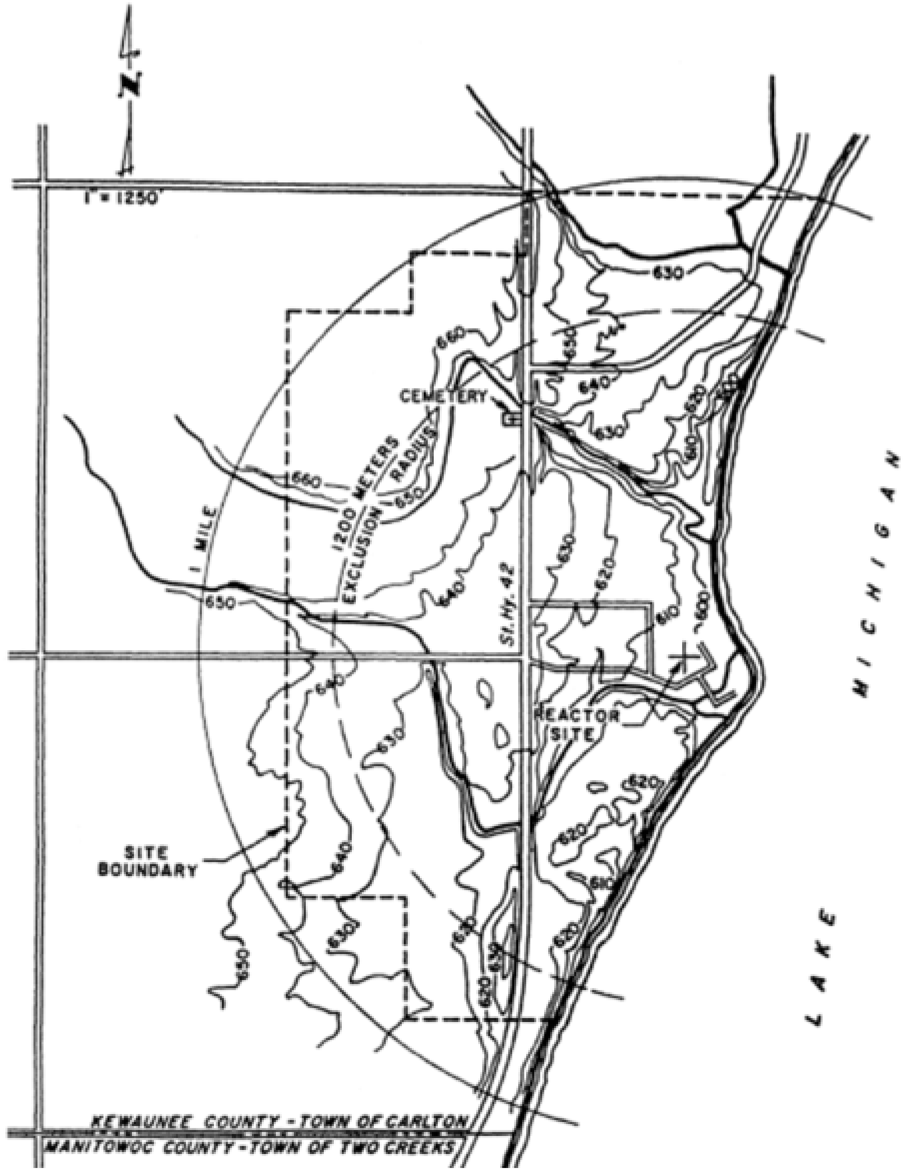


FIGURE 2-2: KEWAUNEE SITE BOUNDARY [4]



As part of the decommissioning process, DEK recently completed transfer of the irradiated fuel from the spent fuel pool to the ISFSI, which is located north of the reactor as shown in **Figure 2-3**. Fuel transfer to the ISFSI began in 2009 and was completed in June 2017. Storage of the SNF removed from the reactor is currently controlled under the U.S. NRC license SFGL-40 (Docket 72-64). It has been estimated that two canisters of GTCC LLW will be loaded in the future [2] (refer to Section 2.2 for more information). Currently, there is no GTCC LLW at the KPS ISFSI.

FIGURE 2-3: KEWAUNEE POWER STATION [5]

The KPS ISFSI is unique in that there are two storage systems currently in use. Between 2009 and 2014, SNF was transferred to 14 Horizontal Storage Modules (HSMs)[1] and during the first half of 2017; the remaining SNF was transferred to 24 Vertical Concrete Casks (VCC). In both cases, the SNF was first loaded into canisters, which were then placed into the storage casks. The HSMs were supplied by TN Americas, LLC, and are part of the Standardized NUHOMS System (Docket 72-1004) [12,14,17], while the VCCs were supplied by NAC International and are part of the NAC MAGNASTOR System (Docket 72-1031) [6,7,8]. Refer to Sections 2.1.1 and 2.1.2 for more information regarding the HSMs and VCCs in use at KPS. Details of the SNF contents and canisters are provided in Sections 2.2 and 2.3, respectively.

The ISFSI, shown in **Figure 2-4** and **Figure 2-5** is surrounded by two fences that enclose an approximate area of 3 acres. There are roughly 25 feet between the fences. Within the fenced area are storage casks and also two storage buildings and a Security/Operations Building along the southern fence line. The eastern edge of the ISFSI is approximately 400 feet from the edge of Lake Michigan.

[1] There are 16 HSMs at the KPS ISFSI. The two modules at the north end are empty and may be used in the future to store GTCC LLW [9].

FIGURE 2-4: KEWAUNEE ISFSI [5]

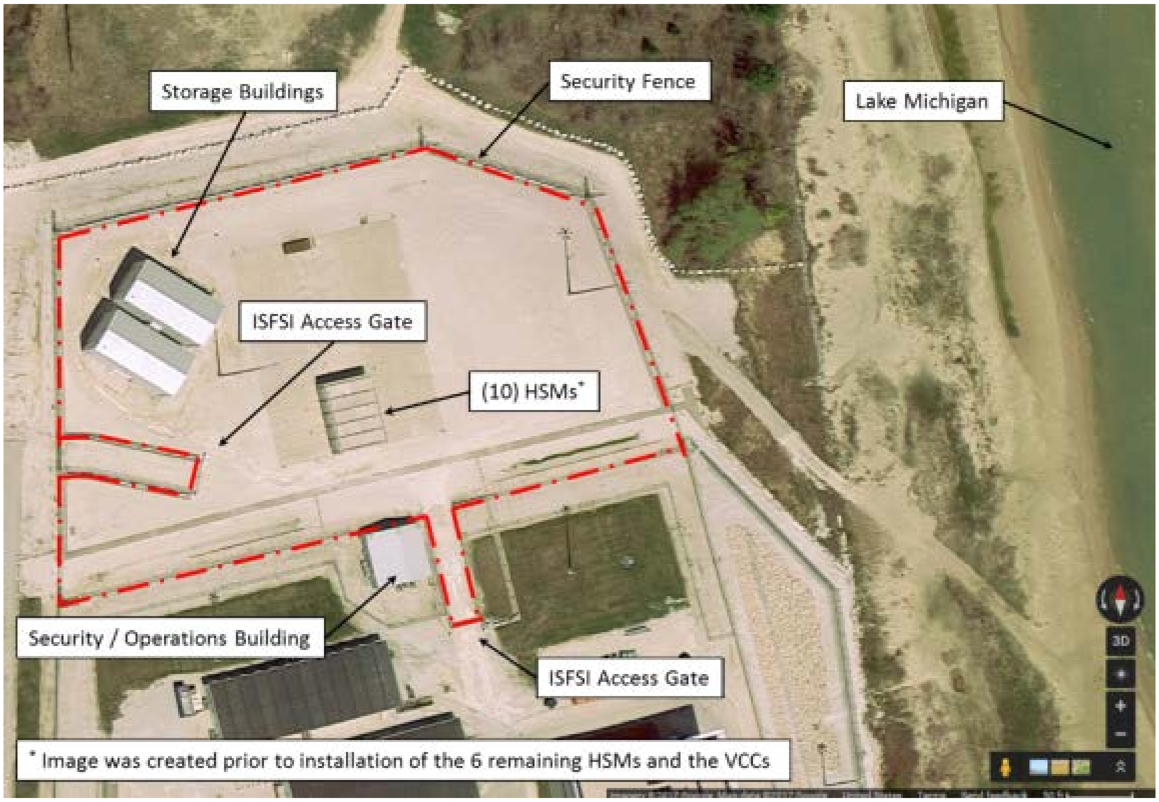


FIGURE 2-5: KEWAUNEE ISFSI STORAGE CASKS

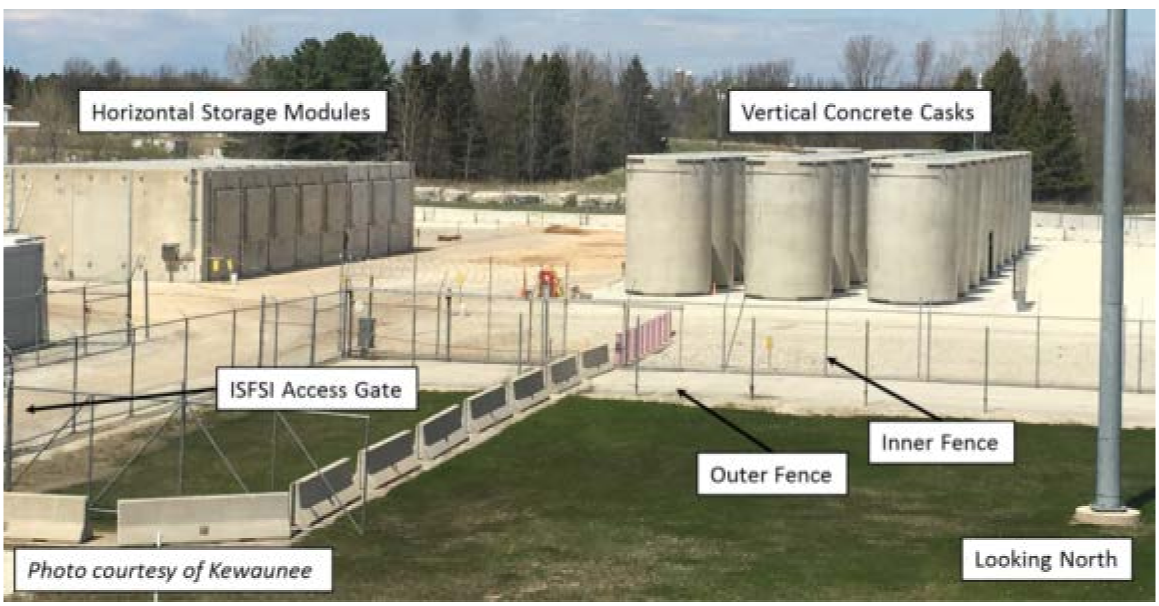
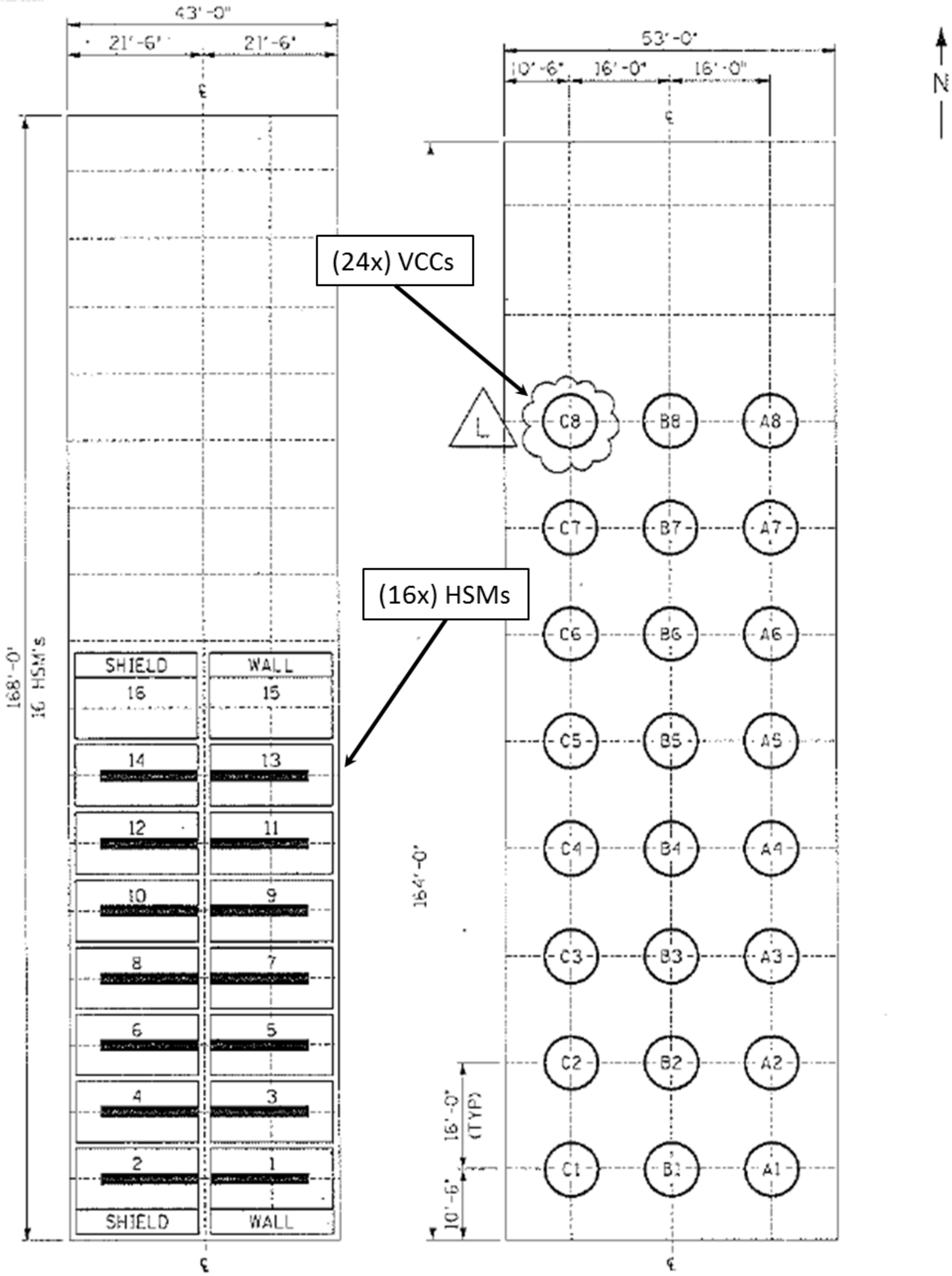


Figure 2-6 shows a layout of the storage systems at the KPS ISFSI. The 24 VCCs are all loaded, whereas the 2 northern HSMs remain empty and may be used in the future for storage of GTCC-LLW.

FIGURE 2-6: KEWAUNEE ISFSI LAYOUT [64]



The KPS site currently only has road access, although there are indications that it had an onsite barge facility during construction. As shown in **Figure 2-7**, the ISFSI is approximately ¼ mile from Wisconsin State Highway 42, which would be the main route out of the site. While there are two main plant access roads from Highway 42, the northern road is in alignment with the western ISFSI access gate and should be used for outbound HHT shipments. Incoming HHTs could use the southern access road, as shown in **Figure 2-7**, and then back into the ISFSI. It is not known if the current access roads from the ISFSI to the highway were built to support HHTs. As such, they may need to be rebuilt or enhanced (see Section 10.0).

FIGURE 2-7: PROPOSED ONSITE HHT ROUTE [5]

KPS is not rail-served, and there is no indication it ever was. Considering that the nearest rail line is approximately 16 miles away in Denmark, WI, the installation of an onsite rail spur is felt to be cost-prohibitive if only used for the shipments of SNF and GTCC LLW from KPS. An onsite barge facility, located on the shore of Lake Michigan, was used during the construction of KPS. Its use was discontinued after KPS was completed and records of its location could not be found. If barge was used for off-site transport of the SNF and GTCC LLW, the access route would be along an existing path that leads from the eastern edge of the ISFSI to the beach, as shown in **Figure 2-8** and **Figure 2-9**. It is estimated that the overall grade for the road would be 9% [11].

FIGURE 2-8: POSSIBLE BARGE LOADING LOCATION [5]

FIGURE 2-9: BEACH ACCESS PATH

Regardless of the final transportation mode and route selected to reach the destination site, all of the transportation casks leaving KPS will be shipped on a Goldhofer HHT to reach the transload site. The HHT will back into the ISFSI using the western gate shown in **Figure 2-7**, where the transportation casks will be loaded. For shipments of both the TN and NAC canisters, the recommended approach is to prepare five casks for transportation and stage them within the ISFSI, prior to starting the campaign to transfer them to the transload site. The area north of the western gate is recommended to serve as the cask preparation and staging area. This will, however, require removal of the two existing storage buildings. According to DEK, these buildings were once used for storage of steam generators and if necessary, can be removed in the future to support ISFSI operations [9].

The operations to transfer a loaded canister from the storage cask to the transportation cask will occur near the storage casks. For the TN system, the transfer operations will occur adjacent to the HSMs. The loaded transportation cask will then be moved to the cask preparation and staging area where the impact limiters will be installed, all inspections and preparations made for transportation, and the configured cask and transport skid will be staged on the ground awaiting loading onto an HHT. For the NAC system, the transfer operations will occur at the north end of the VCC storage pad. The loaded transportation cask will then be moved to the cask preparation and staging area where the cask will be down-ended, the impact limiters installed, all inspections and preparations made for transportation, and the configured cask and transport skid will be staged on the ground awaiting loading onto an HHT. Refer to Sections 6.1.3 and 6.1.4 for details of the canister transfer and cask preparation operations for the NAC and TN systems, respectively.

2.1.1 TN NUHOMS Storage System Details

The 14 NUHOMS 32PT Dry Storage Canisters (DSCs) loaded at KPS, containing a total of 448 fuel assemblies, are currently stored in 14 NUHOMS Model 102 HSMs. The first four DSCs were loaded and are currently maintained under Amendment 9 of CoC 1004 [12] (Docket 72-1004), while the remaining 10 DSCs were loaded and are currently maintained under Amendment 10 of CoC 1004 [13]. The only substantial difference between Amendments 9 and 10 is that the storage of control components is authorized in Amendment 10 [14]. On March 31, 2017, the NRC issued Revision 1 to Amendments 9 and 10 of CoC 1004 [15]. This revision, which has an effective date of April 25, 2017 [16], removes the requirement to return a DSC to the spent fuel pool following the drop of a DSC inside of a transfer cask from greater than 15 inches. The general licensee (in this case DEK) has 180 days from the effective date to implement the changes described in Revision 1.

The HSMs, each measuring 15 feet high by 9 feet, 10 inches wide by 19 feet, 10 inches long, are built of 18-inch reinforced concrete and structural steel. Each HSM is a self-contained modular unit that is placed next to other HSMs, with sufficient shielding provided to enable hands-on loading and unloading activities to occur adjacent to other loaded HSMs. The HSM design provides a means of removing spent fuel decay heat through a combination of radiation, conduction, and convection. Ambient air enters the HSM through ventilation openings in the lower side walls of the HSM and circulates around the DSC. Heated air then exits the HSM through outlet openings in the upper side walls of the HSM. A 6-inch nominal gap between adjacent HSMs is maintained to provide a ventilation flow path between modules. A heat shield is fitted to the ceiling and walls of the HSM to protect the concrete from high canister temperatures [17].

The HSM array at KPS includes two rows of eight HSMs, positioned back-to-back, as shown in **Figure 2-10**. The HSMs are located on a 3-foot-thick concrete pad that measures 40 feet wide and 168 feet long [18]. HSMs adjacent to one another provide adequate shielding from one another, although modules at the end of an array or not in a back-to-back configuration require a supplemental 24-inch-thick shield wall to minimize personnel dose. As such, the ends of the HSM arrays at KPS include a separate shield wall. The northern end of the array includes two empty HSMs, which may be used eventually for storage of GTCC LLW [9]. Refer to **Figure 2-6** for a layout of the 16 HSMs.

To access the HSM, a shield door is provided on the front surface, which consists of reinforced concrete with a steel liner. The shield door is secured to the HSM using four 1½-inch bolts and is handled using a door-handling device attached to an overhead crane. Inside of the HSM is a steel support frame including a set of rails for the canister to slide on during loading and unloading operations. A removable canister axial retainer fits into the HSM and prevents axial movement of the canister during seismic activity [17]. Key features of the NUHOMS Model 102 HSM are included in **Figure 2-11**.

FIGURE 2-10: TYPICAL NUHOMS HSM BACK-TO-BACK LAYOUT [17]

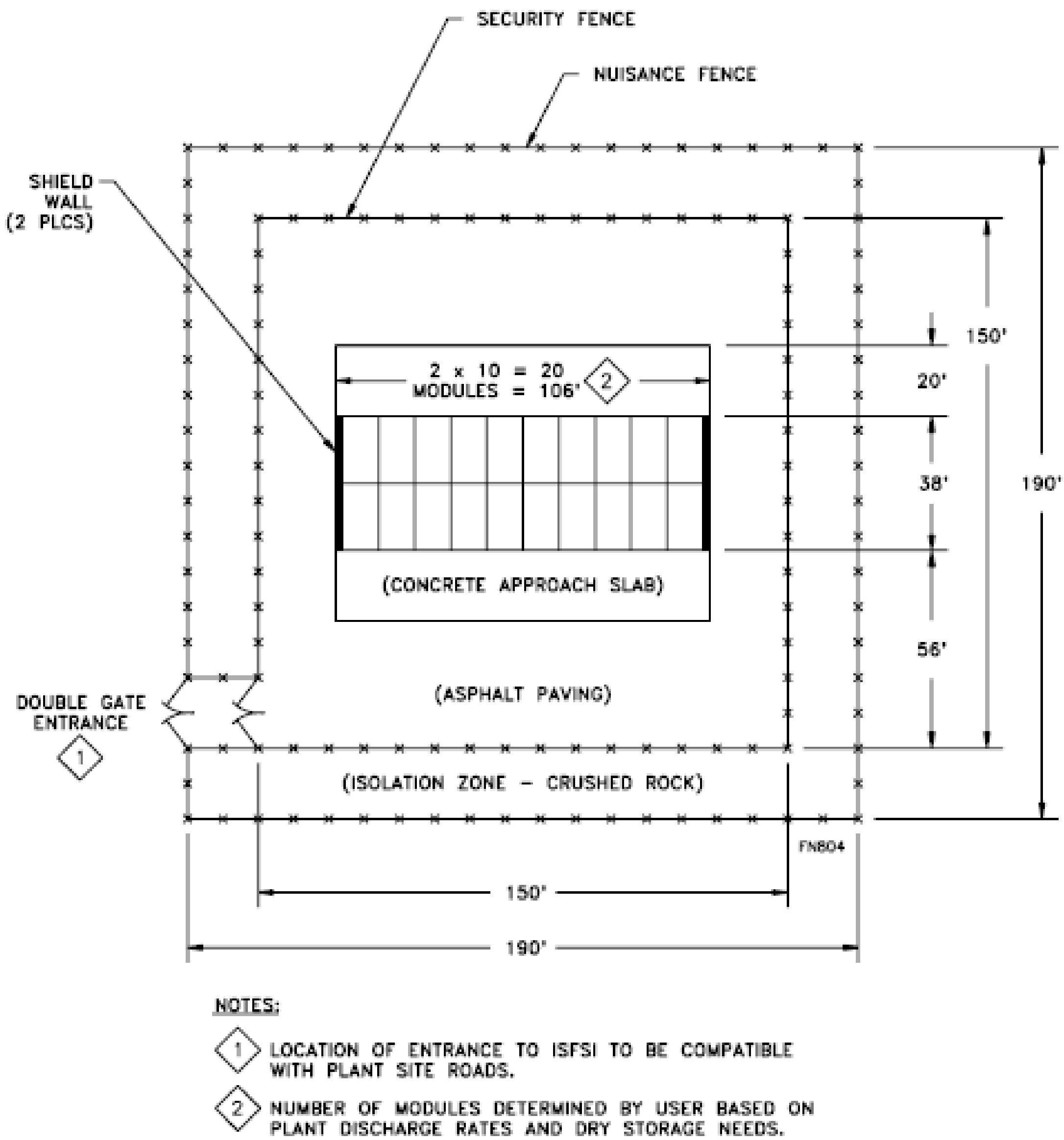
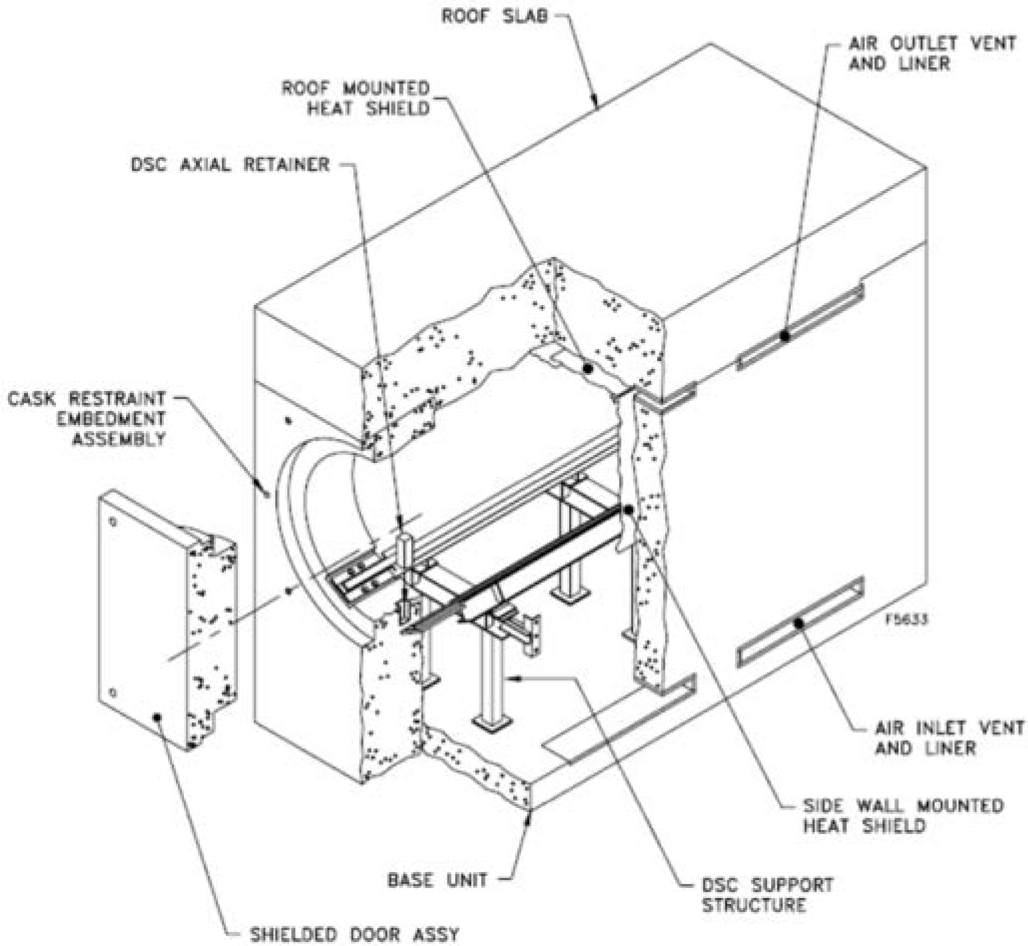


FIGURE 2-11: NUHOMS MODEL 102 HSM [17]



In preparation for loading the 32PT canisters and subsequent placement in the HSMs at KPS, Dominion purchased a complete set of transfer equipment, as listed below. This equipment is currently located at the Millstone nuclear power plant in Connecticut and some of it could be used during the de-inventory operations at KPS. Refer to **Figure 2-12** and **Figure 2-13** for a depiction of the NUHOMS transfer equipment. The canisters were loaded into the HSMs using a transfer cask, although unloading of the canisters will be directly into the transportation cask. As such, the transfer cask will not be used during the de-inventory operations. Due to the heavier weight of the transportation cask, compared to the transfer cask, some of this equipment may require modifications for use during the de-inventory operations at KPS. Refer to Section 2.3.1 for additional information on possible equipment modifications.

- OS-197H Transfer Cask: not required during the de-inventory operations at KPS.
- Transfer Cask Rigging: not required during the de-inventory operations at KPS.
- Transfer Cask Skid: not required during the de-inventory operations at KPS. A new transport skid is recommended that can be used for intermodal transportation as well as for onsite cask handling with the transfer trailer.

- Transfer Trailer: will be needed to position the transportation cask against the HSM. Modification of the existing unit may be required.
- Prime Mover: will be needed to move the transfer trailer.
- Skid Positioning System: will be needed for final alignment of the transportation cask to the HSM. Modification of the existing unit may be required.
- Hydraulic Ram System: will be needed to pull the 32PT canisters into the transportation cask.
- Cask/HSM Restraints: will be needed to secure the transportation cask against the HSM.
- Hydraulic Power Unit: will be needed to power the hydraulic cylinders on the transfer trailer, skid positioning system, and the hydraulic ram system.
- HSM Door-Lifting Device: will be needed for handling of the HSM doors.

FIGURE 2-12: STAGED NUHOMS TRANSFER EQUIPMENT

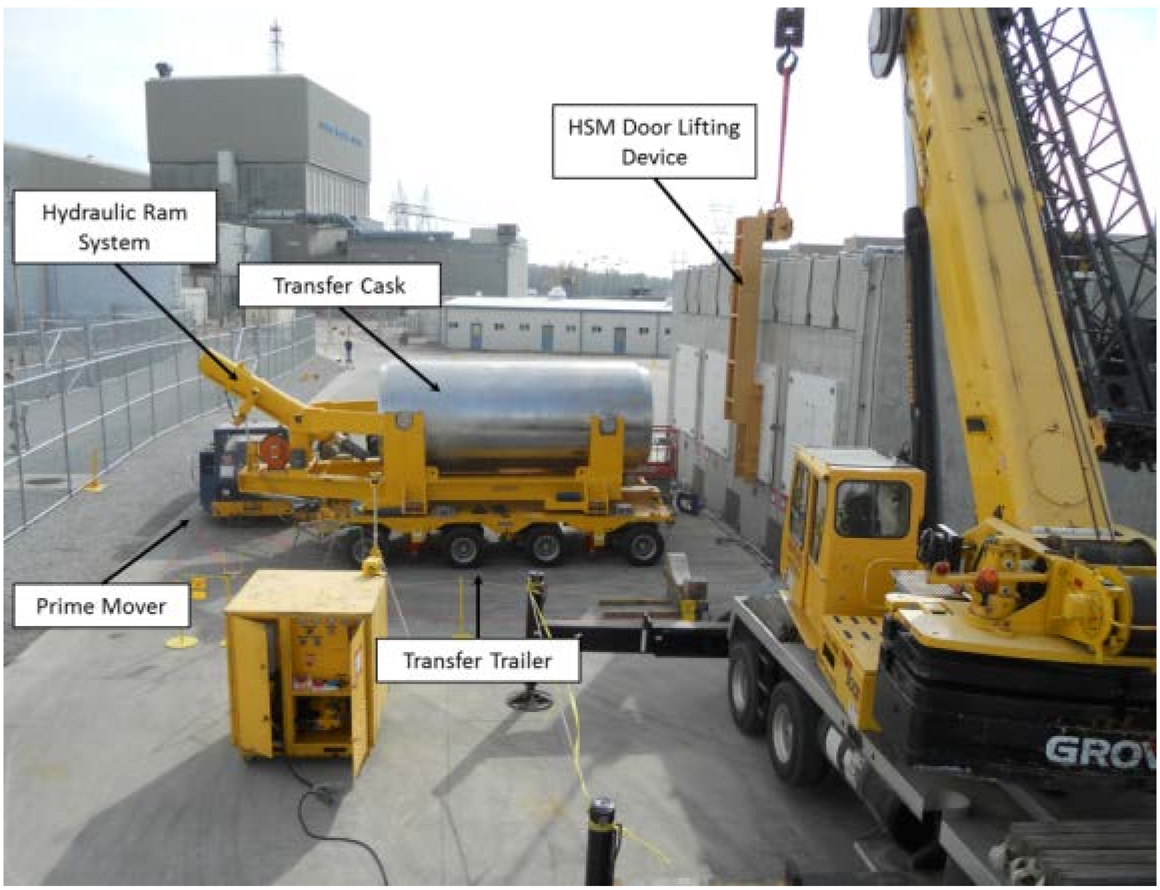


FIGURE 2-13: DOCKED NUHOMS TRANSFER EQUIPMENT

2.1.2 NAC MAGNASTOR Storage System Details

As part of the plant SAFSTOR process, the remainder of the KPS SNF was removed from the spent fuel pool and was moved to the ISFSI by June 15, 2017 for long-term onsite storage in NAC MAGNASTOR systems. The intact fuel assemblies were loaded into 12 MAGNASTOR Transportable Storage Canisters (TSCs), which were then loaded into MAGNASTOR concrete storage casks (VCC Type CC4) and moved to the ISFSI Storage Pad. Damaged fuel assemblies were loaded into Damaged Fuel Cans (DFCs) located in the four corner damaged fuel locations of the Damaged Fuel (DF) TSC. A total of 12 DF TSCs were loaded and placed into storage at the ISFSI in VCCs (Type CC4). Details of the SNF contents can be found in Section 2.2.

The MAGNASTOR system for storage of PWR SNF is comprised of the following components: Fuel TSC (for intact fuel assemblies only), DF TSC (for up to four damaged fuel assemblies and up to 37 undamaged fuel assemblies), VCCs, and a MAGNASTOR Transfer Cask (MTC). The TSCs can be loaded into a corresponding MTC to enable transport of the contents from KPS. The TSCs, VCCs, and MTCs come in two sizes based on the length of the contents. The KPS MAGNASTOR storage systems include 12 Type 1 TSCs (173-inch internal cavity length) and 12 Type 1 DF TSCs. The MAGNASTOR VCCs used at KPS are identified as CC4.

The VCCs, shown in **Figures 2-14** and **2-16** were fabricated onsite and loaded with welded-closed TSCs within the KPS Fuel Building. There are 24 of these storage casks at the KPS ISFSI, with details as follows:

- The MAGNASTOR CC4 casks are 232.4 inches high with lifting lugs installed and 219 inches high with bolted lifting lugs removed, with a diameter of 136 inches [19].
- The reinforced concrete and steel liner walls of the CC4 are 28.25 inches thick and consist of a 1.75-inch-thick inner steel liner surrounded by 26.5 inches of reinforced concrete [20].
- The approximate weights of the MAGNASTOR CC4 casks are 214,500 pounds empty and 318,500 pounds loaded with a MAGNASTOR DF TSC [21].
- The VCC lid, which incorporates concrete neutron shielding, weighs approximately 4,500 pounds and is secured to the cask liner with 6 5/8-inch stainless steel bolts. Three of the six lid bolt holes in the lid are provided threaded for attaching 7/8-9UNC-2B hoist rings for lifting [20].
- The VCCs were loaded and moved out of the KPS Fuel Building using a low-profile HHT. Once out of the Fuel Building, the lifting lugs were installed and a Vertical Cask Transporter (VCT) was moved to access the VCC on the HHT for movement to the ISFSI pad (see **Figures 2-16** and **2-17**). Once in place at the ISFSI designated storage position, the VCC was set down and detached from the VCT.

To enable transferring a TSC from a VCC to a MAGNATRAN transportation cask, an MTC2 [41], shown in **Figures 2-15** and **2-18**, will be used. Details of the MTC2 are as follows:

- The MTC2 transfer cask is 192.8 inches high (including the height of the three retaining block assemblies) and a nominal diameter of 88 inches.
- The inner and outer stainless-steel shells of the MTC2 encase the neutron (NS-4-FR) and lead shielding layers [41].
- The inner cavity of the MTC2 has a nominal diameter of 73 inches and a cavity height of 185.8 inches to accommodate the KPS TSC overall length of 184.8 inches [41].
- The approximate weight of the empty MTC2 is 106,000 pounds and the loaded weights are 212,250 pounds (PWR Fuel TSC) and 216,750 pounds (PWR DF TSC) loaded [6].
- The top of the MTC2 has a set of three retaining blocks that are moved into an engaged position to prevent a TSC from being raised out of the MTC during TSC transfer operations [41].
- Attached to the bottom of the MTC2 is a set of hydraulically operated shield doors to permit passage of a TSC [41].
- The MTC2 includes one pair of lifting trunnions oriented in the opening direction of the shield doors and provide for single-failure-proof (via high design safety factors) lifting with a Secure-Lift Yoke or standard Lift Yoke.
- Following completion of NAC equipment demobilization, the MTC2 used at KPS was moved to off-site storage.

FIGURE 2-14: MAGNASTOR VERTICAL CONCRETE CASK (CC4) [19]

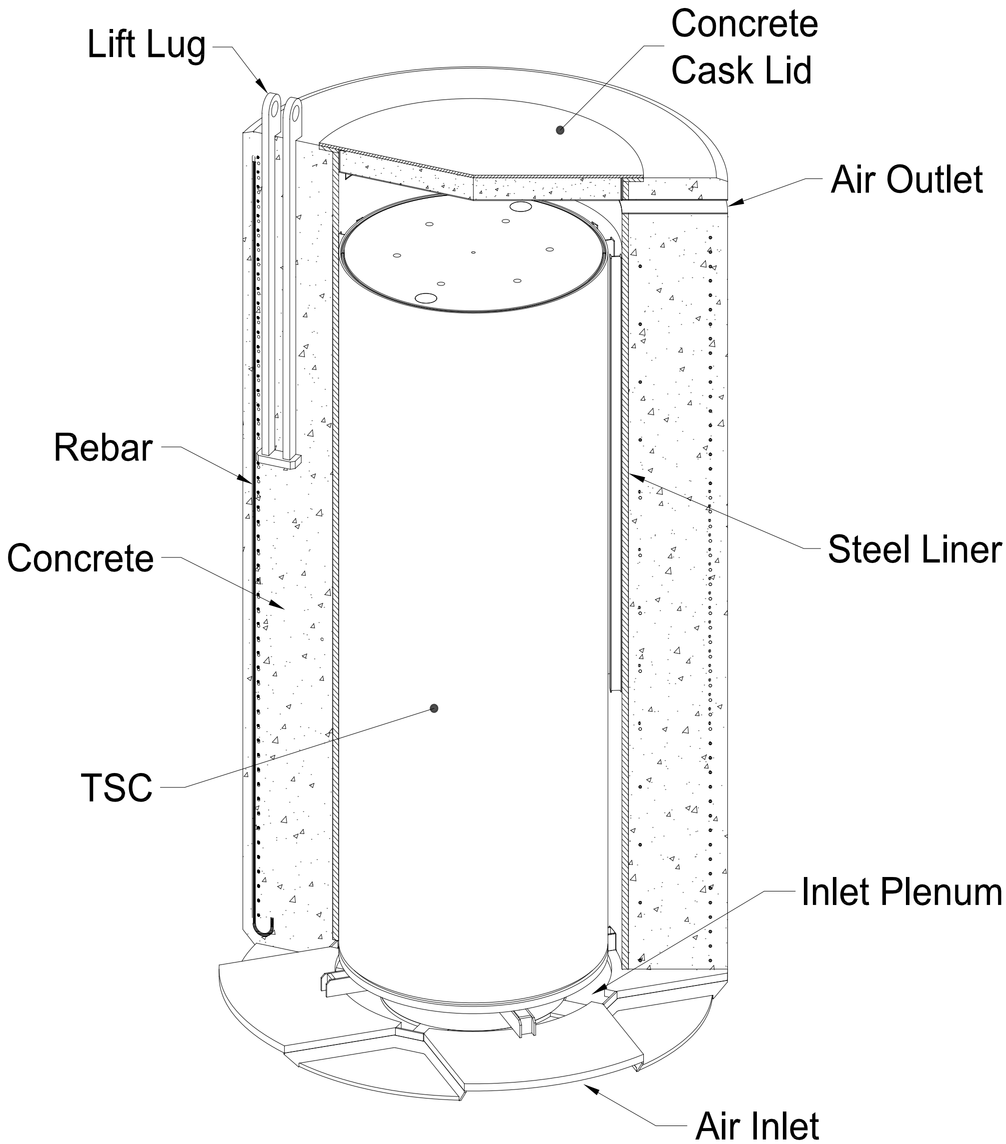


FIGURE 2-15: MAGNASTOR TRANSFER CASK (MTC2) [41] AND TRANSFER ADAPTER

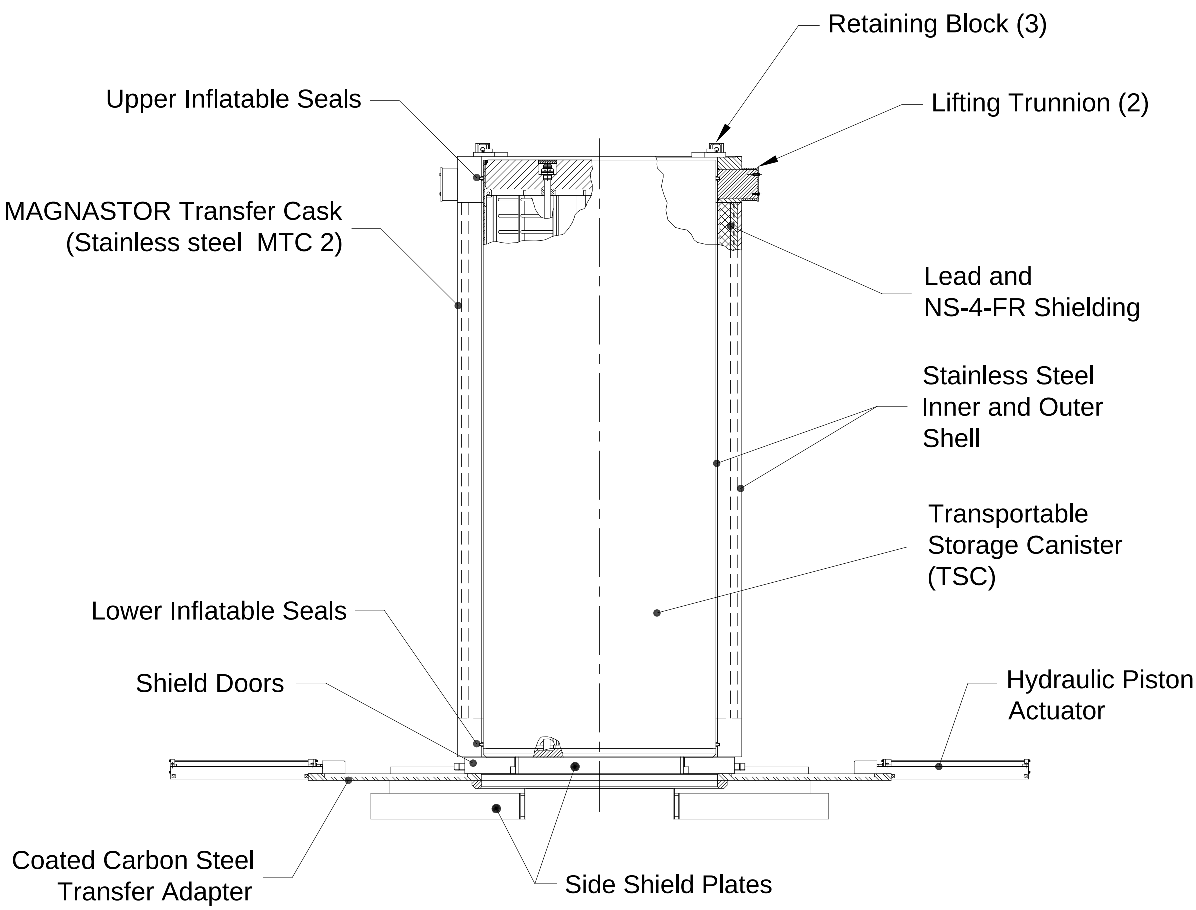
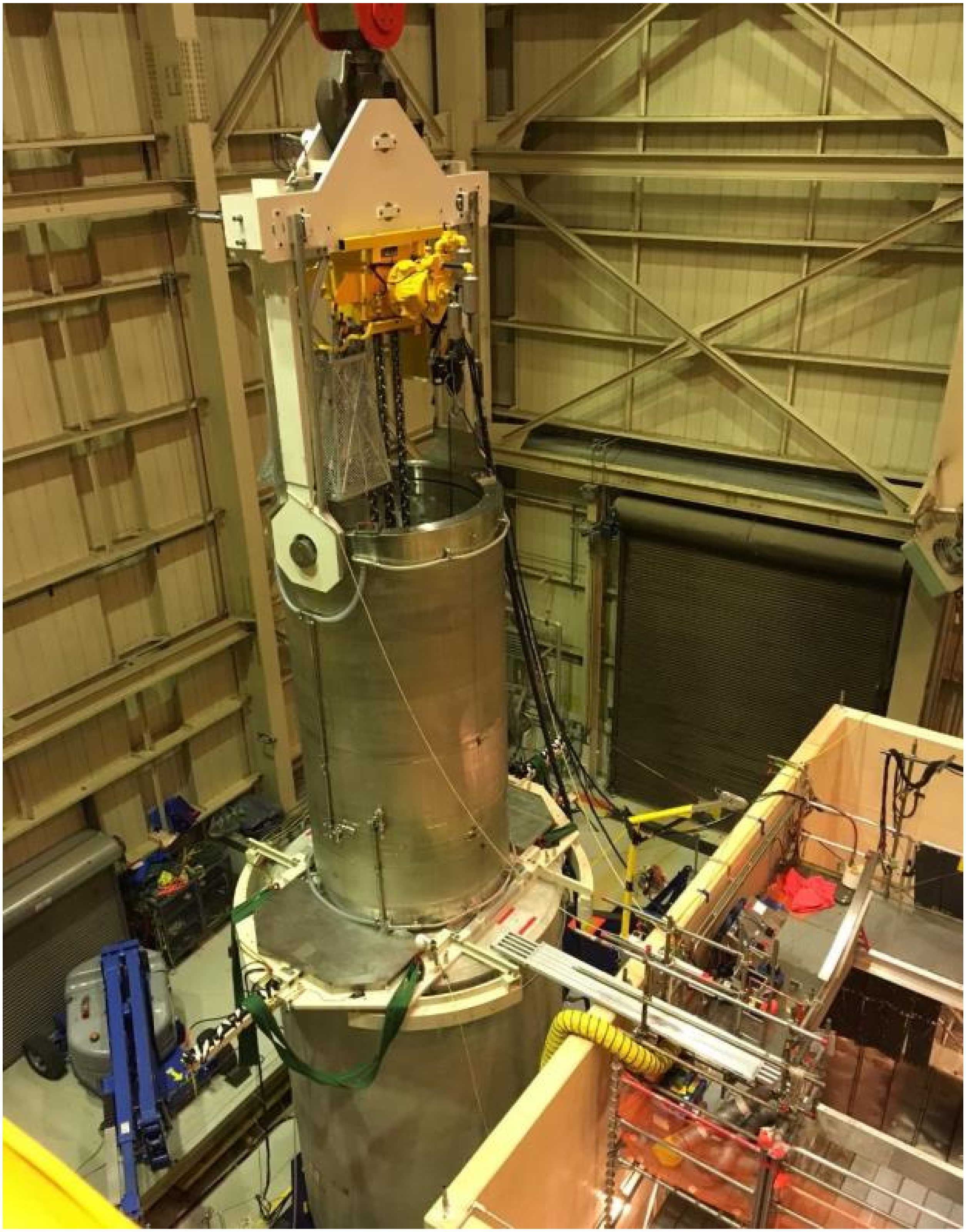


FIGURE 2-16: LOADED MAGNASTOR VERTICAL CONCRETE CASK (CC4) [19] MOVING FROM KPS FUEL BUILDING

FIGURE 2-17: FINAL LOADED MAGNASTOR VERTICAL CONCRETE CASK (CC4) [19] POSITIONED ON KPS ISFSI PAD

FIGURE 2-18: MAGNASTOR TRANSFER CASK (MTC2) [41] WITH TRANSFER ADAPTER ON VCC FOR TSC TRANSFER WITH SECURE-LIFT YOKE AND CHAIN HOIST



2.2 Characteristics of SNF and GTCC LLW to be Shipped

The transfer of the complete inventory of SNF intended to be shipped from the KPS site to the KPS ISFSI was completed on June 15, 2017 and is contained in 14 NUHOMS 32PT canisters, loaded in HSMs, and 24 NAC Fuel and DF TSCs, loaded in VCCs. There is a total of 1,335 SNF assemblies with a total of 518.7 Metric Tons of Heavy Metal (MTHM), which are stored at the KPS ISFSI [22]. Refer to Section 2.2.1 for details of the 448 SNF assemblies loaded in the 32PT canisters. Refer to Section 2.2.2 for details of the remaining 887 SNF assemblies loaded in the MAGNASTOR TSCs.

The KPS SNF is a 14x14 assembly configuration and was supplied by Westinghouse and AREVA[2] in one of five designs. In all cases, the fuel assemblies are 159.8 inches long with a cross section of 7.76 inches. **Table 2-1** provides information on the KPS fuel designs.

It is estimated that 58 cubic feet of GTCC LLW will eventually be removed from the plant, although the current decommissioning schedule shows this occurring in the 2070 timeframe [2]. As it is not known if the GTCC LLW will be stored at the ISFSI or if it will be shipped directly from the plant, this report assumes that the GTCC LLW will be loaded into two NUHOMS Radioactive Waste Containers (RWCs), and stored in the two empty onsite HSMs prior to off-site transportation (see Section 10.0).

TABLE 2-1: KPS FUEL DESIGN INFORMATION [23]

Design	Description	No. of Assemblies at KPS	No. of Assemblies in TN DSCs	No. of Assemblies in NAC TSCs
WE 14x14 Standard (W1414W)	Westinghouse manufactured; zircaloy cladding; stainless steel guide tubes; ~394 kg U.	241	0	241
WE 14x14 OFA (W1414WO)	Westinghouse manufactured; "Optimized Fuel Assemblies"; zircaloy spacer grids; smaller fuel rod diameter; ~358 kg U.	4	0	4
WE 14x14 ANF (W1414A)	AREVA manufactured; shorter, larger diameter fuel rod than WE 14 X 14 ANF Top Rod fuel; ~377 kg U.	659	435	224
WE 14x14 422+ (W1414WL)	Westinghouse supplied	314	0	314
WE 14x14 FRA-ANP Heavy (W1414AH)	AREVA supplied	117	13	104

[2] AREVA was previously known as Exxon Nuclear Corporation, Advanced Nuclear Fuel Corporation, and Siemens Nuclear Corporation.

Tables 2-2 and **2-3** provide data associated with the 1,335 fuel assemblies loaded in the KPS ISFSI. The fuel was discharged from the reactor vessel between 1976 and 2013. The burnup of the fuel varies between 14.7 and 56.3 GWd/MTHM, with 264 fuel assemblies having a burnup greater than 45 GWd/MTHM (i.e., high burnup) [22]. The initial enrichment (^{235}U weight %) of the fuel varied between 2.27% and 4.81% [23].

TABLE 2-2: KPS FUEL DISCHARGE DATA [22]

Assemblies Discharged				Assemblies Discharged			
Year[1]	All	TN[2]	NAC[3]	Year[1]	All	TN[2]	NAC[3]
1976	11	0	11	1992	45	42	3
1977	45	0	45	1993	45	43	2
1978	41	0	41	1994	37	19	18
1979	13	0	13	1995	49	43	6
1980	33	0	33	1996	45	23	22
1981	41	0	41	1998	45	40	5
1982	37	16	21	2000	41	15	26
1983	29	8	21	2001	40	3	37
1984	49	25	24	2003	44	6	38
1985	45	34	11	2004	43	7	36
1986	37	31	6	2006	45	0	45
1987	29	9	20	2008	45	0	45
1988	32	24	8	2009	44	0	44
1989	45	0	45	2011	45	0	45
1990	33	26	7	2012	44	0	44
1991	37	34	3	2013	121	0	121

1 Year indicates when the assemblies were last critical
2 Includes fuel assemblies loaded in the TN 32PT canisters
3 Includes fuel assemblies loaded in the NAC TSC-37 canisters

TABLE 2-3: KPS FUEL BURNUP DATA [22]

Burnup (GWd/MTHM)	All	TN[1]	NAC[2]
10 - 15	7	0	7
15 - 20	48	0	48
20 - 25	7	3	4
25 - 30	79	1	78
30 - 35	311	114	197
35 - 40	450	283	167
40 - 45	169	47	122
45 – 50 (HBU)	153	0	153
50 – 55 (HBU)	103	0	103
55 - 60 (HBU)	8	0	8
Total	**1,335**	**448**	**887**

[1] Includes fuel assemblies loaded in the TN 32PT canisters
[2] Includes fuel assemblies loaded in the NAC TSC-37 canisters

2.2.1 KPS Contents in the TN NUHOMS Storage System

The 14 32PT canisters of SNF contain a total of 448 intact[3] fuel assemblies that were all originally supplied by AREVA. There is no damaged fuel stored in the 32PT canisters, nor was any high burnup fuel loaded into these canisters. **Table 2-4** summarizes the contents of each 32PT canister. The location of each fuel assembly within a particular canister is documented in the canister loading maps [24]. As discussed in Section 2.1.1, the fuel loading into the NUHOMS system was performed under two amendments of Part 72 CoC 1004, specifically Amendment 9 [12] and Amendment 10 [14]. As related to KPS, the only difference between Amendments 9 and 10 is that Amendment 10 allows for storage of fuel assemblies with control components (CC) [14].

As listed in **Table 2-4**, a total of 192 fuel spacers were installed into the 32PT canister compartments as a result of some fuel assemblies being shorter than others. These spacers, while not required under Part 72 storage requirements, are needed for transportation under Part 71 to ensure axial gaps are minimized [17]. Two lengths of spacers were installed, with them being identified as fuel spacer long (FSL) and fuel spacer short (FSS).

[3] Fuel assemblies with pinhole leaks or hairline cracks may be considered as being intact with regards to the requirements associated with storage under CoC 1004 Amendments 9 and 10 [14].

TABLE 2-4: KPS ISFSI CONTENTS [13,24-29, 64]

Canister ID No.	HSM ID No.	Amend-ment No.	Loading Date	No. of FAs (& Design)	No. of CCs	No. of FSLs	No. of FSSs
KPS32PT-S100-A-HZ001	KPS-HSM1	9	8/22/2009	(32) W1414A	0	0	0
KPS32PT-S100-A-HZ003	KPS-HSM3	9	8/27/2009	(32) W1414A	0	0	0
KPS32PT-S100-A-HZ005	KPS-HSM2	9	6/10/2010	(32) W1414A	0	0	0
KPS32PT-S100-A-HZ004	KPS-HSM4	9	6/17/2010	(32) W1414A	0	0	0
KPS32PT-S100-A-HZ002	KPS-HSM6	10	7/14/2011	(32) W1414A	26	0	0
KPS32PT-S100-A-HZ006	KPS-HSM5	10	7/21/2011	(32) W1414A	22	0	0
KPS32PT-S100-A-HZ008	KPS-HSM7	10	8/18/2011	(32) W1414A	0	0	0
KPS32PT-S100-A-HZ007	KPS-HSM7	10	8/25/2011	(32) W1414A	0	0	0
KPS32PT-S100-A16-HZ009	KPS-HSM9	10	7/24/2014	(28) W1414A (4) W1414AH	14	32	0
KPS32PT-S100-A16-HZ010	KPS-HSM10	10	7/31/2014	(30) W1414A (2) W1414AH	16	32	0
KPS32PT-S100-A16-HZ011	KPS-HSM11	10	8/7/2014	(31) W1414A (1) W1414AH	19	31	1
KPS32PT-S100-A16-HZ012	KPS-HSM12	10	8/14/2014	(29) W1414A (3) W1414AH	18	31	1
KPS32PT-S100-A16-HZ013	KPS-HSM13	10	8/21/2014	(31) W1414A (1) W1414AH	13	32	0
KPS32PT-S100-A16-HZ014	KPS-HSM14	10	8/28/2014	(30) W1414A (2) W1414AH	18	32	0

2.2.2 KPS Contents in the NAC MAGNASTOR Storage System

The SNF and associated non-fuel hardware loaded into the MAGNASTOR Systems currently in storage at KPS are listed in **Table 2-5**. A total of 887 KPS SNF assemblies were loaded into 24 MAGNASTOR Systems including 12 standard fuel TSCs and 12 damaged fuel TSCs. A total of 48 DFCs were loaded into the 12 damaged fuel TSCs although only 3 SNF assemblies were identified as "damaged" and required canning. A total of 264 KPS SNF fuel assemblies had burnups exceeding 45,000 MWd/MTU, but were not necessarily loaded into DFCs just because of their burnup.

TABLE 2-5: KPS MAGNASTOR ISFSI CONTENTS [30,31]

Fuel Load Sequence No.	MAGNASTOR VCC / TSC Serial Number	TSC Contents [3, 4]	Heat Load[1] (kW)	Burnup[2] (MWd/ MTU)	Weight of Contents (lbs.)	Date Loaded onto ISFSI
1	VCC-01 / TSC-01	37 SNF FAs (+ 11 BPRA + 8 RCCA + 1 NS)	17.8	52,208	51,201	1/11/17
2	VCC-04 / TSCDF-13	37 SNF FAs + 4 DFCs (+ 4 BPRA + 9 RCCA)	21.7	53,628	51,611	1/20/17
3	VCC-07 / TSC-11	37 SNF FAs (+ 11 BPRA + 8 RCCA + 1 NS)	18.7	52,209	51,251	1/27/17
4	VCC-02 / TSCDF-14	37 SNF FAs + 4 DFCs (+ 14 BPRA + 9 RCCA)	24.98	54,597	51,991	2/3/17
5	VCC-05 / TSCDF-15	37 SNF FAs + 4 DFCs (+ 13 BPRA + 4 RCCA)	24.9	54,663	51,301	2/9/17
6	VCC-03 / TSCDF-16	37 SNF FAs + 4 DFCs (+ 10 BPRA + 9 RCCA)	23.0	49,156	51,831	2/16/17
7	VCC-10 / TSC-02	37 SNF FAs (+ 15 BPRA + 9 RCCA)	22.4	53,672	51,551	2/23/17

Fuel Load Sequence No.	MAGNASTOR VCC / TSC Serial Number	TSC Contents [3, 4]	Heat Load[1] (kW)	Burnup[2] (MWd/ MTU)	Weight of Contents (lbs.)	Date Loaded onto ISFSI
8	VCC-08 / TSC-03	37 SNF FAs (+ 16 BPRA + 9 RCCA)	22.8	48,775	51,751	3/2/17
9	VCC-06 / TSCDF-17	37 SNF FAs + 4 DFCs (+ 10 BPRA + 9 RCCA)	24.3	47,982	51,831	3/9/17
10	VCC-09 / TSC-04	37 SNF FAs (+ 20 BPRA + 9 RCCA)	22.5	55,302	51,731	3/16/17
11	VCC-11 / TSC-05	37 SNF FAs (+ 16 BPRA + 8 RCCA)	23.8	51,330	51,441	3/24/17
12	VCC-12 / TSCDF-18	37 SNF FAs + 4 DFCs (+ 9 BPRA + 2 TP)	23.2	54,492	50,641	3/30/17
13	VCC-13 / TSCDF-19	37 SNF FAs + 4 DFCs (+ 8 BPRA)	23.9	55,250	50,641	4/6/17
14	VCC-16 / TSCDF-20	37 SNF FAs + 4 DFCs (+ 5 BPRA + 5 TP)	23.4	45,729	50,511	4/14/17
15	VCC-19 / TSC-06	37 SNF FAs (+ 12 BPRA + 2 TP)	24.0	54,775	50,241	4/20/17
16	VCC-14 / TSC-07	37 SNF FAs (+ 14 BPRA)	23.4	50,777	50,312	4/26/17
17	VCC-17 / TSC-08	37 SNF FAs (+ 14 BPRA)	24.3	55,250	50,312	5/4/17
18	VCC-15 / TSCDF-21	37 SNF FAs + 4 DFCs (+ 8 BPRA)	23.1	48,598	50,581	5/12/17

Fuel Load Sequence No.	MAGNASTOR VCC / TSC Serial Number	TSC Contents [3, 4]	Heat Load[1] (kW)	Burnup[2] (MWd/ MTU)	Weight of Contents (lbs.)	Date Loaded onto ISFSI
19	VCC-18 / TSCDF-22	37 SNF FAs + 4 DFCs (+ 9 BPRA)	23.5	48,598	50,621	5/17/17
20	VCC-20 / TSC-09	37 SNF FAs (+ 13 BPRA)	24.7	54,661	50,281	5/25/17
21	VCC-22 / TSCDF-23	37 SNF FAs + 4 DFCs (+ 2 BPRA + 1 RCCA + 5 TP)	23.6	45,933	50,521	6/1/17
22	VCC-21 / TSC-10	37 SNF FAs (+ 8 BPRA + 1 RCCA)	22.9	36,498	50,211	6/8/17
23	VCC-23 / TSC-12	37 SNF FAs (+ 8 BPRA + 2 RCCA)	23.3	46,228	50,341	6/11/17
24	VCC-24 / TSCDF-24	36 SNF FAs + 4 DFCs (+ 8 BPRA + 1 TP)	23.4	46,071	50,591	6/15/17

1 Heat load values are for the entire system based on KPS data at time of loading

2 Burnup values are for the maximum fuel assembly in the MAGNASTOR System TSC

3 Content abbreviations FA – Fuel Assemblies (Max. Assembly 1283#); DFC – Damaged Fuel Can (123#); BPRA – Burnable Poison Rod Assembly (40#); RCCA – Reactor Core Control Assembly (130#); NS – Neutron Source (10#); TP – Thimble Plug (10#)

4 Forty-eight DFCs loaded in TSCDF canisters, but only three assemblies confirmed as damaged per sipping campaign. The three damaged KPS fuel assemblies were individually loaded into TSC-DF 17, 22 and 24 in DFCs.

2.3 Description of Canisters/Overpacks to be Shipped

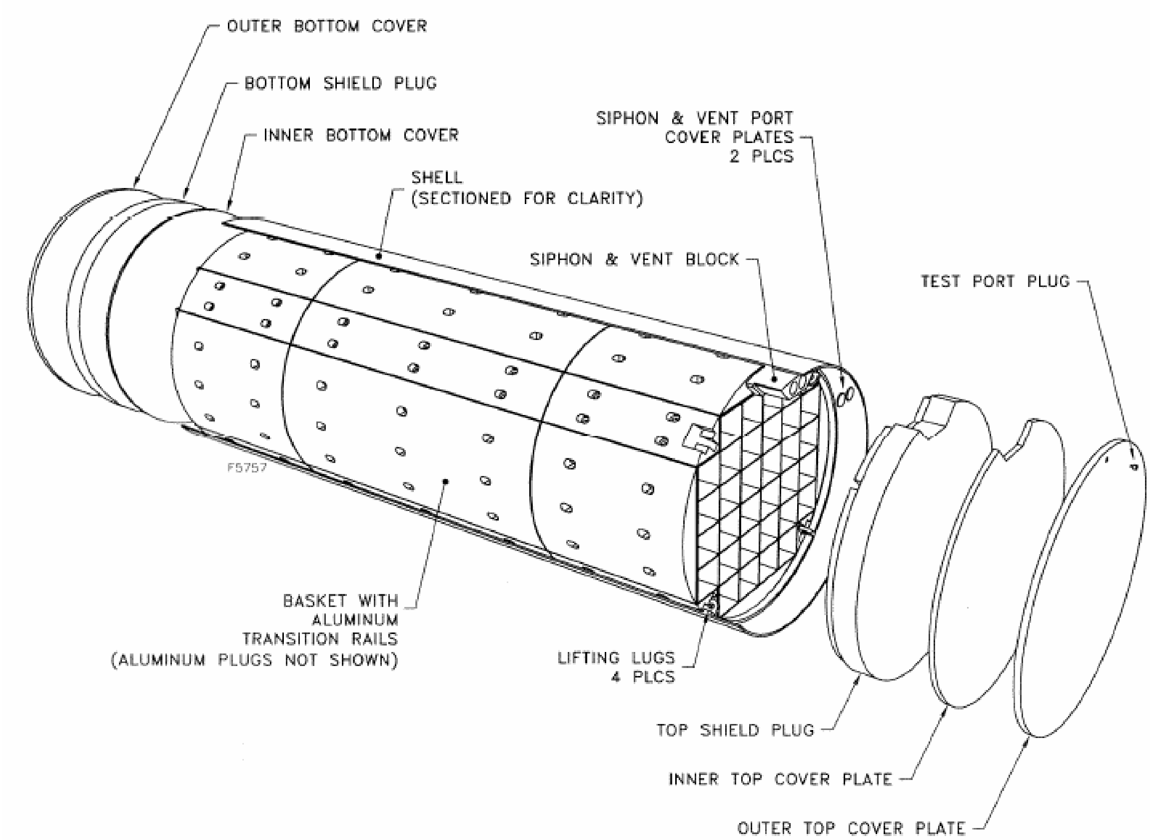
The KPS ISFSI includes two different storage systems, which will in turn require the use of two different transportation packaging systems. Section 2.3.1 provides a description of the NUHOMS 32PT DSC and the associated NUHOMS MP197HB transportation cask. Section 2.3.2 provides a description of the MAGNASTOR TSC-37 and the associated MAGNATRAN transportation cask.

2.3.1 TN NUHOMS Transportation System Details

The NUHOMS 32PT DSCs, shown in **Figure 2-19**, are stainless steel and provide confinement of the contents. The NUHOMS 32PT DSC design includes four models of various sizes. The 14 loaded DSCs stored at KPS are the 32PT-S100 model. Details of this DSC design are as follows [17]:

- The canisters are 186.2 inches long and have an outer diameter of 67.19 inches.
- The maximum nominal loaded weights of the canisters are 88,200 pounds.
- A basket assembly is located within the canister, which includes 32 fuel compartments for PWR fuel assemblies with or without control components.
- To reduce personnel dose, shield plugs are located at each end of the 32PT canister, which are located within the sealed confinement boundary of the canister.
- A grapple ring is included on the bottom end of the canister, which is used by the NUHOMS transfer equipment to push or pull the canister.
- There are no lifting features included in the design to enable lifting a loaded canister.

FIGURE 2-19: NUHOMS 32PT DRY STORAGE CANISTER [17]



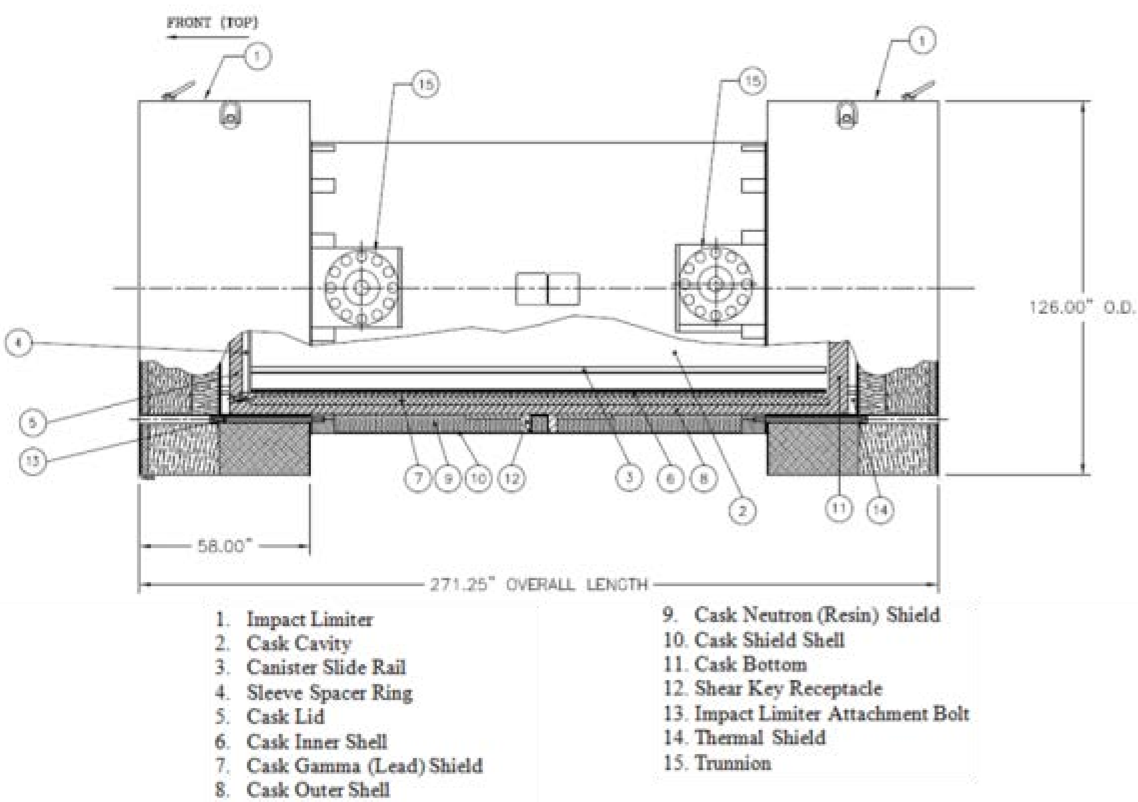
The inventory of 32PT DSCs at the KPS ISFSI to be evaluated for shipment includes the 14 canisters listed in **Table 2-4**. The 32PT DSC design is certified by the NRC for transportation of SNF in the NUHOMS MP197HB cask under CoC 71-9302, Revision 8, which expires on August 31, 2022 [10] (refer to Section 10.0). The MP197HB cask is also certified for transportation of LLW packaged in an RWC, which is similar in design to the NUHOMS DSCs. The RWC could likely be used for storage and transportation of the GTCC LLW that is planned to be removed from KPS. Once the waste has been characterized, an evaluation will be required to ensure the RWC and MP197HB are designed and licensed for the contents (see Section 10.0).

There are currently no MP197HB casks that have been fabricated, although the first unit is partially completed. The cask is designed with an inner stainless-steel shell, a poured-in-place lead gamma shield, a stainless-steel outer shell, and a solid neutron shield encased in a stainless-steel closure. An outer sleeve with fins is an optional feature that can be installed around the cask body when transporting high burnup fuel, although this will not be required for shipment of the 32PT DSCs from KPS. The inner cavity of the cask includes a set of rails for the DSC to slide on during loading and unloading operations. While the main cask lid is located at the top of the cask, a smaller opening is provided in the bottom end to enable the use of a ram for the horizontal loading and unloading of a DSC. The cask body includes four locations to mount trunnions, which are used for lifting and restraint of the cask. For critical lifts, single failure proof trunnions can be installed at all four locations. For other lifts and restraint scenarios, non-single failure proof trunnions are used. During transportation, the trunnions are removed and replaced with trunnion plugs containing neutron shielding. Tie-down of the cask during transportation includes the use of saddles and two metal straps that provide the vertical and lateral restraint, while a shear key that interfaces with the cask body is used for longitudinal restraint [32].

The MP197HB cask is authorized to transport nine different NUHOMS DSCs and the RWC, which vary in size. For the smaller diameter canisters, including the 32PT DSCs at KPS, an inner sleeve is installed in the cask. This sleeve includes a set of rails for the DSC to slide on, and is restrained in the cask using a removable spacer ring. For shorter DSCs, spacers can be added at either end of the cask cavity as required to reduce axial gaps between the canister and the cask [32].

During transportation, the containment boundary of the MP197HB cask (including the inner shell, the cask lid, the bottom ram access closure plate, the vent and drain ports, and the associated seals) is pressurized with helium to preclude air in-leakage and assist in heat removal. The cask lid and the bottom ram access closure plate include dual seals and a test port to perform leak testing between the seals. Leak testing of the vent and drain port seals involve the use of a special test port tool to verify the integrity of those seals [32]. **Figure 2-20** includes the main features of the MP197HB cask.

FIGURE 2-20: NUHOMS MP197HB TRANSPORT CASK [32]



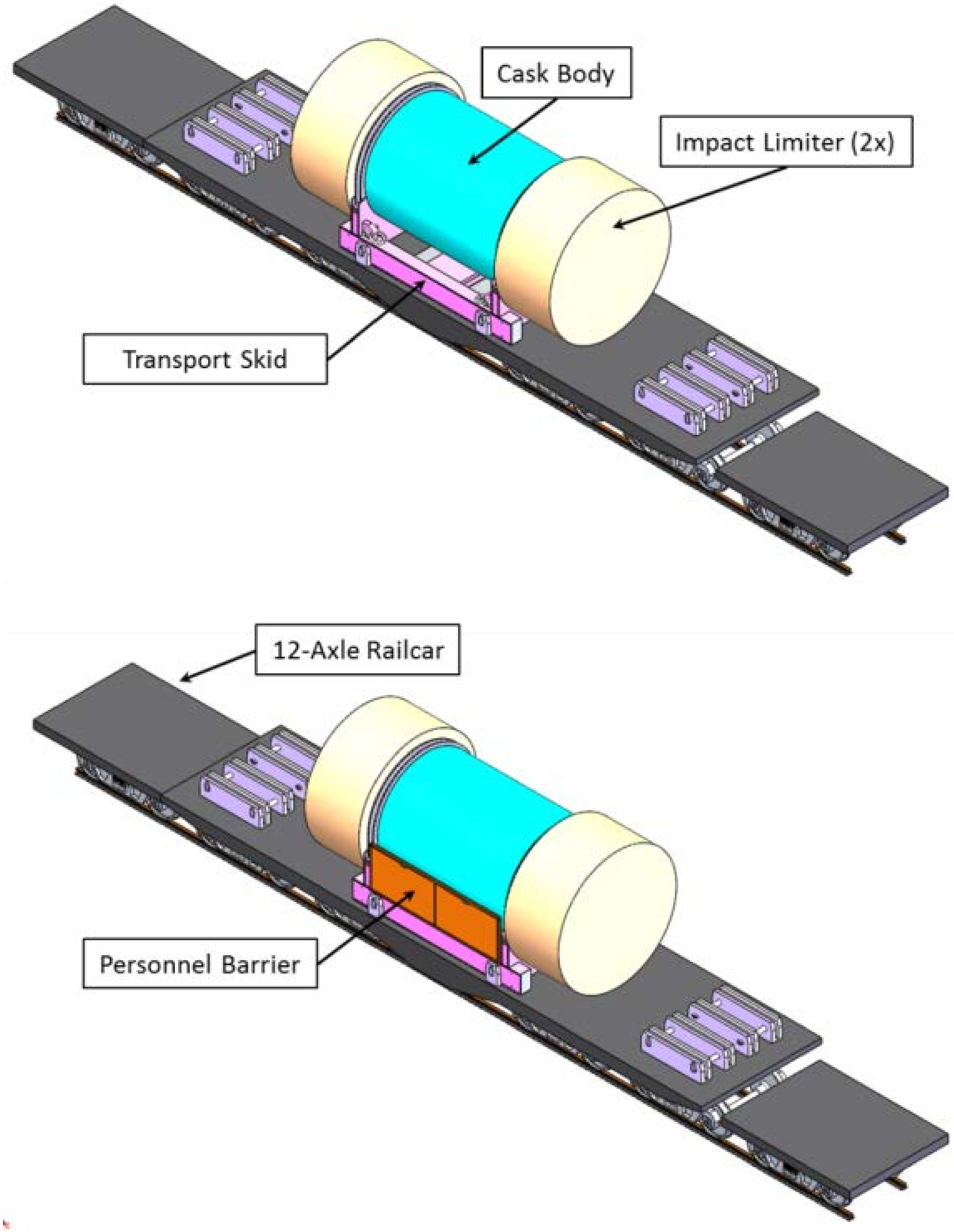
The weights and dimensions of the NUHOMS MP197HB transport packaging are shown in **Table 2-6**.

TABLE 2-6: NUHOMS MP197HB WEIGHTS AND DIMENSIONS [32]

Attribute	Value (lbs / in)	Comments
Empty Cask Weight	157,500	Without impact limiters or lid
Cask Lid Weight	6,000	
Impact Limiter Weights	25,000	Includes both impact limiters
Loaded Cask Weight	303,600	With impact limiters installed
Maximum Transport Load	335,000	Loaded overpack, impact limiters, personnel barrier, cradle, + margin
Overall Overpack Length	271.25	With impact limiters
Overpack Length	210.25	Without impact limiters
Overpack Diameter	97.75	Without impact limiters
Impact Limiter Diameter	126	Overall width and height

The HHT and barge transport operations are expected to use the same intermodal transport cradle, and the same connection methods as used for the railcar transport, although further evaluations would be needed, as the transport design loads are less for road and barge than for rail (refer to Section 10.0). The overall transport weight and dimensions for each NUHOMS MP197HB cask, including margins, is estimated to be: 335,000 pounds, 23 feet long, 10 feet 6 inches wide, and 11 feet high (measured from the cradle base). It is important to note that the 126-inch load width, which is driven by the impact limiters, will not exceed the 128-inch width limit imposed by the Association of American Railroads (AAR) for unrestricted interchange service. **Figure 2-21** shows a representation of a NUHOMS MP197HB cask on an intermodal cradle secured to a 12-axle railcar, where the top and bottom images show the cask with and without the personal barrier installed.

FIGURE 2-21: NUHOMS MP197HB CASK ON RAILCAR



The transfer of a DSC from an HSM to an NUHOMS MP197HB, and subsequent preparations for transport, will include the following high-level activities (detailed operations are described in Section 6.1.4):

- Verify the integrity of the DSC and that the contents are authorized for the MP197HB [10] (see Section 10.0).
- Transfer the empty cask and transport skid from the HHT to the transfer trailer.
- Remove the personnel barrier and impact limiters.
- Remove the front trunnion covers from the cask and install the front trunnions.
- Remove the cask lid and then, if present, remove the canister sleeve spacer ring.
- If not present, install the canister sleeve inside the cask.
- Install the unloading flange into the cask opening.
- Install the DSC spacer into the bottom of the cask.
- Remove the ram access closure plate.
- Position the cask in close proximity to the HSM.
- Remove the HSM door and the DSC seismic restraint assembly.
- Align and dock the cask to the HSM.
- Install the cask/HSM restraints.
- Install the ram, extend through the cask bottom port, and engage the DSC grapple ring.
- Retract the ram, pulling the DSC into the cask.
- Remove the ram cylinder and install the ram access closure plate.
- Remove the cask/HSM restraints and reposition the loaded cask away from the HSM.
- Remove the unloading flange and install the canister sleeve spacer ring into the cask.
- Install the cask lid.
- Remove the cask front trunnions and install the associated trunnion covers.
- Perform the containment boundary leak tests.
- Install the impact limiters and then install the personnel barrier.
- Transfer the loaded cask and the transport skid from the transfer trailer to the HHT.

To perform the above activities, the below ancillary devices would be required [32]. Unless specifically addressed, these components are not considered to be safety-related or important to safety.

- Leak Test System: Prior to transport of the MP197HB casks, the containment boundary seals would need to be leak tested. This is done after the cask cavity has been evacuated with a vacuum system and then backfilled with helium. In addition to the vacuum system, a helium mass spectrometer along with a test port tool will be required. It is recommended that this equipment be obtained from the cask vendor when the cask is supplied.

- Replacement seals for cask lid and for the vent, drain, and test port plugs: Prior to performing the final containment boundary seal leak tests, new seals need to be installed. This will need to occur each time the cask is used for a transport, so several seal sets will be required. It is recommended that multiple sets of the seals be obtained from the cask vendor when the cask is supplied. These seals are considered important to safety as they are used to maintain the containment boundary during transport.
- DSC Spacer: Due to the shorter length of the 32PT DSC, an 11.7-inch-long spacer needs to be installed between the bottom of the cask and the DSC. It is recommended that this equipment is obtained from the cask vendor when the cask is supplied. This spacer is considered important to safety as it is used to prevent movement of the DSC during transport.
- Canister Sleeve: Due to the smaller diameter of the 32PT DSC, an aluminum sleeve needs to be installed inside the cask. This sleeve will fit around the rails in the cask and will include a second set of rails for the DSC to slide on during loading. It is recommended that this equipment is obtained from the cask vendor when the cask is supplied. This sleeve is considered important to safety as it is used to prevent movement of the DSC during transport.
- Canister Sleeve Spacer Ring: To prevent the canister sleeve from moving axially during transport, a removable spacer ring is installed between the sleeve and the cask lid. It is recommended that this equipment is obtained from the cask vendor when the cask is supplied. This spacer ring is considered important to safety as it is used to prevent movement of the canister sleeve during transport.
- Unloading Flange: Prior to transferring a smaller diameter DSC, such as the 32PT, from the HSM to the cask, an unloading flange is to be installed into the cask opening to restrain the canister sleeve during loading and unloading. It is recommended that this equipment is obtained from the cask vendor when the cask is supplied.
- Transportation cradle/skid: A cradle (also referred to as a skid) for the MP197HB will need to be designed and fabricated. It is assumed that this cradle will be used during the DSC transfer operations as well as for the subsequent transportation (truck, rail, and/or barge) from the site. A conceptual design of this cradle [33], depicted in **Figure 2-21**, includes straps that go over the cask body to secure the cask to the cradle. A shear key is included in the cradle, which interfaces with the shear key pocket in the cask body to resist axial transportation loads. Lifting points on the cradle allow for lifting the cradle with the loaded cask attached and configured for transport (with impact limiters and personnel barrier). The final design and fabrication of this cradle will likely need to be performed by the cask vendor.
- Transport Cask Lift Beam: The horizontal intermodal transport cradle lift beam would be used to lift and move an empty or loaded transportation cradle containing an empty or loaded MP197HB cask with impact limiters and personnel barrier installed at the loading site, transloading (intermodal transfer) site, and/or at the cask receiving and unloading

location. This device will need to be fabricated and should be provided by the vendor supplying the transportation cradle.

- Transfer Trailer: An onsite transfer trailer would be used to position the horizontally oriented MP197HB cask at the HSM. The transfer trailer used at KPS during loading of the HSMs is owned by Dominion and stored at their Millstone plant. This trailer was designed to handle the OS197 Transfer Cask and has a payload capacity of 125 tons, which will likely need to be modified for transferring the DSCs from the HSMs to the MP197HB due to the weight and dimensions of the MP197HB cask being greater than the transfer cask. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services.
- Prime Mover: An HHT, or other similar prime mover, will be needed to move the transfer trailer. The cask vendor, who will address any needed trailer modifications, will be able to provide the specifications for this equipment. It is possible that the existing prime mover, located at the Millstone plant, can be used at KPS.
- Skid Positioning System: A series of hydraulic cylinders and low-friction contact pads are used between the transfer trailer and cask cradle (skid) to allow final alignment of the cask to the HSM. The skid positioning system used at KPS during loading of the HSMs is owned by Dominion and stored at their Millstone plant. This system was designed to handle the OS197 Transfer Cask and will likely need to be modified for transferring the DSCs from the HSMs to the MP197HB due to the weight and dimensions of the MP197HB cask being greater than the transfer cask. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services.
- Hydraulic Ram and Grapple: A hydraulic ram, with a capacity of 80,000 pounds and a minimum stroke of 20 feet, will be required for retracting the DSC from the HSM into the cask. A grapple is located at the end of the ram for attaching to the DSC grapple ring. The ram used at KPS during loading of the HSMs is owned by Dominion and stored at their Millstone plant. It is expected that the same equipment can be used during the cask loading operations, although a new ram securement system will be needed to mount the ram directly to the bottom of the MP197HB cask, rather than to the transfer skid used previously during HSM loading operations. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services.
- Hydraulic Power Unit: A hydraulic system, consisting of a pump, control valves, and a control system, is used to power the hydraulic cylinders on the transfer trailer, skid positioning system, and the hydraulic ram. The hydraulic power unit used at KPS during loading of the HSMs is owned by Dominion Energy, Inc. (Dominion) and stored at their Millstone plant. It is expected that the same equipment can be used during the cask loading operations.
- Cask/HSM Restraints: A set of adjustable restraints are needed to secure the front trunnions of the MP197HB cask to mounting points embedded in the front face of the HSM. These are used to prevent movement of the cask during DSC transfer operations between the HSM and the cask. The restraints used at KPS during loading of the HSMs are owned by Dominion and stored at their Millstone plant. Due to differences in trunnion diameters, it is expected that a new set of cask/HSM restraints will be needed for cask

loading operations. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services.

- Cask Lid Handling Device: A below-the-hook lifting device will be required to handle the lid of the MP197HB cask, while the cask is oriented horizontally. This device will attach to threaded holes in the lid and will be designed such that the lid will hang vertically when it is being removed or installed. It is recommended that this equipment is obtained from the cask vendor when the cask is supplied.
- HSM Door-Handling Device: A second below the hook-lifting device will be required to handle the door of the HSM. The device used at KPS during loading of the HSMs is owned by Dominion and stored at their Millstone plant. It is expected that the same equipment can be used during the cask loading operations.
- Cranes: It is envisioned that a single mobile crane would be required for the transfer and loading operations. This crane would be used to lift the transportation cask, as well as to handle all the ancillary equipment. Assuming the impact limiters are installed onto the loaded MP197HB transportation cask prior to lifting, a commercially available mobile crane will be sufficient.
- Impact limiters: The transportation cask will arrive with two impact limiters according to the requirements of the Safety Analysis Report (SAR). The impact limiters would be fabricated as part of the transport cask procurement and fabrication. These impact limiters are considered important to safety as they are used to protect the cask during a design basis accident.
- Personnel barrier: As required by the SAR, a personnel barrier would be placed around the loaded cask. The barrier, which attaches to the cradle, spans the distance between the impact limiters and matches the outer diameter of the impact limiters. This device does not currently exist, so it would need to be designed and fabricated. There are no unique requirements that would present expected complications with the lead time and cost of obtaining personnel barriers.

2.3.2 NAC MAGNATRAN Transportation System Details

The inventory of MAGNASTOR TSCs at the KPS ISFSI to be evaluated for shipment includes the 24 MAGNASTOR TSCs listed in **Table 2-5** [7]. The MAGNASTOR TSCs have been submitted to the NRC for certification for transportation of SNF in the MAGNATRAN transport cask under Docket No. 71-9356 [34] (refer to Section 10.0). The characteristics of the MAGNASTOR contents proposed for authorization in proposed draft CoC No. 71-9356 [35] are provided in **Table 2-7** and are as listed in MAGNASTOR CoC No. 1031, Appendix B, Table B2-1. The MAGNASTOR TSC is presented in **Figure 2-22** and the TSC PWR fuel basket is shown in **Figure 2-23**.

TABLE 2-7: DESCRIPTION OF KPS MAGNASTOR TSC CONTENTS PER MAGNASTOR TECHNICAL SPECIFICATIONS [7]

Assembly Manufacture/Type	PWR[1] 14 x 14 in Fuel TSC	PWR[1] 14 x 14 in DF TSC
Cladding Material	Zirconium-Based Alloy	Zirconium-Based Alloy
Maximum Number Assemblies	37	37 (with up to 4 damaged fuel assemblies in DFCs in DF TSC corner locations)
Maximum Initial Uranium Content (kg/assembly)	418.8	418.8
Maximum Initial Enrichment (wt% ^{235}U)	5.0	5.0
Minimum Initial Enrichment (wt% ^{235}U)	1.3	1.3
Maximum Assembly Weight (lbs)	≤ 1,765	≤ 1,765
Maximum Burnup (MWd/MTU)	62,500	62,500
Maximum Decay Heat per Assembly (kW)[2]	1.8	1.8
Minimum Cool Time (yrs)	2.5	2.5
Maximum Active Fuel Length (in)	≤ 145.2	≤ 145.2

1 Zirconium-based Alloy fuel assemblies manufactured by Westinghouse Electric Co. and AREVA

2 Maximum decay heat load based on four-zone loading

FIGURE 2-22: MAGNASTOR TRANSPORTABLE STORAGE CANISTER (TSC) [21, 36]

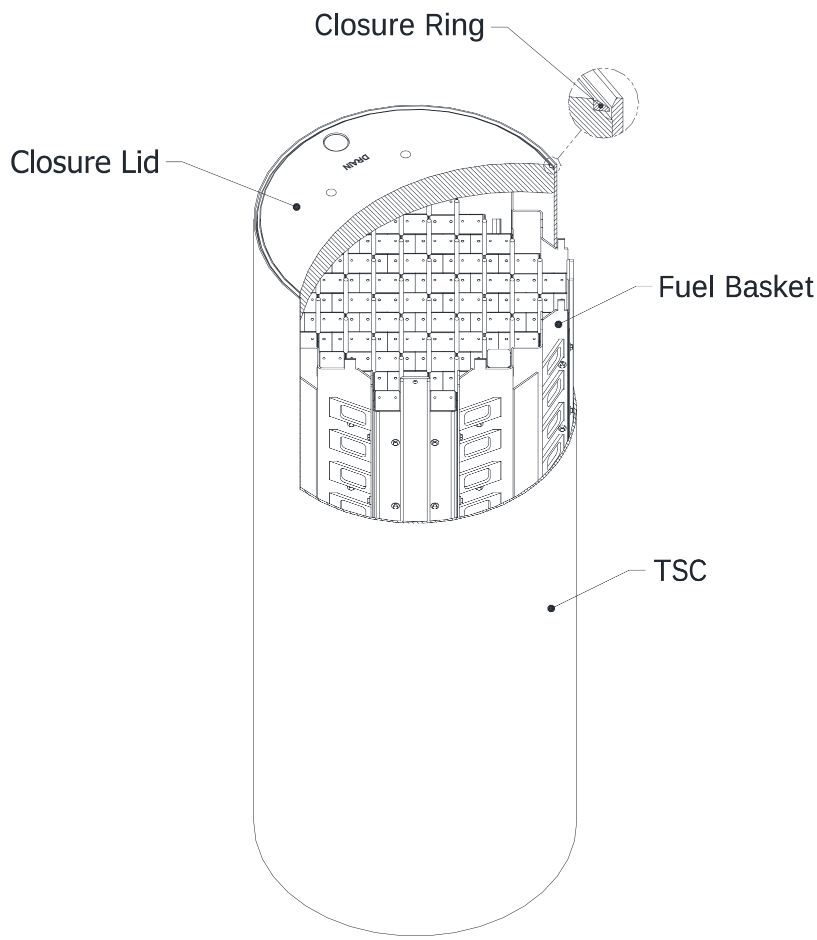
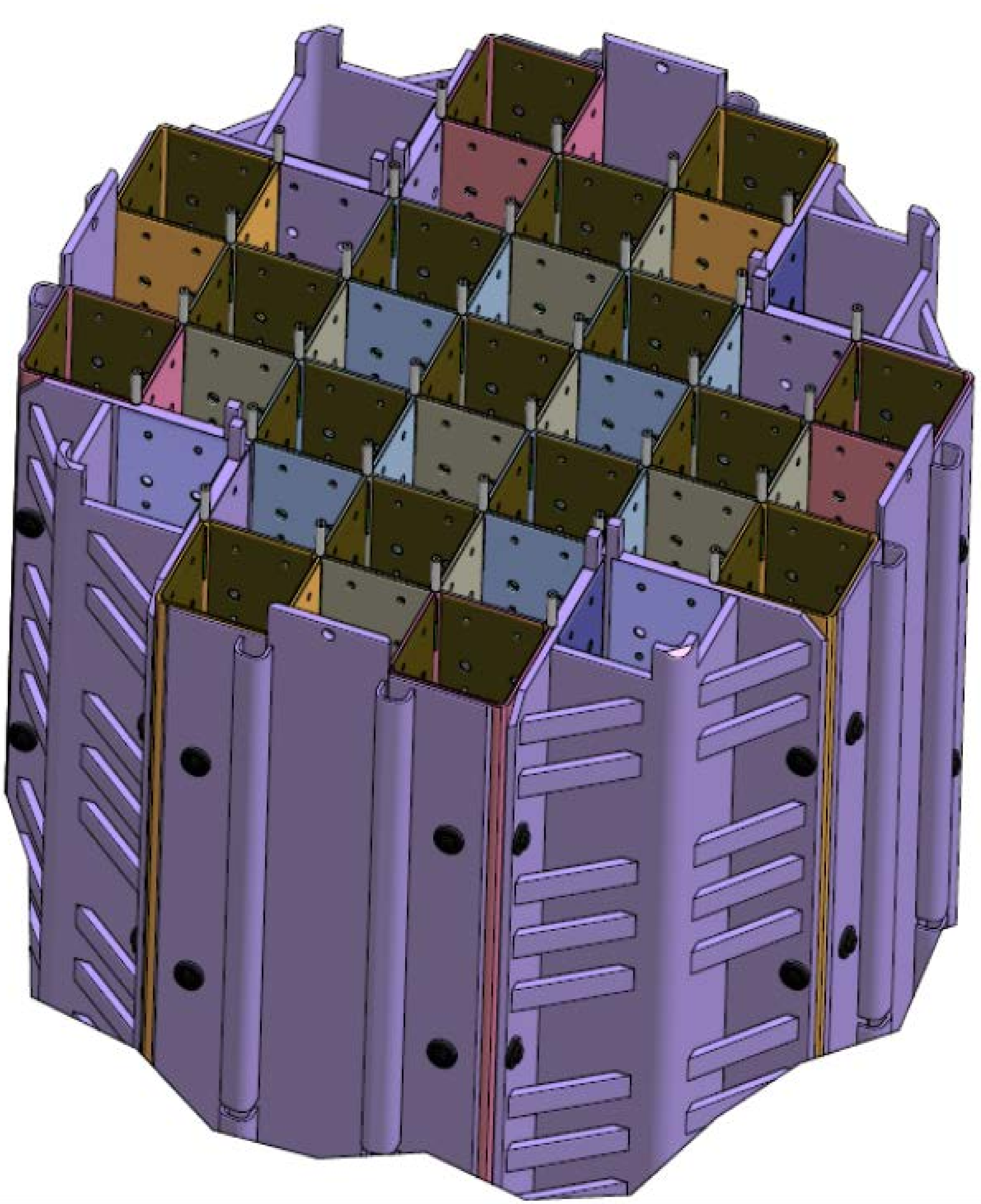


FIGURE 2-23: MAGNASTOR DF TSC FUEL BASKET [37]



The proposed MAGNATRAN PWR fuel content conditions for both undamaged and damaged PWR fuel assemblies contained in the draft CoC No. 9356 reflecting the analyses submitted in the MAGNATRAN SAR [34] modified for KPS fuel contents are presented in **Tables 2-8** through **2-13**.

TABLE 2-8: DESCRIPTION OF KPS PWR TSC CONTENTS FOR TRANSPORT IN MAGNATRAN [35]

Intact PWR Fuel Class Assembly Characteristics		
Characteristic	Fuel Class	
	14x14	14x14
Base Fuel Type[1]	CE, SPC	W, SPC
Max Initial Enrichment (wt. % ^{235}U) [2]	5.0	5.0
Min Initial Enrichment (wt. % ^{235}U) [2]	1.3	1.3
Number of Fuel Rods [3]	176	179
Max Assembly Average Burnup (MWd/MTU) [4]	70,000	70,000
Min Cool Time (years)	4	4
Max Weight per Storage Location (lbs.)	See Note 6	See Note 6
Max Decay Heat per Fuel Location (Watts) [5]	622	622

1 Indicates assembly and/or nuclear steam supply system (NSSS) vendor/type reference for fuel input data. Fuel acceptability for loading is not restricted to the indicated vendor provided that the fuel assembly meets the load limits. Abbreviations are as follows: Westinghouse (W, WE), Combustion Engineering (CE), Siemens Power Corporation (SPC), Framatome Cogema Fuels (FCF) and Babcock and Wilcox (BW, B&W).

2 All reported enrichment values are nominal pre-irradiation fabrication values. PWR fuel is loaded using burnup credit. Maximum enrichment is a function of minimum burnup. Maximum initial enrichment represents the peak fuel rod enrichment for variably-enriched fuel assemblies.

3 Assemblies may contain nonfuel hardware and/or fuel replacement rods.

4 All fuel with burnup >45,000 MWd/MTU is placed into DFCs. (Note: it is NAC's intent to delete this requirement for high burnup fuel (HBU) as NRC gains additional information on the integrity of HBU fuel assemblies).

5 Maximum uniform heat load per storage location. (Note: it is NAC's intent to revise this thermal limit based on the zoned loading patterns allowed per the MAGNASTOR CoC.)

6 Maximum weight per storage location is 1,765 lbs. (including nonfuel hardware and spacers) with a maximum contents weight of 62,160 lbs. for the PWR basket and 61,184 lbs. for the DF basket.

TABLE 2-9: DESCRIPTION OF KPS NONFUEL HARDWARE TSC CONTENTS COOLING TIMES FOR TRANSPORT IN MAGNATRAN [35]

Additional Fuel Assembly Cool Time Required to Load Nonfuel Hardware			
Core (Assembly)	Additional Cool Time (Years)		
	BPAA/HFRA	GTPD/NSA	RCC
CE 14x14	--	--	0.1
WE 14x14	1.1	0.1	1.3

TABLE 2-10: DESCRIPTION OF KPS NONFUEL HARDWARE TSC CONTENTS BURNUP AND COOLING TIMES FOR TRANSPORT IN MAGNATRAN [35]

Nonfuel Hardware Max Burnup and Required Cool Times (Years)		
Hardware	Maximum Burnup (GWd/MTU)	Minimum Cool Time (Years) [1]
		WE 14x14
BPRA	70	8.0
GTPD/NSA	180	8.0

[1] Minimum cool time for KPS nonfuel hardware should be met by 2023 for newest assembly.

TABLE 2-11: DESCRIPTION OF KPS NONFUEL HARDWARE TSC ^{60}CO ACTIVITY FOR TRANSPORT IN MAGNATRAN [35]

Nonfuel Hardware Max ^{60}Co Activity (Ci)	
Hardware	WE 14x14
BPRA	704.0
GTPD/NSA	60.5

TABLE 2-12: DESCRIPTION OF KPS DFC TSC CONTENTS COOLING TIMES FOR TRANSPORT IN MAGNATRAN [35]

Required Burnup - 37 Assembly Damaged Fuel Configuration - 20 Year Minimum Cool Time								
Assembly ID	10B Absorber (g/cm3)	Zero (0) Burnup Maximum Enrichment (wt. % 235U)	Minimum Required Burnup (GWd/MTU) = C1 x Enrichment (wt. % 235U) - C2					
			Burnup (GWd/MTU) < 18		18 ≤ Burnup (GWd/MTU) ≤ 30		Burnup (GWd/MTU) > 30	
			C1	C2	C1	C2	C1	C2
WE14	0.036	1.9	22.0	39.0	17.4	31.0	16.6	31.0

TABLE 2-13: DESCRIPTION OF KPS RCC TSC CONTENTS COOLING TIMES FOR TRANSPORT IN MAGNATRAN [35]

RCC Cool Time (Years) [1]			
Maximum Exposure (GWd/MTU)	180	270	360
Minimum Cool Time (Years)	10.0	14.0	20.0

[1] Minimum cool time for KPS RCCAs should be met by 2025

Note: For the up to four DFC locations in a damaged fuel basket assembly containing damaged fuel, the damaged fuel must have a minimum burnup of 5 GWd/MTU, a maximum enrichment of 3.8 wt. % ^{235}U, and a minimum cool time of 20 years. For loaded KPS fuel, minimum cool time of 20 years will be met in 2035 (earliest shipment date). A CoC amendment could be submitted to reduce cool time based on zoned loading conditions.

The MAGNATRAN transport cask is designed to be compatible with all MAGNASTOR TSCs currently deployed at four ISFSIs in the U.S. including Dominion's KPS, Duke Power's Catawba and McGuire Nuclear Station, and Exelon's Zion Nuclear Power Plant, and any future PWR or Boiling Water Reactor (BWR) facilities using MAGNASTOR storage systems. Primarily based on their lengths, two categories of PWR and two categories of BWR fuel assemblies have been evaluated in the safety analysis for transport. Two lengths of TSCs are designed to transport the two categories of PWR and BWR fuel assemblies. The MAGNASTOR TSCs at KPS are the short length PWR design (i.e., TSC2).

The weights of the KPS MAGNASTOR system and MAGNATRAN transport packaging components are shown in **Table 2-14** and the overall characteristics and dimensions are shown in **Table 2-15**.

TABLE 2-14: NAC MAGNASTOR STORAGE AND MAGNATRAN TRANSPORT CASK WEIGHTS [6, 34]

MAGNASTOR and MAGNATRAN Component Description	KPS Fuel TSC and MAGNATRAN Weights (pounds)	KPS DF TSC and MAGNATRAN Weights (pounds)
TSC Empty Weight (w/basket, w/o fuel or closure lid)	29,000	33,500
TSC Closure Lid	10,500	10,500
TSC Contents	51,751	51,991
Loaded/Closed Canister	91,251	95,991
VCC (empty w/lid)	210,000	210,000
VCC Lid	4,500	4,500
VCC Loaded	305,751	310,491
MTC (empty)	106,000	106,000
MTC w/TSC	197,251	201,991
MAGNASTOR Transfer Adapter	12,850	12,850

MAGNASTOR and MAGNATRAN Component Description	KPS Fuel TSC and MAGNATRAN Weights (pounds)	KPS DF TSC and MAGNATRAN Weights (pounds)
KPS Integrated Secure-Lift Yoke and Hoist System	23,000	23,000
Loaded MTC Under-the-Hook Weight	220,251	224,991[1]
MAGNATRAN TSC Content Weight (Maximum)	101,000	104,500
MAGNATRAN Transport Spacer for TSC2	1,375	1,375
MAGNATRAN Top Impact Limiter	8,000	8,000
MAGNATRAN Bottom Impact Limiter (Balsa)	8,000	8,000
MAGNATRAN Lid (w/Closure Bolts)	10,500	10,500
MAGNATRAN Cask Body	180,500	180,500
MAGNATRAN with Lid and Closure Bolts	191,000	191,000
MAGNATRAN with Lids + Spacer	192,000	192,000
Loaded MAGNATRAN with KPS TSC Contents	283,251	287,991
MAGNATRAN Lift Yoke (nominal estimated weight)	10,000	10,000
Loaded MAGNATRAN Under-the-hook Weight (dry) [2]	293,251	297,991
MAGNATRAN Package Transport Ready Weight (KPS) [3]	299,251	303,991
MAGNATRAN Package Design Transport Weight [4]	312,000	312,000
Intermodal Transport Cradle (estimated weight) [5]	46,200	46,200

1 Transfer Cask (TFR) Under-the-hook weight: MAGNASTOR MTC with loaded KPS DF TSC and Integrated Secure-Lift Yoke and Hoist.

2 MAGNATRAN Under-the hook weight: MAGNATRAN loaded with KPS MAGNASTOR TSC contents, Closure Lid, MAGNATRAN transport cavity spacer, and MAGNATRAN lift yoke.

3 MAGNATRAN Package – Transport-ready weight: loaded cask with impact limiters, KPS MAGNASTOR TSCs containing KPS SNF, etc.

4 Design Maximum MAGNATRAN Package Transport Weight based on design basis DF TSC contents.

5 Intermodal Transport Cradle weight based on Atlas Railcar Project conceptual design [33, 34]

TABLE 2-15: MAGNATRAN TRANSPORT CASK DESIGN CHARACTERISTICS AND COMPONENT DIMENSIONS [34]

Design Characteristic	Value	Material
MAGNATRAN Overall Length without Impact Limiters	214 in.	--
MAGNATRAN Overall Length with Impact Limiters	322 in.	--
MAGNATRAN Body Maximum Cross-Section Diameter • Across corners of neutron shield plates • Across tips of cooling fins	 99.5 in. 110 in.	--
MAGNATRAN Upper Forging Diameter	86.7 in.	--
MAGNATRAN Bottom Forging Diameter	86.7 in.	--
Impact Limiter Diameter	128 in.	--
MAGNATRAN Limiter Height	66.1 in.	--
MAGNATRAN Cavity Length	192.5 in.	--
Cask Cavity Diameter	72.5 in.	--
Cask Capacity (No. of PWR SNF assemblies) • PWR Fuel • PWR DF	 37 37 (incl. up to 4 DFC)	 -- --
Inner Shell Thickness	1.75 in.	Type 304 Stainless Steel
Gamma Shield Thickness	3.2 in.	Chemical-Copper Lead
Outer Shell Thickness	2.25 in.	Type 304 Stainless Steel
Top Forging – Radial Thickness at Cavity Diameter	7.22 in.	Type 304 Stainless Steel
Bottom Thickness (total) • Bottom Inner Forging • Bottom Plate	13.65 in. 5.0 in. 8.65 in.	 Type 304 Stainless Steel Type 304 Stainless Steel
Neutron Shield Assembly - Thickness • Neutron Shielding • Outer and Inner Shell • Bottom / Top End Plates	 5.5 in. 0.125 in. 0.25 in.	 NS-4-FR, Solid Synthetic Polymer Type 304 Stainless Steel Type 304 Stainless Steel
Lifting Trunnions • Trunnion Diameter • Trunnion Shaft Length • Trunnion Bushing Diameter • Trunnion Cap Diameter • Trunnion Cap Thickness • Bolts (9) • Torque • Trunnion Weight (handling)	 6.25 in. 3.75 in. 7.5 in. 8.0 in. 0.378 in. 1-1/8 8 UN-3A 120 ± 20 ft.-lbs. 115 lbs.	 Type 17-4 PH Stainless Steel (bolted) Nitronic 60 Stainless Steel 304 Stainless Steel SB-637, GR N07718, Nickel Alloy Steel

Design Characteristic	Value	Material
• Rotation Trunnion Diameter • Rotation Trunnion Available Shaft Length • Rotation Trunnion Support	6.0 in. 2.5 in. 15.0 x 11.6 x thickness of 6.67 / 7.9 in.	Type 17-4 PH SS (pinned to Trunnion Support) XM-19 Stainless Steel
MAGNATRAN Lid Assembly • Total Thickness • Overall Lid Diameter • Recessed Lid Diameter • Top Lid Section Diameter • Lid Rim at Bolt Circle • Bolts (48) • Torque • Inner O-Ring • Outer O-Ring • Leak Test Port Plug	 7.75 in. 81.96 in. 72.0 in. 73.7 in. 2.25 in. 2 - 8 UN – 2A 4600 ± 200 ft.-lbs. Metal EPDM 1	17-4 PH Stainless Steel 17-4 PH Stainless Steel Helicoflex H-311676 0.275 E740-75 120 ± 5 in.-lbs.
Vent Coverplate • Body thickness • Diameter • Bolts (4) • Torque • Inner O-Ring • Outer O-Ring • Leak Test Port Plug	 1.25 in. 5.25 1/2 - 13 UNC 160 ± 20 in-lbs. Metal EPDM 1	 Type 304 Stainless Steel SA-193, GR B6, Type 410 SS Helicoflex U42412-2500SEB Parker 2-234 E740-75 120 ± 5 in.-lbs.

Figure 2-24 shows a representation of a MAGNATRAN cask [38] on an intermodal transport cradle secured to a 12-axle railcar. **Figure 2-25** shows a picture of a NAC-STC transport package, similar in dimensions to a MAGNATRAN transport cask, being placed on an HHT with personnel barrier for transport in China.

The HHT and barge transport operations are expected to use the same intermodal transport cradle, and the same connection methods used for the railcar transport, although further evaluations would be needed, as the transport design loads are less for road and barge than for rail (refer to Section 10.0). The overall transport weight and dimensions for each MAGNATRAN package, including margins, is estimated to be: 360,000 pounds, 27 feet long, 10 feet 8 inches wide, and 11 feet high (measured from base of the cradle). It is important to note that the 128-inch load width, which is driven by the impact limiters, will not exceed the 128-inch width limit imposed by the AAR for unrestricted interchange service.

FIGURE 2-24: MAGNATRAN ON TRANSPORT FRAME MOUNTED ON 12-AXLE RAILCAR

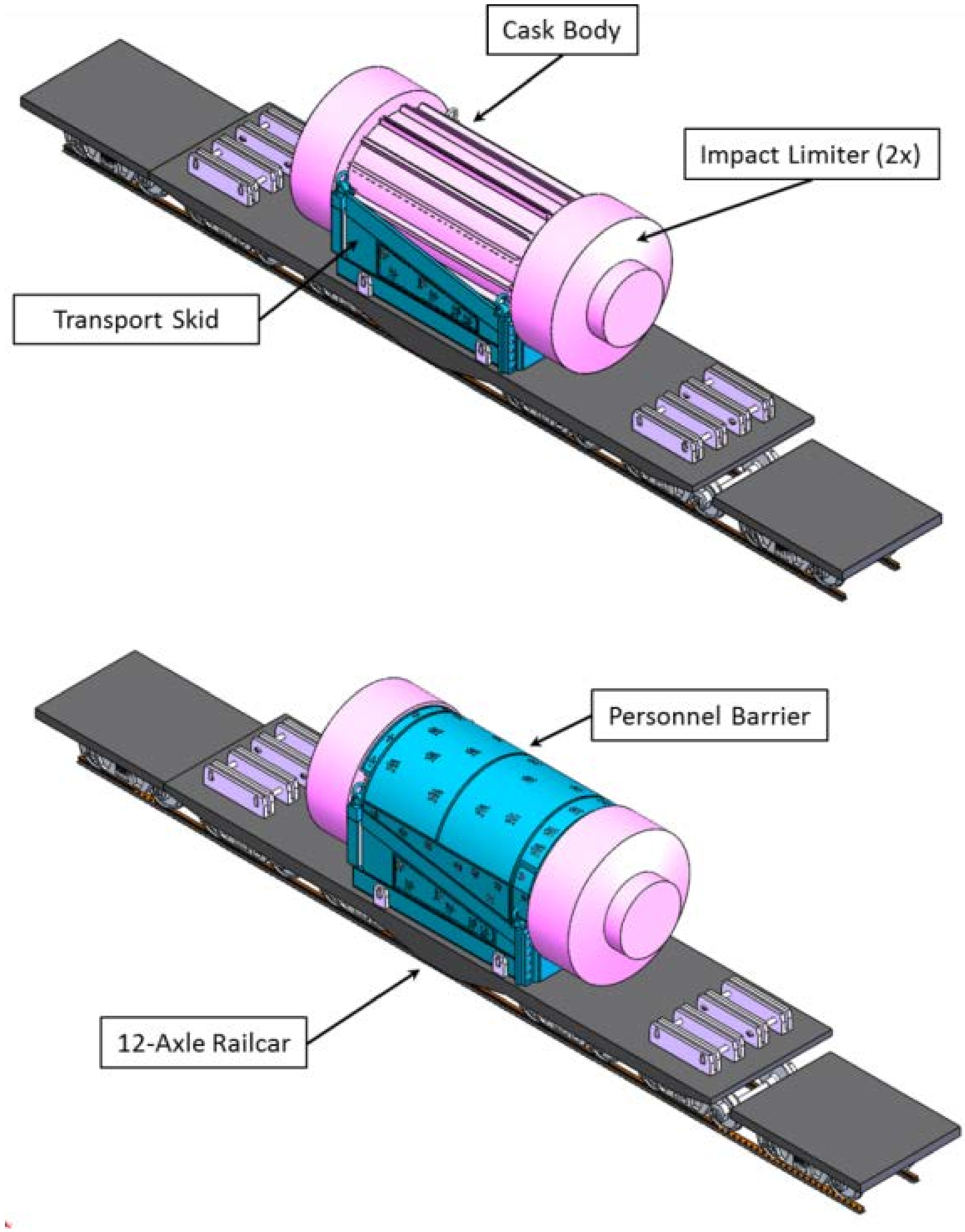


FIGURE 2-25: NAC-STC PACKAGE PERSONNEL BARRIER REMOVAL

This photo was obtained from a source internal to the team, therefore no reference is required.

The MAGNATRAN packages at KPS will be loaded with TSCs containing SNF. The major components of the package are shown in **Figure 2-26** and include the cask body, bolted lifting trunnions, rear rotation trunnions, transport lid, and vent port and coverplate. The MAGNASTOR KPS TSC consists of the canister shell, a spent fuel basket (standard or DF), a closure lid with vent and drain ports and redundant port coverplates (not accessible during transfer and loading of the MAGNASTOR TSC into the MAGNATRAN), and closure ring providing a redundant confinement boundary to the closure lid to shell weld, as shown in **Figure 2-22**. The closure lid lifting holes are designed for the safe handling and transfer of the loaded TSC to and from the

VCC, and to the MAGNATRAN transport cask for off-site transport. The MAGNASTOR TSCs are constructed of stainless steel and after loading, are welded closed, vacuum dried, backfilled with high-purity helium, and the closure lid vent and drain inner port coverplates are leak tested prior to the installation and welding of the outer vent and drain port coverplates. During storage operations, the TSCs are provided for confinement of the radioactive contents.

Following the transfer of the KPS MAGNASTOR TSCs from the VCC into the MAGNATRAN transport cask, the transport lid with a cask cavity spacer bolted to the lid's underside is installed with a new inner metallic (containment) and a reusable outer Ethylene Propylene Diene Monomer (EPDM) O-ring seals. The MAGNATRAN cavity is then evacuated and backfilled with high-purity helium and the transport lid and new vent port coverplate inner metallic containment boundary O-ring seal are leak tested using a helium Mass Spectrometer Leak Detection (MSLD) system to leaktight criteria in accordance with ANSI N14.5-1997 [7]. After loading of the KPS MAGNASTOR TSC in the MAGNATRAN transport cask and transport lid closure helium leak testing, the MAGNATRAN cask provides the transport containment boundary under normal and accident conditions of transport.

The MAGNATRAN transportation package containment boundary, shown in **Figure 2-27**, includes the MAGNASTOR inner shell, upper forging, bottom inner forging, body, transport lid, vent port coverplate, and transport lid and vent port coverplate metallic O-ring seals. The MAGNATRAN metallic containment seals are each individually inspected, replaced, and leakage tested prior to each loaded transport.

During fabrication, the MAGNATRAN cask containment boundary weldment including the inner shell, bottom inner 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 leak testing to confirm a total leakage rate of $\leq 2.0 \times 10^{-7}$ cm^3/sec, helium (leaktight in accordance with ANSI N14.5-1997[45]). Following completion of the hydrostatic test of the MAGNATRAN cask, the transport lid and vent port cover containment components and metallic O-ring seals are fabrication leakage rate tested to confirm that the individual leakage rates are $\leq 2.0 \times 10^{-7}$ cm^3/sec, helium, in accordance with ANSI N14.5-1997 as specified in the submitted SAR Containment Evaluation.

The first operational sequence for the transfer of the KPS MAGNASTOR TSCs from the VCCs to the MAGNATRAN transport cask is the receipt and off-loading of the MAGNATRAN cask from the HHT vehicle and transport frame. At KPS, a Goldhofer HHT will be used either to transport the loaded MAGNATRAN packages to a direct rail transload facility or to a roll-on/roll-off (RO/RO) barge positioned on the shore line at the KPS site. After performance of the receipt inspection of the MAGNATRAN and removal of the front and rear impact limiters, the MAGNATRAN lifting trunnions will be bolted and torqued to the upper forging. The MAGNATRAN lift yoke will then be engaged to a mobile crane of sufficient lift capacity and the cask will be uprighted on its rear trunnions, removed from the transport frame, and moved to a suitable position at the Transfer Station using the mobile crane, or using a VCT. At KPS, there is sufficient space on the MAGNASTOR ISFSI pad to use as the Transfer Station. An appropriate cask work platform or scaffolding will be established around the cask to provide personnel access to the cask lid area. The MAGNATRAN transport lid bolts are removed and the lid is removed using the four-legged transport lid lifting sling set and hoist rings, and temporarily stored while protecting the lid O-rings and seating surfaces. The transport lid inner metallic O-ring is removed, the O-ring groove will be cleaned and inspected, and a new seal installed on the lid prior to re-installation of the lid after TSC loading.

The MAGNATRAN transfer shield ring, designed to protect the cask's O-ring sealing surface and provide additional shielding, is installed and bolted in place in the transport lid recess of the cask. A MAGNASTOR/MAGNATRAN transfer adapter is then lifted and placed on the transfer shield ring and bolted in place. A Foreign Material Exclusion (FME) cover is then placed over the MAGNATRAN cask cavity to protect from foreign material entry and the cask is ready for TSC transfer.

Once the MAGNATRAN is in position, the VCT is used to retrieve the MAGNASTOR VCC to be unloaded. The VCC would be positioned adjacent to the transport cask and appropriate scaffolding, and work platforms or man-lifts provided to access the top of the concrete cask. The VCC lid bolts would be removed and a four-legged VCC lid lift ring used to remove and temporarily store the VCC lid.

Figure 2-28 presents the next operational sequence and equipment requirements for retrieving a loaded MAGNASTOR TSC from a VCC. Following VCC lid removal, the MAGNASTOR transfer adapter is installed on top of the VCC. The TSC lift adapter plate is bolted to the MAGNASTOR TSC closure lid using the six bolt holes provided in the TSC closure lid. The MTC, with the retaining blocks in the engaged position, is then placed on top of the adapter plate using the KPS Secure-Lift Yoke and Hoist combined with a qualified mobile crane. The Secure-Lift Yoke and Hoist would eliminate the need for a Canister Handling Facility (CHF), as required per the MAGNASTOR CoC Technical Specifications to restrain or maintain the MTC on top of the VCC or the MAGNATRAN cask during the TSC transfer operations, as the Secure-Lift Yoke would maintain operational and stability control of the MTC throughout the TSC transfer operation. Additional details on the Secure-Lift Yoke and Hoist design and operational features are provided in Section 6.1.3. The MTC shield doors are opened using the adapter plate auxiliary hydraulic system. Once the Secure-Lift Yoke and Hoist is in place to restrain and maintain the stability of the MTC using a mobile crane atop the VCC, the air-powered hoist is engaged to the TSC lift adapter plate and engaged with the hydraulically actuated engagement pins to the hoist hook. The hoist is then activated to lift the TSC from the VCC into the MTC annulus. The shield doors are closed and the TSC is set down on the shield doors. The shield doors are then secured with lock pins.

Figure 2-29 shows the next operational sequence where the TSC is transferred into the MAGNATRAN cask cavity. When ready to perform the transfer operation, the FME cover is removed from the top of the MAGNATRAN cask and the internal cavity inspected for any foreign materials. The MTC containing a loaded TSC is then lowered in place atop the adapter plate using the Secure-Lift Yoke and Hoist, and the MTC shield door connector is engaged to the hydraulic actuators. The MTC door lock pins are then removed, the Secure-Lift Hoist is then re-engaged to the TSC lift adapter plate using the lift adapter plates' hydraulic cylinders. The Secure-Lift Hoist is activated to lift the MAGNASTOR TSC off the shield doors, the doors opened with the auxiliary hydraulic system, and the TSC slowly lowered into the MAGNATRAN cavity to rest on the transport casks bottom inner forging. **Figure 2-29** shows a MAGNASTOR TSC partially inserted into the MAGNATRAN cask cavity during transfer from the MTC. The Secure-Lift Yoke and Hoist remains attached to the MTC and TSC throughout the operational sequence.

FIGURE 2-26: MAGNATRAN SECTION VIEWS [40]

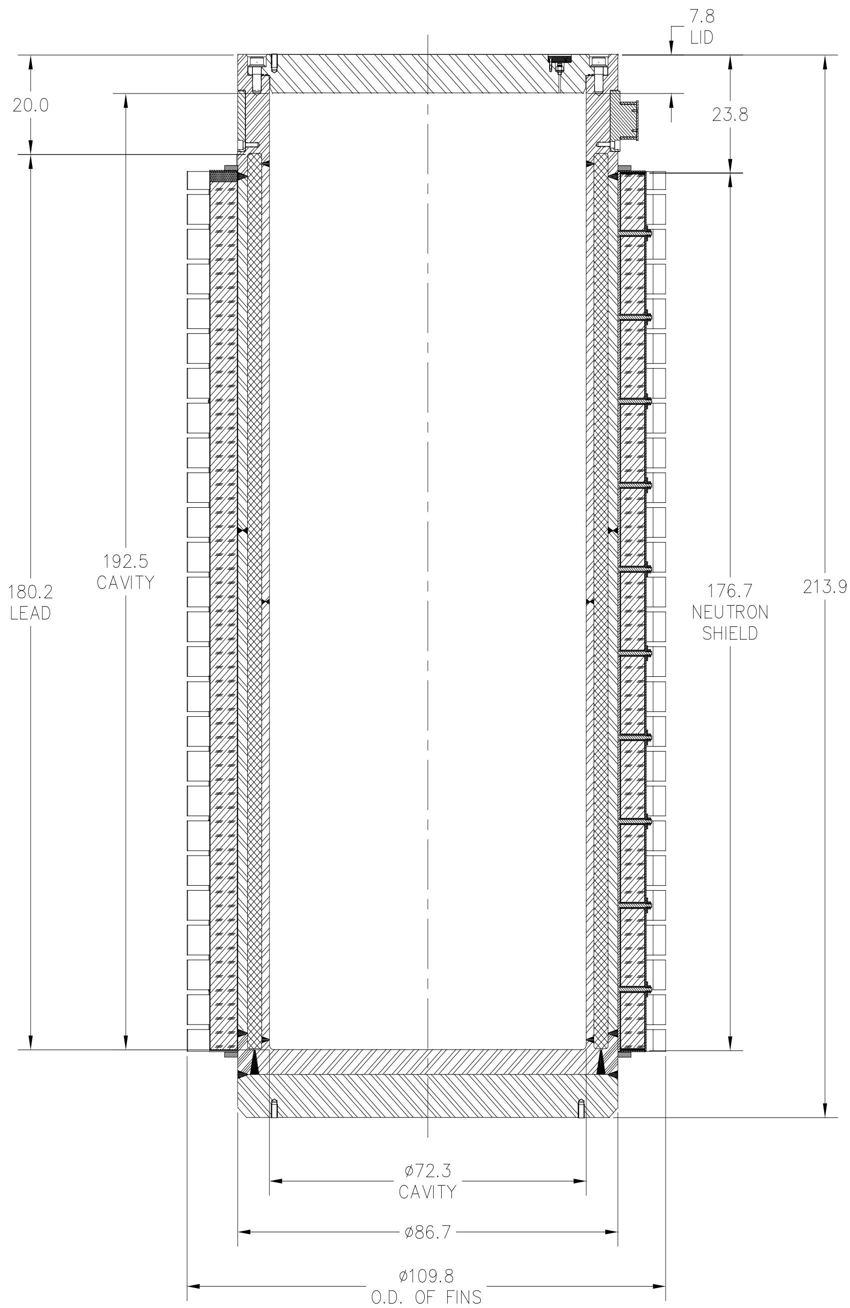


FIGURE 2-27: MAGNATRAN CONTAINMENT BOUNDARY [34]

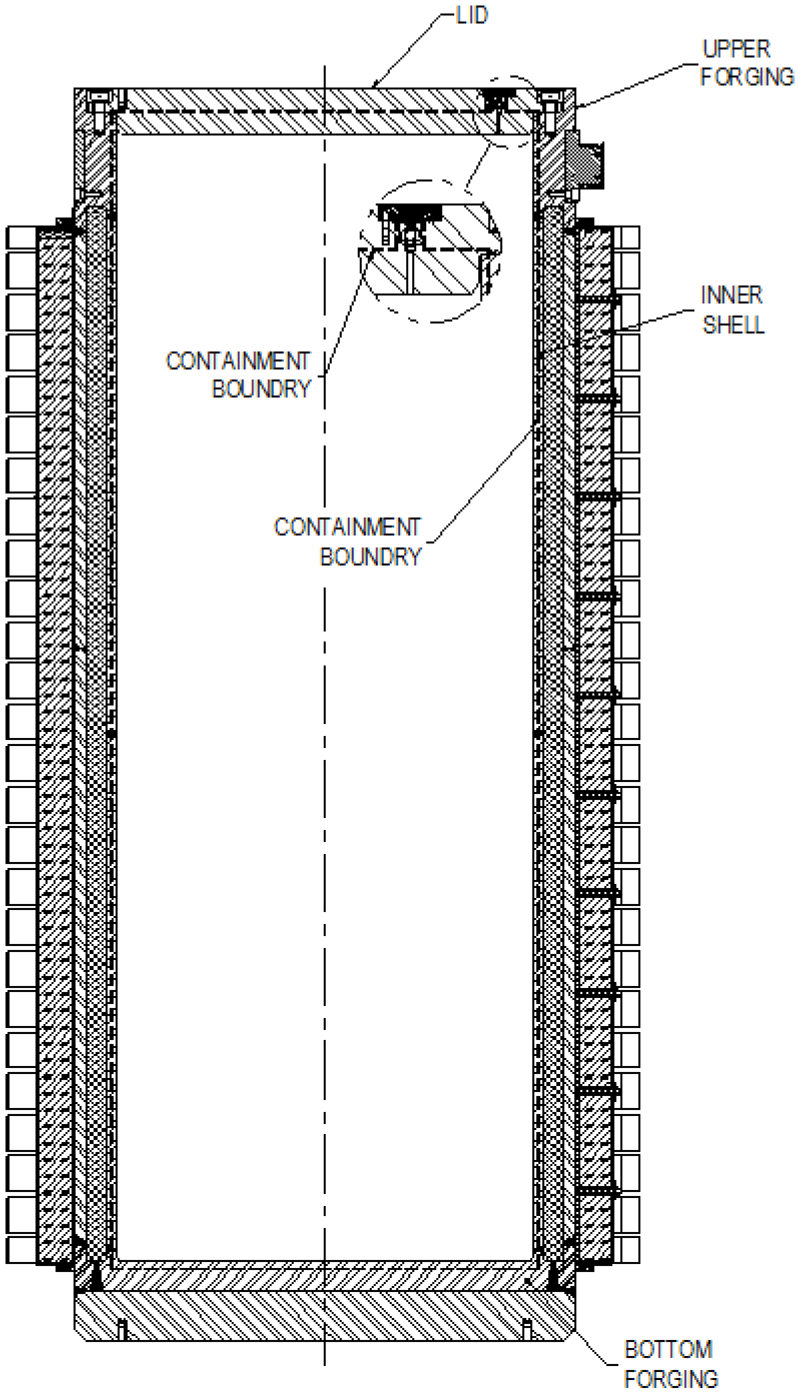
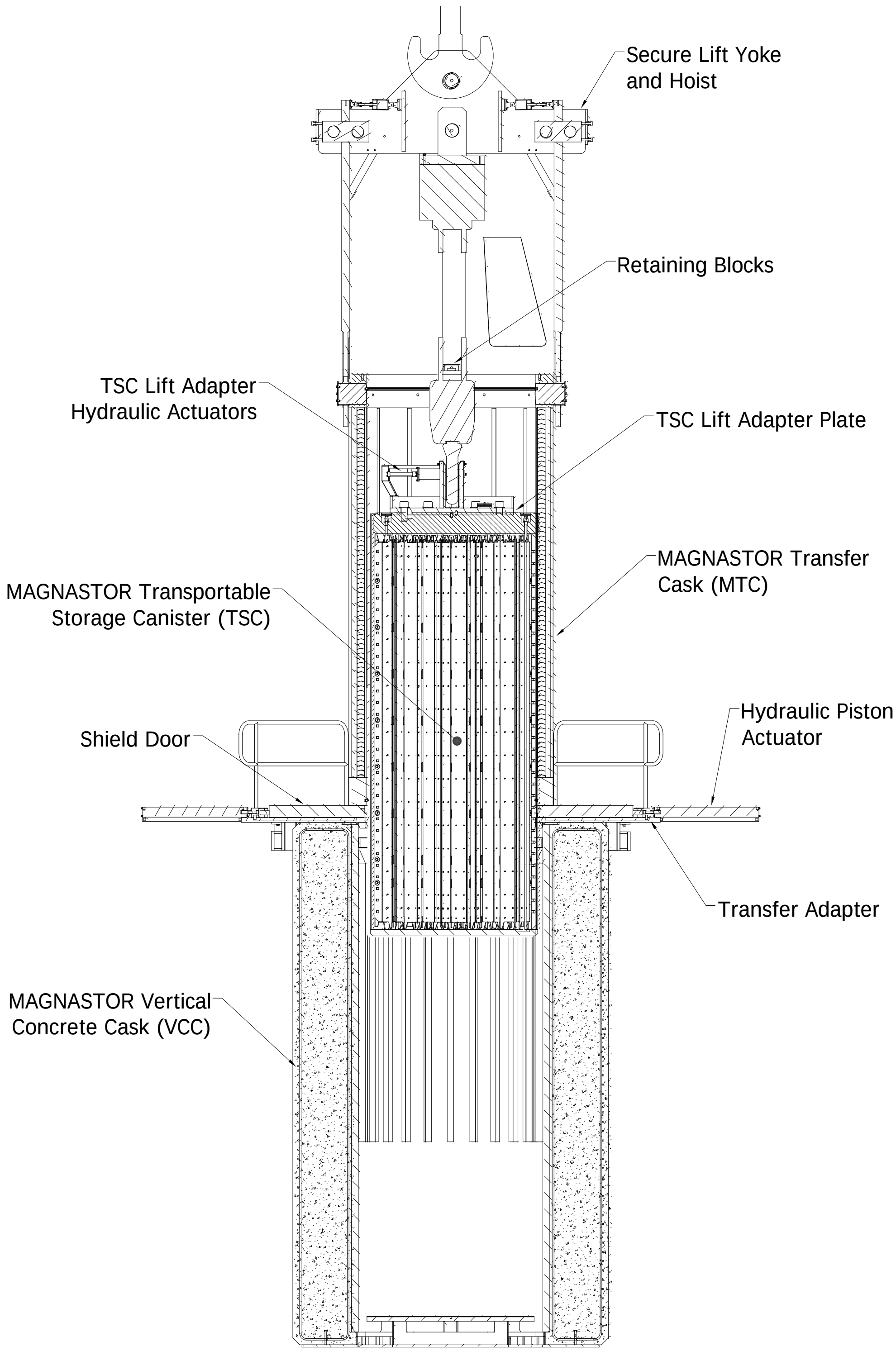
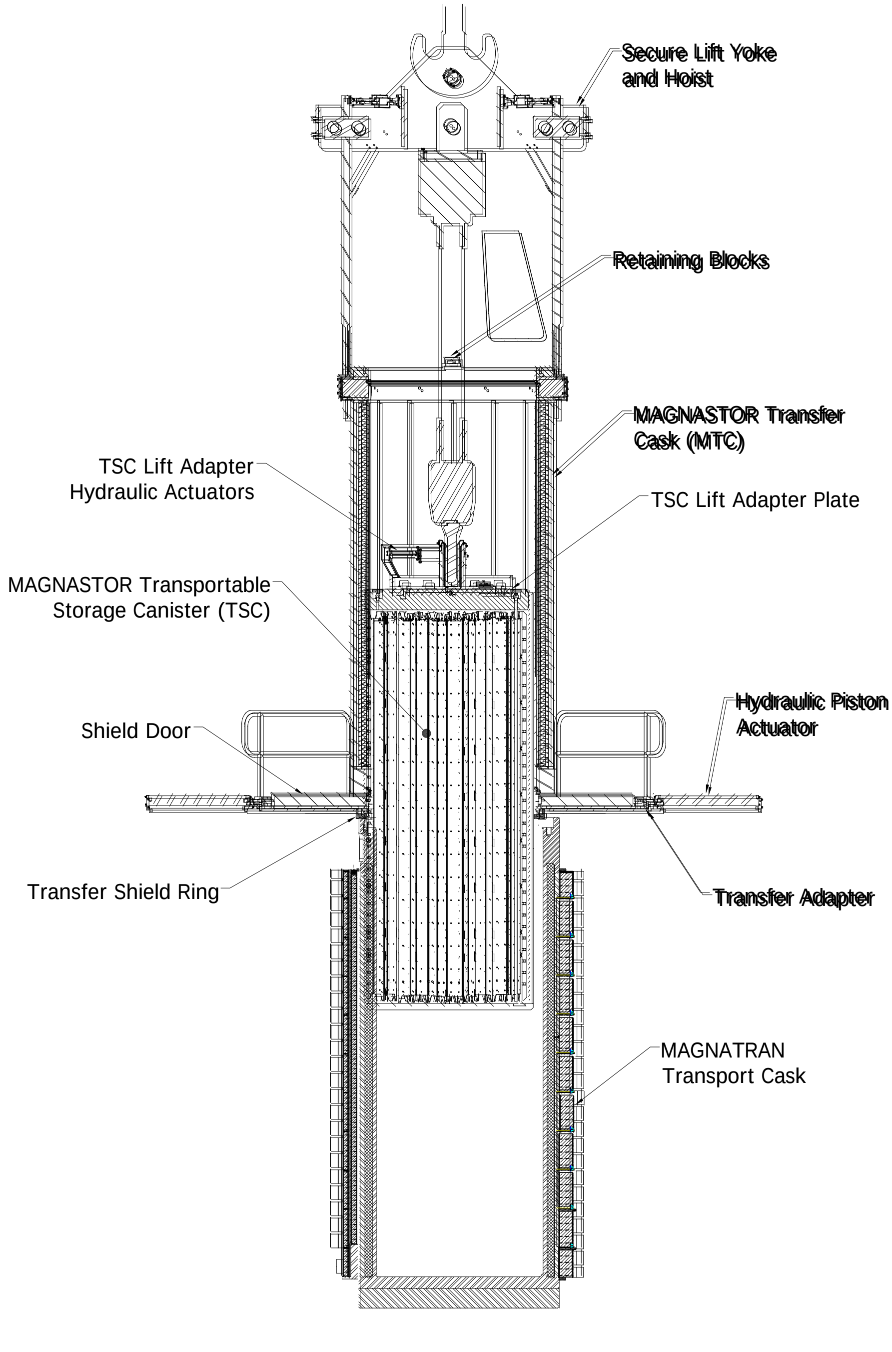


FIGURE 2-28: MAGNASTOR VCC UNLOADING TRANSFER OPERATION WITH TSC PARTIALLY REMOVED [6]



Note: Figure is not to scale

FIGURE 2-29: MAGNATRAN TRANSFER OPERATION WITH MAGNASTOR TSC PARTIALLY INSERTED [6]



Note: Figure is not to scale

As shown in **Figure 2-27**, the MAGNATRAN cask includes a vent port in the transport lid. The vent consists of a ½-inch quick disconnect fitting with a seal and a cover plate with an inner metallic O-ring and outer EPDM seal that is secured with 4 ½-inch diameter bolts. The MAGNATRAN transport lid contains an inner metallic O-ring and outer EPDM seal, and is secured to the cask body with 48 2-inch diameter bolts. The lid also includes a test port that is used to leak test the MAGNATRAN transport lid containment seal integrity. **Figure 2-27** shows the MAGNATRAN containment boundary.

The unloading of a MAGNASTOR TSC from a VCC and transfer to a MAGNATRAN transport cask, and preparation of the MAGNATRAN cask for transport, will include the following high-level activities (additional operational details are described in Section 6.1.3 and draft MAGNATRAN SAR [34] and MAGNASTOR FSAR [6]):

1) At receipt of the empty MAGNATRAN onsite, perform radiation and removable contamination surveys and record results in accordance with 10 CFR 20.1906 to ensure removable contamination levels comply with 10 CFR 71.87(i) and radiation levels comply with 10 CFR 71.47. Inspect MAGNATRAN packaging including impact limiters and radial neutron shields for possible transport damage and record inspection results on cask receiving/loading report. Clean the packaging exterior to ensure that surfaces are cleaned of chloride-containing salts and other corrosive agents.
2) Using a horizontal lift beam, lift intermodal transport skid off the over-the-road HHT with impact limiters and tie-downs installed and set the transport skid down adjacent to the designated TSC Transfer Station.
3) At the Transfer Station, prepare the MAGNATRAN packaging for loading by removing the personnel barrier, front and rear impact limiters, releasing front tie-downs, and cleaning the cask exterior of road dirt.
4) Remove the two trunnion plugs held in place by 4 1x1/8x8-inch socket head cap screws and install the two lifting trunnions and torque the 9 1x1/8x8-inch socket head cap screws torqued to 120 ± 20 ft.-lbs. Ensure trunnion bushings and trunnion caps are installed on the lifting trunnions.
5) Install the MAGNATRAN lift yoke to a suitable crane and engage the yoke arms to the lifting trunnions. Use the vertical lift yoke to upright the cask by rotating on the rear trunnions and position it on the Transfer Station pad using the crane or VCT. Set up appropriate scaffolding and man-lifts to provide access to the top of the cask.
6) Remove 48 transport lid bolts in sequence indicated on the lid and store. Using transport lid lift slings and hoist rings, remove the transport lid and store. Visually inspect lid bolts. Store inner lid and inner lid bolts to prevent damage to O-ring grooves/surfaces and threads. Prior to inner lid re-installation the inner lid metallic O-rings will be replaced and outer EDPM O-rings inspected and replaced, if required.
7) Install MAGNATRAN transfer shield ring to protect cask body sealing surfaces and bolt to cask body.
8) Install MAGNASTOR transfer adapter to the top of the cask and bolt the adapter to the transfer shield ring. Connect auxiliary hydraulic system to the two hydraulic cylinders on the transfer adapter. Position the connector assemblies in the engage position extender to engage the MTC shield door connectors.

9) Install FME cover over open MAGNATRAN cavity to prevent intrusion of foreign materials and to protect from weather.

10) Prepare KPS MAGNASTOR VCC for movement to the TSC Transfer Station location by performing radiation survey and disconnecting temperature monitoring system. Remove the eight hex head cap screws from each lift lug embedment and install the two lifting-lug sets to the embedments using the eight VCC lifting-lug bolts and washers. Torque the bolts to 115 ± 10 ft.-lbs.

11) Position the VCT adjacent to the ISFSI pad and the VCC to be moved.

12) Position VCT above the VCC to be moved and engage the lifting lugs to the VCT lifting links.

13) Move the VCT with KPS MAGNASTOR VCC to TSC Transfer Station (see Figure 2-30) and set down VCC. Disengage the VCT from the lifting lugs and move the VCT from the area. Position appropriate scaffolding and/or man-lifts to allow access to the top of the VCC.

14) Remove six VCC lid bolts and install lifting slings and hoist rings to three lifting holes identified on the lid. Using a suitable crane, remove and store VCC lid and lid bolts.

15) Remove closure lid lifting hole shield plugs if installed, and using a suitable crane, lift and position the TSC lift adapter plate (approximate weight 3,400 lbs.) (see Figure 2-31) on the top of the closure lid. Install and torque the 6 2½-inch bolts and washers.

16) Prepare MTC for receipt of the TSC by performing pre-use inspection and engaging retaining blocks to engaged position.

17) Install transfer adapter plate (see Figure 2-34) on top of the VCC. Connect auxiliary hydraulic actuating system to the transfer adapter door hydraulic cylinders and position them in the engage position to connect to the shield door connectors.

18) Remove FME cover from the top of the MAGNATRAN cask, opening the cask cavity for receipt of the loaded KPS MAGNASTOR TSC.

19) Engage the Secure-Lift Yoke and Chain Hoist (see Figures 2-31, 2-32, and 2-33) to a suitable mobile crane with 200% load capacity over load to be handled. Connect air-powered hoist system to a suitable air compressor (minimum of 500 CFM capacity) and engage the lift yoke arms to the MTC's lifting trunnions. Lift and set the MTC down on top of VCC transfer adapter plate engaging the shield door male connectors to the hydraulic cylinder female connectors. Remove the shield door lock pins.

20) Using the transfer adapter hydraulic system, open the MTC shield doors allowing access to the TSC lift adapter plate.

21) Lower the chain hoist sister hook to engage the TSC lift adapter plate. Engage the lift adapter hydraulic cylinders to engage the two lift adapter plate pins to the sister hook.

22) Using the Secure-Lift Yoke Chain Hoist, lift the TSC from the VCC cavity until the top of the TSC is within a ½ inch of the base of the retaining blocks. Stop hoist, and using transfer adapter plate auxiliary hydraulic system, close the shield doors. Install the shield door lock pins.
Note: Per the Operating Procedures in the MAGNATRAN SAR, there is a maximum time

limit of 41 hours from the lifting of the TSC off the VCC pedestal (Step 22) to placement of the MAGNATRAN package in a horizontal position on the intermodal transport frame (Step 40).

23) Using the Secure-Lift Yoke and Hoist engaged to a crane, lift the MTC from the top of the VCC and position the MTC on top of the adapter plate on the MAGNATRAN cask. Engage the shield door connectors.

24) Using the chain hoist attached to the TSC lift adapter plate to lift TSC off the MTC shield doors approximately a ½ inch to prevent contact with the retaining blocks, remove the shield door lock pins and open the shield door hydraulics to open the shield doors.

25) Using the chain hoist, slowly lower the TSC into the MAGNATRAN cask cavity. Once the TSC is fully down, disengage the TSC lift adapter plate from the hoist sister hook and withdraw the hoist to the full up position.

26) When the chain hoist is clear, close shield doors, install door lock pins, and remove the MTC from the top of the MAGNATRAN cask.

27) Remove the TSC lift adapter plate from the TSC closure lid and store. Unbolt the transfer adapter from the transfer shield ring and remove the transfer adapter. Unbolt and remove the transfer shield ring and store.

28) Ensure all equipment is removed from the top of the MAGNATRAN cask and TSC.

29) Clean the transport lid metallic seal groove and install a new inner containment boundary metallic O-ring seal and retention clips.

30) Using MAGNATRAN transport lid lifting slings and crane, install the transport lid including the cask cavity spacer (approximate weight 1,000 lbs.) bolted to the underside of the lid to properly limit KPS TSC movement during transport. [Note: MAGNATRAN transport casks provided for KPS TSC transports will be supplied with cavity spacer installed. Empty MAGNATRAN transports can be performed with cavity spacer installed.]

31) Install 48 lid bolts and tighten to hand tight. Torque all bolts to 4,600 ± 200 ft.-lbs. in accordance with the torqueing sequence marked on the lid in three passes until all bolts are verified at final torque.

32) Remove vent port coverplate and connect vacuum pumping and helium backfill system to the vent port quick disconnect valve.

33) Operate vacuum pump until a final vacuum of ≤ 3 torr is reached and then turn off vacuum pump.

34) Backfill MAGNATRAN cask cavity with high-purity helium to a pressure of 1 atm and disconnect the vacuum and helium backfill system from the vent port.

35) Clean vent port coverplate metallic seal groove and install new inner containment boundary metallic O-ring seal and retention clips. Visually inspect outer EPDM O-ring for damage and replace if required.

36) Install vent port coverplate and torque to 160 ± 20 in.-lbs.

37) Remove vent port test plug, connect helium MSLD system to the port and evacuate the interseal 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 cm3/s, helium with a minimum test system sensitivity of ≤ 1 x 10-7 cm3/s, helium. If test is acceptable, re-install the vent port coverplate test plug with new O-ring.

38) Remove transport lid interseal test port plug, connect helium MSLD system to the port, and evacuate the interseal 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 cm3/s, helium with a minimum test system sensitivity of ≤ 1 x 10-7 cm3/s, helium. If test is acceptable, re-install the inner lid interseal test port plug with new O-ring.

39) Using the VCT or MAGNATRAN lift yoke connected to a suitable crane, lift loaded cask and move to a position adjacent to the HHT. If VCT is used to move the cask, disengage the VCT from the lifting trunnions and engage to MAGNATRAN lift yoke.

40) Lift the MAGNATRAN and position the rear rotation trunnions over the rear saddle on the intermodal transport frame, lower the cask to engage the rear trunnions supports, and rotate the cask from vertical to horizontal orientation. [As noted following Step 22, the positioning of the loaded MAGNATRAN cask in a horizontal position on the transport frame is required to be completed in 41 hours.]

41) Install front tie down over cask upper forging.

42) Install top and bottom impact limiters and install tamper indication device (TID) between adjacent upper impact limiter retaining rods to detect tampering during transport.

43) If intermodal transport frame was positioned on the pad, use a horizontal lift yoke to lift the loaded intermodal transport frame and position it on the HHT. Complete tie-down of the frame to the HHT.

44) Perform final radiation and contamination surveys. Apply fissile material labels on the package.

45) Install personnel barrier and padlock barrier access portal.

46) Affix applicable placards to transport vehicle.

47) Complete all shipping documentation and provide special instruction to carrier/shipper for an Exclusive Use Shipment.

48) At site's convenience, the empty VCC can be prepared for return to the ISFSI by removing the transfer adapter, reinstalling and bolting the VCC lid, and lifting and transporting the VCC back to the pad using the VCT.

Note: The MAGNATRAN transport cask systems provided to perform MAGNASTOR TSC transports from KPS will be in full compliance with the maintenance program as specified in Chapter 8 of the MAGNATRAN Safety Analysis Report (SAR), which specifies the required maintenance program for the cask (see draft MAGNATRAN Maintenance Schedule Table in Table 6-2 in Section 6.1.4. NAC or the cask supplier would certify that the cask is compliant with the current annual maintenance program, which would include dye penetrant [penetrant testing (PT)] examination of the lifting trunnions and replacement of quick disconnects.

Equipment and Auxiliary System Requirements:

To perform the above sequence of operations, many ancillary devices, equipment, and systems will be required. These ancillary equipment and systems, along with a description of their purposes and availability are listed below. 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 over-the-road HHT will be required for transport of the empty or loaded MAGNATRAN cask either for direct road transport to a rail transfer location, or for transport to a proposed barge loading area on the lake front adjacent to the site. A similar HHT design supplied by Goldhofer has been proposed for the de-inventory of other dry storage facilities. The HHT would be capable of securing the intermodal transport skid containing a MAGNATRAN package in accordance with NRC and DOT requirements.

Vertical Cask Transporter:

A VCT will be required to lift and move the loaded VCCs at the ISFSI to and from the TSC Transfer Station for TSC transfer operations. The VCT can also be used to vertically transport the empty or loaded MAGNATRAN transport cask and the empty MTC. The VCT used at both Zion and KPS was designed and manufactured by Lift Systems Inc.

The self-powered VCT is shown in **Figures 2-30** and **2-35** transporting a VCC by the lift lugs. After loading of the VCC with a TSC, the VCC is brought from the fuel building on a lowboy self-propelled trailer, where it is engaged by the VCT as shown in **Figure 2-35**. The VCT is a specially designed heavy-lifting device to lift the VCC by engaging the transporters' lifting components to the VCC's lifting lugs. The lift height of the base of the loaded VCC during lifting and transport operations is limited to ≤24 inches by the CoC's Technical Specifications, Appendix A, Paragraph 4.3.1(h).

The VCT is designed to have the following critical physical capabilities and attributes:

- Minimum rated capacity of 180 tons. Tare weight of 167,000 lbs.
- Fully loaded weight of 527,000 lbs. with a MAGNASTOR VCC weighing a maximum of 360,000 lbs.
- VCT to interface with a MAGNASTOR VCC with an overall height of 232.4 inches with lifting lugs installed.
- VCT to interface with an MTC with the following characteristics: empty weight of 55 tons; overall height of 192.2 inches; nominal outer diameter of 88 inches; approximately 100 inches across trunnion pair each having a diameter of 10 inches (including bushing); and 10.5-inch end caps.
- The VCT's header beam, lift links, and lift link pins to be designed in accordance with ANSI N14.6.
- VCT maximum width to be 19 feet.
- VCT maximum length between ends of front and rear tow eyes to be 24 feet, 4 inches.
- VCT fuel tank capacity shall be limited to a maximum of 50 gallons.

- VCT travel speed under full load to be 0.5 mph on level ground.
- VCT able to operate under full load with a maximum grade of 10%.
- VCT able to maneuver under full load with a roadway side to side slope of up to 4%.
- VCT limits average ground bearing pressure under full load to less than 50 psi.
- VCT under full load to have full autorotation capability.
- VCT is provided with an Automatic Wedgelock System (e.g., a redundant drop prevention system replacing manual pins).
- VCT is provided with a Computer Assisted Remote Lifting (CARL) control system including radio remote controls.
- VCT is provided with a mechanical stop to prevent a loaded VCC from exceeding a 24-inch lift height.

FIGURE 2-30: MAGNASTOR VCC ENGAGED TO SELF-PROPELLED VCT

MAGNASTOR Transfer Cask (MTC) and Retaining Retaining Blocks:

The MTC is designed, fabricated, and tested to meet the requirements of ANSI N14.6 as a special lifting device. The standard MTC is fabricated from carbon steels and is designed to be compatible with longer length BWR and PWR SNF assemblies. The stainless steel MTC2 is specifically designed to accommodate the shorter MAGNASTOR TSC for Westinghouse length fuel assemblies used at KPS and for B&W SNF assemblies. The MTC2 is provided with two lifting trunnions located near the top of the cask. There are threaded holes provided in the top and bottom rings (forgings) of the MTC2 and in each shield door for attachment of handling lugs for use in receipt, up-righting, and handling of an empty cask or shield door. The MTC2 provides biological shielding and structural protection for a loaded TSC and is used to lift and move the TSC between workstations. The MTC2 is also used to shield the vertical transfer of a TSC into or out of a VCC or a MAGNATRAN transport cask.

The MTC2 design incorporates three retaining blocks, pin-locked in place, to prevent a loaded TSC from being inadvertently lifted through its top opening. The MTC2 has retractable bottom shield doors. During TSC loading and handling operations, the shield doors are closed and secured. After placement of the MTC2 on the Transfer Adapter on the VCC or the MAGNATRAN transport cask, the locking pins are removed and the doors are retracted using hydraulic cylinders and an auxiliary hydraulic supply system.

The MTC2 used at KPS was leased from NAC and was previously used for MAGNASTOR storage operations at Zion Nuclear Power Plant. It is available for future de-inventory projects containing MAGNASTOR storage systems such as Zion and KPS. Duke Power's Catawba and McGuire Nuclear Stations, which also use MAGNASTOR, own their MTC2s. **Figure 2-31** shows an example of an MTC2 engaged to a secure-life yoke.

FIGURE 2-31: MAGNASTOR TRANSFER CASK [41] ENGAGED TO SECURE-LIFT YOKE

MTC Transfer Adapter:

The MTC Transfer Adapter Plate (**Figures 2-15** and **2-18**) is used to hydraulically operate the MTC shield doors. The Transfer Adapter also incorporates shields and rails to reduce the dose to operational personnel during the TSC transfer operations. The adapter incorporates two hydraulic cylinders mounted on each end of the plate that extend female connectors 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. The operational sequence proposed herein is based on the use of two MTC Transfer Adapters so that the TSC can be transferred directly from the VCC to the MAGNATRAN cask without the need to reposition the transfer adapter. It is expected that two transfer adapters would be available for the KPS de-inventory project.

Secure-Lift Yoke and Integrated Chain Hoist Assembly:

The MTC Secure-Lift Yoke is designed for the lifting and movement of the loaded MTC from the top of the VCC positioned at the ISFSI TSC Transfer Station while engaged to a suitable mobile crane using a single pin engagement. The MTC Secure-Lift Yoke will then move the loaded MTC to a transfer position on the top of the MAGNATRAN cask fitted with an MTC Transfer Adapter. MTC Secure-Lift Yoke remains engaged to the MTC from time of engagement to the MTC lifting trunnions, through MTC transfer and placement on the VCC/adapter plate, lifting of the TSC into the MTC with the Chain Hoist Assembly (CHA), and during movement to the MAGNATRAN and lowering of the TSC into the cask cavity. The MTC Secure-Lift Yoke is designed for single-failure-proof handling of the MTC and TSC through use of high design safety factors in accordance with ANSI N14.6 [42] and NUREG 0612 [43]. The maximum design rated load for the Secure-Lift Yoke is 110 tons.

The Secure-Lift Yoke arms and strongback are constructed of high-strength alloy steel and the lift arms are pneumatically actuated. The MTC Secure-Lift Yoke can withstand seismic loadings imparted by the cask handling crane, and will provide for the attachment point of the TSC Chain Hoist System as described below. The MTC Secure-Lift Yoke arms will be engaged and disengaged pneumatically using remote control operation, and the MTC Secure-Lift Yoke arms will be locked in the closed orientation during MTC handling, lifting, and TSC transfer operations.

The TSC Chain Hoist System is designed to transfer (i.e., raise and lower) a loaded TSC from the VCC to the MTC, and from the MTC to the MAGNATRAN cavity. The MTC will be positioned on the top a transfer adapter plate which will be positioned on the top of the VCC to provide the interface for mating of the MTC to the VCC and MAGNATRAN cask, and for operation of the MTC shield doors prior to TSC transfer. The MTC will be lifted, positioned and maintained in the required position and orientation on top of the VCC and MAGNATRAN cask throughout the TSC transfer operation by the MTC Secure-Lift Yoke. The total height of the Secure-Lift Yoke above the pad surface to the centerline of the yoke’s engagement pin to the mobile crane hook is approximately 45 feet.

The CHA will be connected to the 110-ton Secure-Lift Yoke by means of a clevis adapter and connecting pin. The lower attachment point of the hoist system is a sister hook that will be connected to the TSC lift adapter plate installed and bolted to the TSC. The engagement of the CHA hook to the TSC lift adapter plate by dual-pin assemblies will be actuated by the use of remotely operated hydraulic cylinders.

The CHA will be built upon a 110-ton air-operated chain hoist and will comply with the requirements of ASME B30.16 [65], and will have an established maximum critical lift (MCL) of 55 tons in accordance with the requirements of ASME NUM-1 [66], Type 1B for a critical lift chain hoist.

TSC Lift Adapter Plate:

The Secure-Lift Yoke and Chain Hoist System is designed to interface with a single-failure-proof by high design safety factors in accordance with ANSI N14.6 [42] and NUREG 0612 [43]. The TSC lift adapter plate is bolted to the TSC closure lid to allow the remote engagement of the Chain Hoist sister hook using two hydraulically operated engagement pins.

The Secure-Lift Yoke and Chain Hoist Assembly on a storage stand with the TSC lift adapter plate shown in the foreground is provided in **Figure 2-33**. A view of the Secure-Lift Yoke and Chain Hoist is provided below in **Figure 2-32** and the actual components are shown in **Figure 2-33**.

FIGURE 2-32: SECURE-LIFT YOKE AND CHAIN HOIST

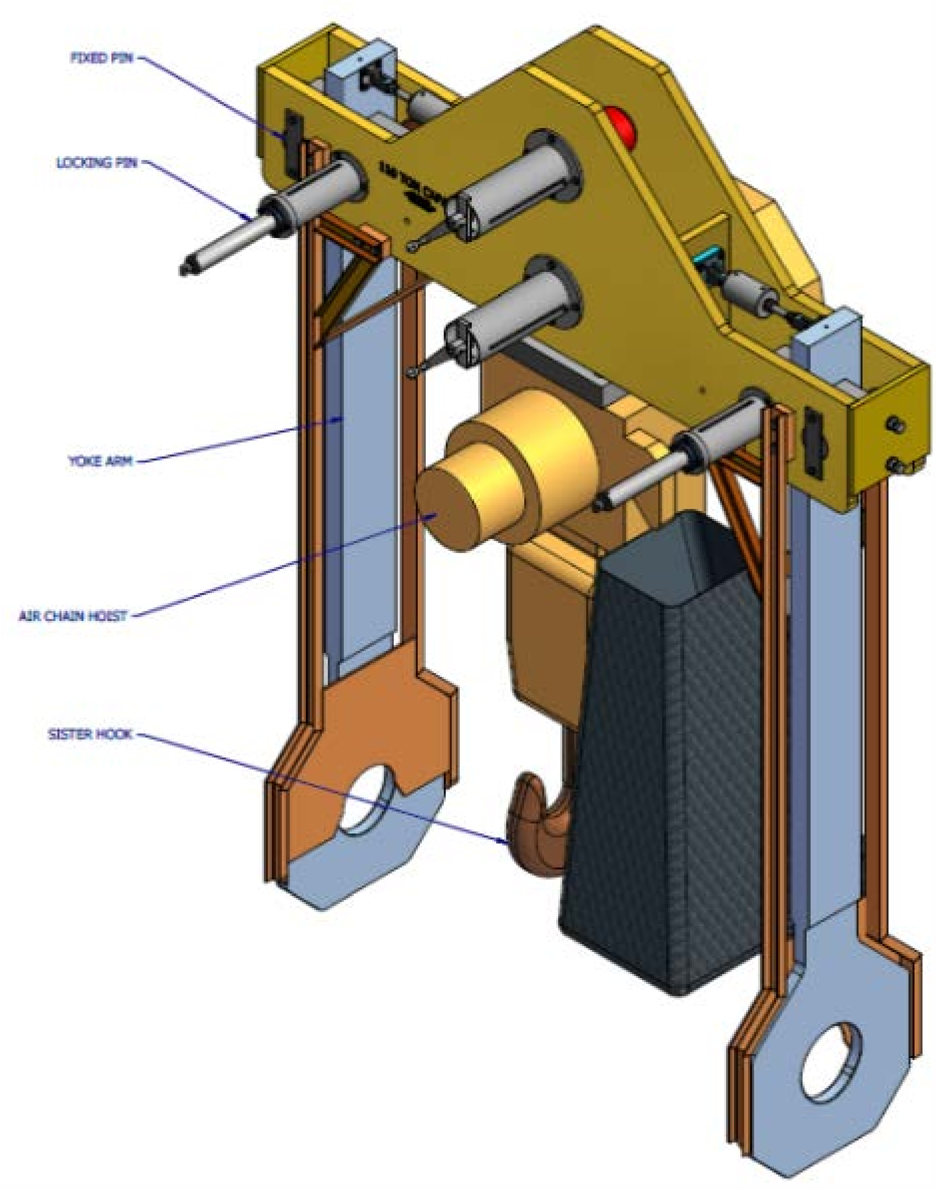


FIGURE 2-33: MAGNASTOR SECURE-LIFT YOKE AND CHAIN HOIST WITH TSC LIFT ADAPTER PLATE

Auxiliary Hydraulic System for Transfer Adapters:

An electrically powered, high-pressure hydraulic pump, hoses, valves, and connectors are required to operate the hydraulic cylinders mounted on the transfer adapters to open and close the MTC shield doors to allow the TSC to be lowered into or lifted from the VCC or the MAGNATRAN cask. The auxiliary hydraulic system is installed after the transfer adapter is placed on the VCC and transport cask. A single hydraulic system with a second set of supply and return hoses could operate two separate transfer adapter plate hydraulic cylinder sets. This equipment will be available for lease from NAC.

Auxiliary Lifting Rigs:

A number of slings and rigging attachments are required to handle various MAGNASTOR and MAGNATRAN components and to safely operate the system. The lifting sling systems are designed to meet the requirements of ANSI N14.6 [42] and ASME B30.9 [44], as applicable, and to comply with the guidance provided in NUREG-0612 [43] 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%. Following ISFSI loading operations, a complete set of new lifting rigs including associated hoist rings and turnbuckles for both MAGNASTOR and MAGNATRAN components will need to be procured and tested prior to the start of the KPS de-inventory campaign.

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

- MTC Transfer Adapter Lifting Rig: this lifting rig is used to place and remove the Transfer Adapter assembly onto the VCC or MAGNATRAN 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.
- MAGNASTOR 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.
- MAGNATRAN Transport Lid Lifting Rig: this lifting rig is used to install and remove the transport cask lid using a four-point lift. The four-legged sling is attached to the cask lid by four hoist rings.
- MAGNATRAN Transport Cask Cavity Spacer Lifting Rig: this lifting rig is used to install and remove the TSC cavity spacer 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 cask cavity spacer following TSC loading and remove it prior to TSC unloading from the MAGNATRAN transport cask.
- MAGNATRAN Impact Limiter Lifting Rig: this lifting rig is used to remove and install the impact limiters to the front and rear of the MAGNATRAN cask. The four-legged sling is attached to the four lifting lugs welded to the top of the impact limiter using shackles.
- MAGNATRAN Personnel Barrier Lifting Rig: this lifting rig is used to remove and install the personnel barrier on the intermodal transport frame which prevents personnel contact with the center section of the transport cask between the front and rear impact limiters.

Mobile Diesel-Powered Air Compressor:

A diesel-powered air compressor with a rated capacity of approximately 900 CFM is required to properly operate the Secure-Lift Yoke and Chain Hoist system. The air compressor will need to be located close to the TSC Transfer Station. There are currently no diesel air compressors at KPS. NAC has a single KAESER Mobilair 260 T air compressor meeting project requirements available for lease. Similar diesel-driven air compressors are available for lease or purchase as redundant air supplies from air compressor suppliers.

Vacuum Pumping and Helium Backfill System:

Following loading of the KPS MAGNASTOR TSC into the MAGNATRAN and installation and torqueing of the transport lid, the cask cavity is evacuated to ≤ 3 torr using a vacuum pumping system connected to the MAGNATRAN transport lid 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 MAGNATRAN cavity loaded with a KPS MAGNASTOR TSC, the source of the contamination will be required to be determined prior to final preparations for shipment of the package. (*Note: The MAGNASTOR TSCs may have residual removable contamination because of in-pool loading as allowed by MAGNASTOR TS LCO 3.3.1*). 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 KPS. A NAC system will be available at the time of the de-inventory project for lease.

Helium Mass Spectrometer Leak Detection (MSLD) System:

Prior to transport of the loaded MAGNATRAN transport cask, the inner metallic containment boundary seals of the transport lid and vent port coverplate will require replacement and maintenance leakage rate testing to leak-tight criteria in accordance with ANSI N14.5-1997 [45] as specified in the MAGNATRAN SAR [34] using a helium MSLD system including a calibrated leak. Additional equipment required for helium-evacuated envelope leakage testing would include high purity helium (≥ 99.1%), appropriate tubing, valves, calibrated pressure and vacuum gauges of the appropriate sensitivity and connectors to mate with the vent and transport lid port leak test connection.

Replacement O-Ring Seals:

Following replacement of the transport lid and vent port coverplate 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 MAGNATRAN package transport lid and vent port coverplate containment O-ring seals is to confirm a leakage rate of ≤ 2.0×10^{-7} cm^3/sec, helium at a minimum test sensitivity of ≤ 1.0×10^{-7} cm^3/sec, helium. The testing requirements and procedural guidance are specified in Chapter 7, Section 7.1.2 of the MAGNATRAN SAR. There is no MSLD currently available at KPS and a new system will be required to be leased or procured, and specialized connectors for connection to the MAGNATRAN containment leakage transport lid and vent port coverplate test ports will need to be leased or procured.

Cranes:

A number of overhead lifting devices would be required for the operations of sufficient capacity to meet the requirements of the MAGNASTOR CoC 1025 TSs Appendix A, Section 4.4, "TSC Handling and Transfer Facility" located at a Transfer Station. It is expected that the two ISFSI pads and adjacent areas provide sufficient space to locate the Transfer Station and TSC Handling and Transfer Facility. At the Transfer Station pad, a TSC Handling and Transfer Facility will be required to meet the criteria specified in Section 4.4 of the Appendix A TSs, and any stationary or mobile crane used to lift and handle the loaded MAGNASTOR MTC must meet the requirements of this TS. One large-capacity crane would be required for vertical lifting and movement of the MTC, and the upending and downending of the MAGNATRAN from and to the intermodal transport frame located on the HHT or on the ground, and subsequently lifted horizontally and loaded onto the HHT. A smaller crane would be required for lifting ancillary items, such as the VCC lid, transfer adapters, MAGNATRAN transport lid, transport impact limiters, and personnel barrier.

Man-lifts:

A minimum of one man-lift capable of accessing the top of the MTC when in stackup position on the VCC or the MAGNATRAN cask will be required. Minimum lift height would be approximately 35 feet.

Impact Limiters:

The MAGNATRAN will arrive with two impact limiters bolted to the cask lid and bottom forging of the cask according to the requirements of the SAR. The impact limiters would be fabricated as part of the transport cask procurement and fabrication. Each impact limiter assembly is provided with a set of two stainless steel Anti-Rotation Angles (3 x 3 x ¼) welded to the impact limiter shell. The anti-rotation angles allow the limiters to be stored in a vertical orientation after removal from the cask.

Intermodal Transport Frame and Tie-down Straps/Restraints:

An intermodal transport skid/shipping frame, associated tie-down straps, and restraints would need to be fabricated for each of the MAGNTRAN casks. These devices will be specific for the MAGNATRAN cask and do not currently exist, or may be based on a universal transport cradle design developed under DOE auspices. A conceptual design is currently being developed [33], although final detail design and fabrication would need to be planned. The same equipment would be used for HHT, rail, and barge transport. The equipment will be designed to allow for horizontal handling for intermodal transfer between transport modes.

Personnel Barrier:

As required by the MAGNATRAN draft CoC, a personnel barrier would be placed around the loaded package. The barrier, which attaches to the transport frame, spans the distance between the impact limiters and matches the outer diameter of the impact limiters. It is expected that personnel barrier designs and supply would be part of the design and supply of the intermodal transport frames.

Hydraulic Bolt Torqueing Equipment and Standard Tools:

To properly install and torque the 48 MAGNATRAN transport lid bolts to the required torque of 4,600 ± 200 ft-lb, a hydraulic torqueing device(s) capable of torques up to 5,000 ft.-lbs. will be required. A set of standard tools and equipment will be required to remove and install other MAGNATRAN components, MAGNASTOR VCC components, cask 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.

MAGNATRAN Lift Yoke:

A MAGNATRAN Lifting Yoke will be required for rotation and vertical handling of the MAGNATRAN cask to and from the intermodal transport frame. The MAGNATRAN Lift Yoke is designed for single-failure-proof handling of the MAGNATRAN using high design safety factors in accordance with ANSI N14.6 [42] and NUREG 0612 [43]. No MAGNATRAN Lift Yokes have been fabricated to date for use. The MAGNATRAN Lifting Yoke would be supplied as part of the MAGNATRAN cask supply package and would be procured and fabricated as part of the cask fabrication project.

Horizontal Intermodal Transport Frame Lift Beam:

The horizontal intermodal transport cradle lift beam would be used to lift and move an empty or loaded transport frame containing an empty or loaded MAGNATRAN 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 frame and the horizontal frame lift beam has been developed by others and is expected to be suitable for use with the MAGNATRAN transport cask system.

MAGNATRAN Transport Cask Cavity Spacer:

A MAGNATRAN cask cavity spacer, in accordance with the proposed SAR License Drawings, will be required for each MAGNATRAN cask transporting KPS MAGNASTOR TSCs. The cask cavity spacer is 7.0 inches in height and 70.7 inches in diameter and weighs approximately 1,000 lbs. Each spacer will be required to be bolted to the underside of the transport lid prior to delivery of the cask to KPS.

Equipment Availability Onsite:

Based on the demobilization of essentially all cask-loading equipment from KPS upon completion of the fuel loading campaign in June 2017, it is expected that essentially all of the identified equipment and systems will be required to be procured or leased from NAC or others, as described above.

Note: The MTC, transfer adapter, lifting yokes and chain hoists, mobile and fixed lifting and handling equipment, lifting rig sets, and other auxiliary equipment and systems will be required to be maintained, inspected, and load and/or functionally tested as required by the MAGNASTOR and MAGNATRAN Operations Manuals, SAR and FSAR, and component specific maintenance manuals, as appropriate, prior to use at KPS.

FIGURE 2-34: MTC ENGAGEMENT WITH TRANSFER ADAPTER POSITIONED ON VCC

FIGURE 2-35: VCC ENGAGEMENT TO VCT FROM LOWBOY HHT

3.0 TRANSPORTATION ROUTE ANALYSIS

This section describes the available routes identified to transport the transportation casks from KPS for delivery to a Class I railroad. 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 vast number of options available and chose a total of five scenarios to consider further using the MUA process, as covered in detail in Section 5.0.

3.1 Heavy Haul Trucking Routes

KPS is located in Carlton, WI on WI-42 on the western shore of Lake Michigan. The access road leads to WI-42. Interstate highways and routes are close to the site. Depending on which loading site is selected, navigation north and south from the site on WI-42 is accessible. Alternate routes are available using multiple county roads. There are no state designated heavy haul routes.

As seen in **Figure 3-1**, the site is somewhat isolated from rail tracks, with few viable loading locations. Many of the potential loading tracks do not have sufficient track length to accommodate the necessary configuration for setting up a secure transloading operation and landing the entire consist. No existing commercial transload facilities/companies are in the immediate area. Almost every HHT route to a loading track requires crossing some bridges, culverts, and/or roundabouts but none present an obstacle to reaching the sites selected for evaluation or the MUA-recommended transload location.

START [1] was utilized to create routes to sites considered viable for the transload of a transportation cask from HHT to rail. Routes were configured to utilize interstate highways wherever available to avoid using two-lane country roads and potentially alleviate congestion during tourist seasons.

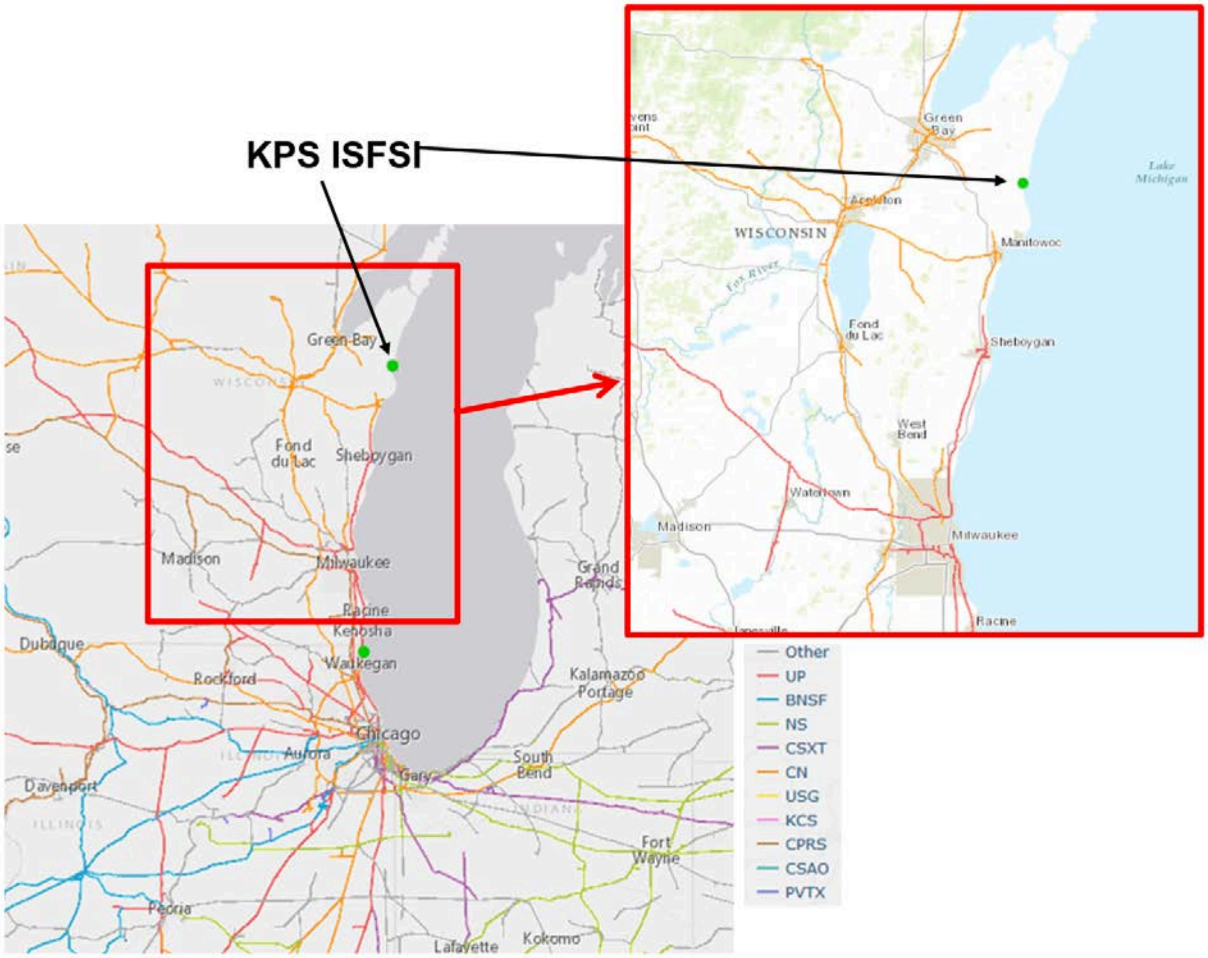
Table 3-1 identifies sidings considered in this assessment, with length of track and any restrictions or benefits associated with the siding. The closest tracks to the site can be reached by HHT transport, and include Denmark, WI, Luxemburg, WI, and Bellevue, WI. These sites are not ideal due to: limited track length at the sites; the designated tracks were already being shared among multiple users; and the high likelihood of potential interference with these existing businesses.

The Rockwood and Manitowoc locations are also accessible by truck, but were not suitable for loading trains. At both locations, there are obstructions to the track, limited track in a proper loading configuration, and potential interference with active business operations.

Some of the track located in the Port of Green Bay included coal operations. Although there is ample track available at this and other sites in the port, these companies routinely ship/receive unit trains, and it is impractical to run an intermittent loading campaign in a unit train environment where trains are turned in 12-24 hours. Therefore, service interruption was a dominant factor in screening out some potential loading locations.

The most direct route from the plant to an ideal site in Green Bay for loading trains involves (see inset on **Figure 3-17**): exiting from the access road onto WI-42, driving north for approximately 6.25 miles, turning left onto West Limits Road, traveling for approximately 1.5 miles, turning left onto Highway 29 Trunk, proceeding for 7.7 miles, turning right onto County Road AB, traveling for 4.8 miles, making a left turn onto County Road N, traveling 12.65 miles, making a left onto University Avenue, following it for 2.7 miles, making a right onto N. Quincy Street, and finally proceeding to the entrance gate of the Georgia-Pacific Plant.

FIGURE 3-1: NEAREST RAIL TRACKS TO THE KEWAUNEE SITE [1]



Note: The green dots are a symbol produced by START[1] representing shutdown reactor sites. KPS is labeled on the figure. The unlabeled green dot is Zion Nuclear Power Station.

TABLE 3-1: NEAREST RAIL TRACKS TO THE KEWAUNEE SITE

Track Location	Siding Length (ft)	HHT Mileage to Track	Site Description	Challenges/Considerations
110 East Pine St Denmark, WI 54208	830	16	Private Industry Track: United Cooperative (grain elevator)	This is a shared track with Dufeck Wood Products Approximately 830' and 775' of non contiguous track Facility does not permit receipt of Class 7 materials as it is used for shipping of a food commodity
210 Maple St Denmark, WI 54208	775	16	Private Industry Track: Dufeck Wood Products	This is a shared track with United Cooperative Approximately 830' and 775' of non contigous track
112 Cedar St Luxemburg, WI 54217	1,580	21	Private Industry Track: Luxemburg Milling	Insuffcient track length (2 non-contiguous tracks: 800' & 780') Higher-density residential area nearby 80 lb rail poses potential issue
112 Fourth St Luxemburg, WI 54217	0	22	Private Industry Track: N.E.W. Plastics Corp.	No track located here, but included as this site was considered in other analyses [22]. A shipper most likely using the track at Luxemburg Milling for shipments 80 lb rail poses potential issue
715 Frontier Rd Luxemburg, WI 54217	2,040 1,960	22	Private Industry Track: Unknown Milling/Grain Elevator	Active grain elevator Two loading tracks at this site indicating shipping of grain in large quantities Higher-density residential area nearby 80 lb rail poses potential issue
4410 Rockwood Rd Manitowoc, WI 54220	1,105	22	Private Industry Track: Carmeuse Lime & Stone	Active limestone quarry with silo over track Must go through this facility to reach another rail-served customer: Country Visions Co-op
1815 Freedom Way Manitowoc, WI 54220	0	24	Manitowoc County Airport	Active airport No available loading facility Rail siding and switch must be constructed to use this location as a transload site Facility likely does not permit receipt of Class 7 materials
Site north of Manitowoc County Airport, Manitowoc, WI	0	24	Farm land along straight portion of rail line near Manitowoc County Building	No track available (new build necessary) Along straight portion of track to Rockwood Rd. in large farming area with decent road access.

Track Location	Siding Length (ft)	HHT Mileage to Track	Site Description	Challenges/Considerations
101 S. 16th St, Manitowoc, WI 54220	0	23	Broadwind Towers Inc.	Site is not rail served Difficult to add switch Higher-density residential area nearby
3175 Wall St Bellevue, WI 54311	1,220	27	Private Industry Track: Warehousing Company	Much of the available track is against a warehouse, so it is accessible only on one side for approximately 350' High-density residential area nearby HSMs were delivered to this site
725 Lombardi Avenue, Green Bay, WI 54304	1,132	33	Port Facility: Port of Green Bay	Not enough track to load the entire consist, overhead obstructions, 641' of the track is against a building
500 Day St Green Bay, WI 53402	3,630	35	Private Industry Track: Georgia-Pacific Corporation	Over 2,500' of track in the plant, 1,145' is straight. Two possible loading sites on the property. The plant is an active shipper, so coordination would be required to ensure no interruption of the business.
1226 S Water St Manitowoc, WI 54220	982	21	Manitowoc Waterfront Area-Red Arrow Products, Inc.	Limited track (cannot load a full consist), not enough physical space at the property to conduct the transfer operation. The track is close to the water's edge and there is limited space for truck placement during loading (i.e., an active shipper could not use track while loading campaign was being conducted)
444 Highland Dr, Kohler, WI 53044	2,265	52	Private Industry Track: Kohler Co.	No major issues
1200 S Lincoln Memorial Dr, Milwaukee, WI 53207	Equivalent of 13.5 miles	109	Port Facility: Port of Milwaukee	HHT distance concerns It is easier to load from barge to rail at the port than truck to rail however there are no major impediments

3.2 Rail Access Locations

The site is not and has never been rail served. The closest rail track to the site is approximately 16 miles away. It may be possible to build track to the ISFSI; however, a survey would be required to determine the feasibility of obtaining property ownership and access between the closest track and the site. The closest track is served by Canadian National Railway.

Canadian National Railway is a Class I railroad that serves the majority of rail sidings within close proximity to KPS and in the general geographical area. The next two closest railroads are other

Class I carriers: the Union Pacific Railroad and Canadian Pacific Railway (CPRS), which both serve the Port of Milwaukee. Although CPRS could be used to transport the loaded train from the Port of Milwaukee, an additional Class I carrier would be required in the route to reach the GCUS and therefore, it was screened out from options, as two other Class I direct options are present (one from the Port of Milwaukee and another from the Port of Green Bay). For analysis purposes, there are three Class I carriers located within 111 miles of KPS.

There are several short lines operating in Wisconsin, but none have track suitable for consideration as transload locations for this project, mostly because of the distance from the site or the length of available track for an ongoing operation. The Wisconsin and Southern Railroad (WSOR) serves Oshkosh, WI and the Escanaba & Lake Superior Railroad (ELSS) operates from Green Bay, WI to Rockland, MI. These are the closest short lines to the site.

As discussed in Section 3.1, the HHT route from KPS is via the access road to WI-42 and there are no designated heavy haul routes by the state of Wisconsin DOT. Loading on a private site served by one of the Class I carriers provides a direct link to the Class I carrier without an intermediate short line connection. The fact that no other carriers are involved in the recommended route also eliminates intermediate interchange points and therefore reduces the transit time to the GCUS. **Table 3-2** lists the railroads in the geographic area.

TABLE 3-2: CLASS I AND REGIONAL RAILROADS NEAR KPS

Railroad	Railroad Class	Notes
Canadian National Railway	Class I Carrier	Serves the majority of rail served sites near KPS
CPRS	Class I Carrier	Directly serves Port of Milwaukee
ELSS	Short line railroad	Operates from Green Bay, WI to Rockland, MI
Union Pacific Railroad	Class I Carrier	Directly serves Port of Milwaukee
WSOR	Regional Carrier	Oshkosh, WI

Table 3-1 identifies the railroad tracks that are located close to the site which potentially could be used as rail transloading sites. **Figures 3-2** through **3-10** depict the potential loading sites. The barge loading and unloading sites are captured in Section 3.3 and 3.4, respectively. Challenges, also identified in **Table 3-1**, exist with many of the potential sidings being used as transload sites. The down-selection process, discussed in Section 3.5, summarizes rationale for those sites that were not considered as viable options for the MUA evaluation.

FIGURE 3-2: TRACK AT POTENTIAL LOADING SITE: 110 EAST PINE ST AND 210 MAPLE ST, DENMARK, WI [1]

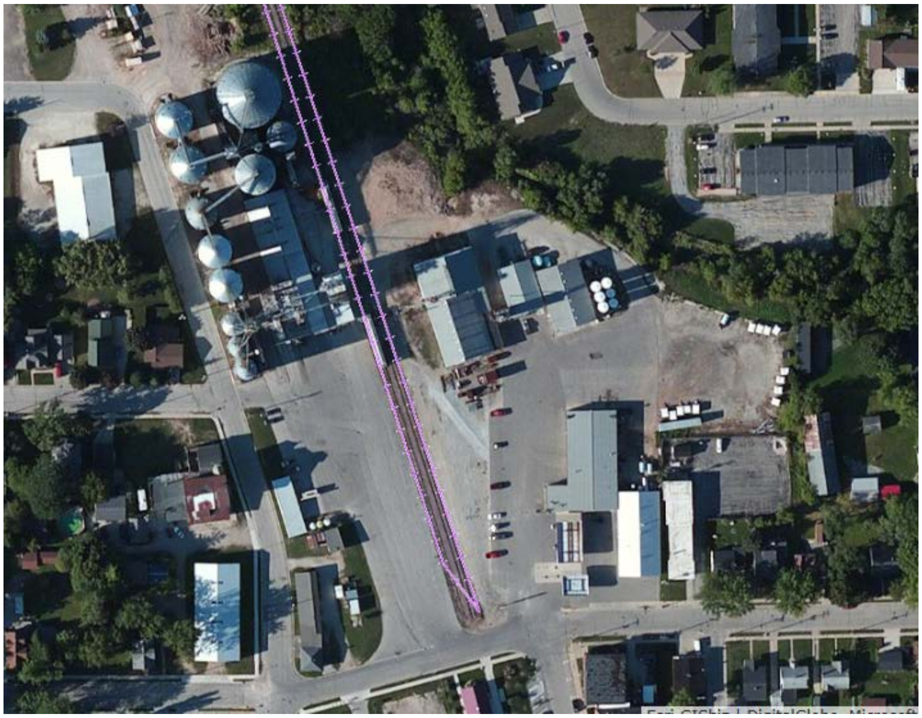
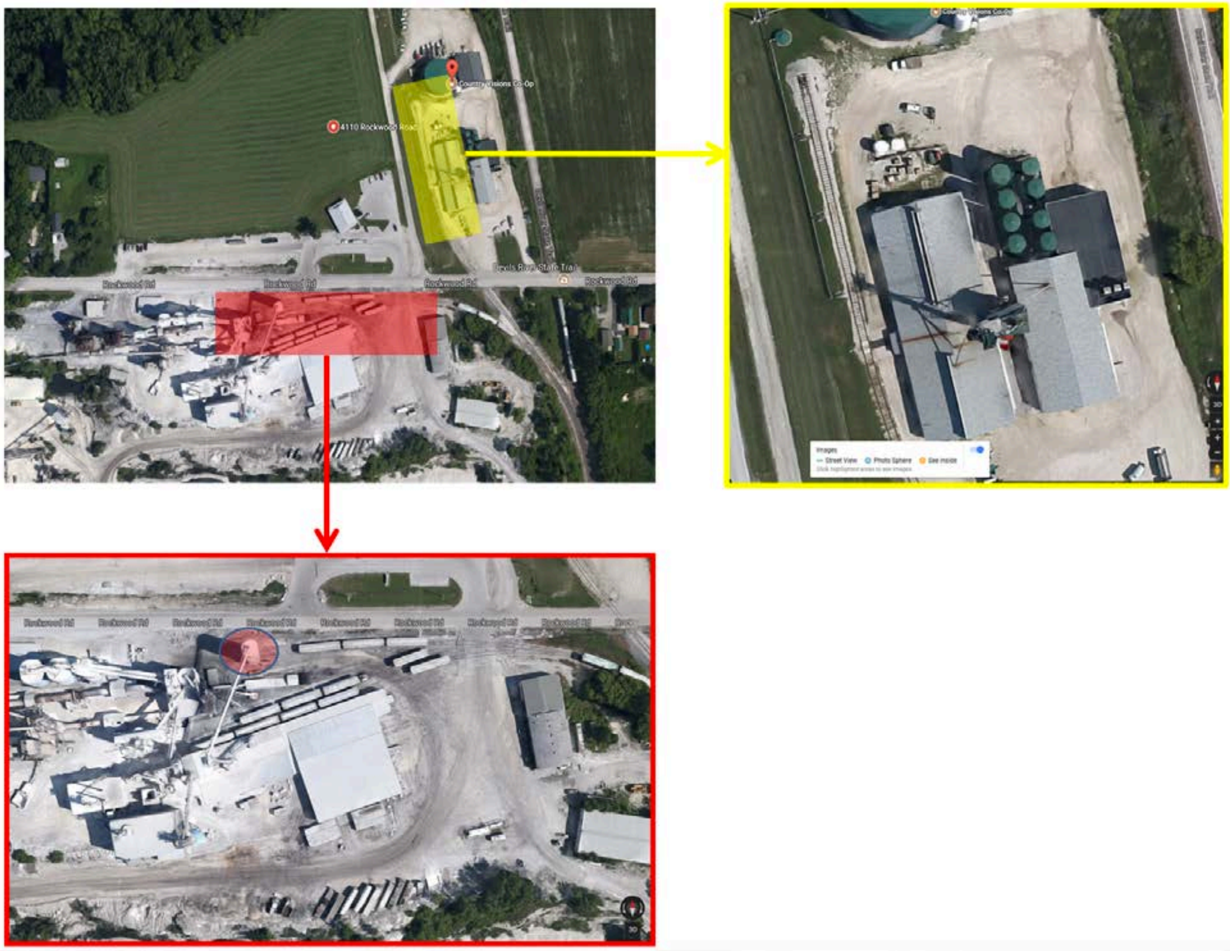


FIGURE 3-3: TRACK AT POTENTIAL LOADING SITE: 112 CEDAR ST, LUXEMBURG, WI [1]

FIGURE 3-4: TRACK AT POTENTIAL LOADING SITE: 715 FRONTIER RD, LUXEMBURG, WI [1]

FIGURE 3-5: TRACK AT POTENTIAL LOADING SITE: 4410 ROCKWOOD RD, MANITOWOC, WI [1]



Note: The red shaded area is part of an active limestone quarry. The yellow shaded area is a food co-op.

FIGURE 3-6: TRACK AT POTENTIAL LOADING SITE: 1815 FREEDOM WAY, MANITOWOC, WI [1]

FIGURE 3-7: TRACK AT POTENTIAL LOADING SITE: 3175 WALL ST, BELLEVUE, WI [1]

Note: the upper track should not be highlighted because it is not part of the siding; it is the mainline. In addition, this location was used to receive inbound HSM units by flat car, which were trucked to Kewaunee for use in the ISFSI.

FIGURE 3-8: TRACK AT POTENTIAL LOADING SITE: 500 DAY ST, GREEN BAY, WI [1]

Note: the red dashed lines represent the ideal transloading locations on this site.

FIGURE 3-9: TRACK AT POTENTIAL LOADING SITE: 1226 S WATER ST MANITOWOC, WI [1]

FIGURE 3-10: TRACK AT POTENTIAL LOADING SITE: 444 HIGHLAND DR, KOHLER, WI [1]

Note: the red dashed lines represent the ideal transloading location on this site.

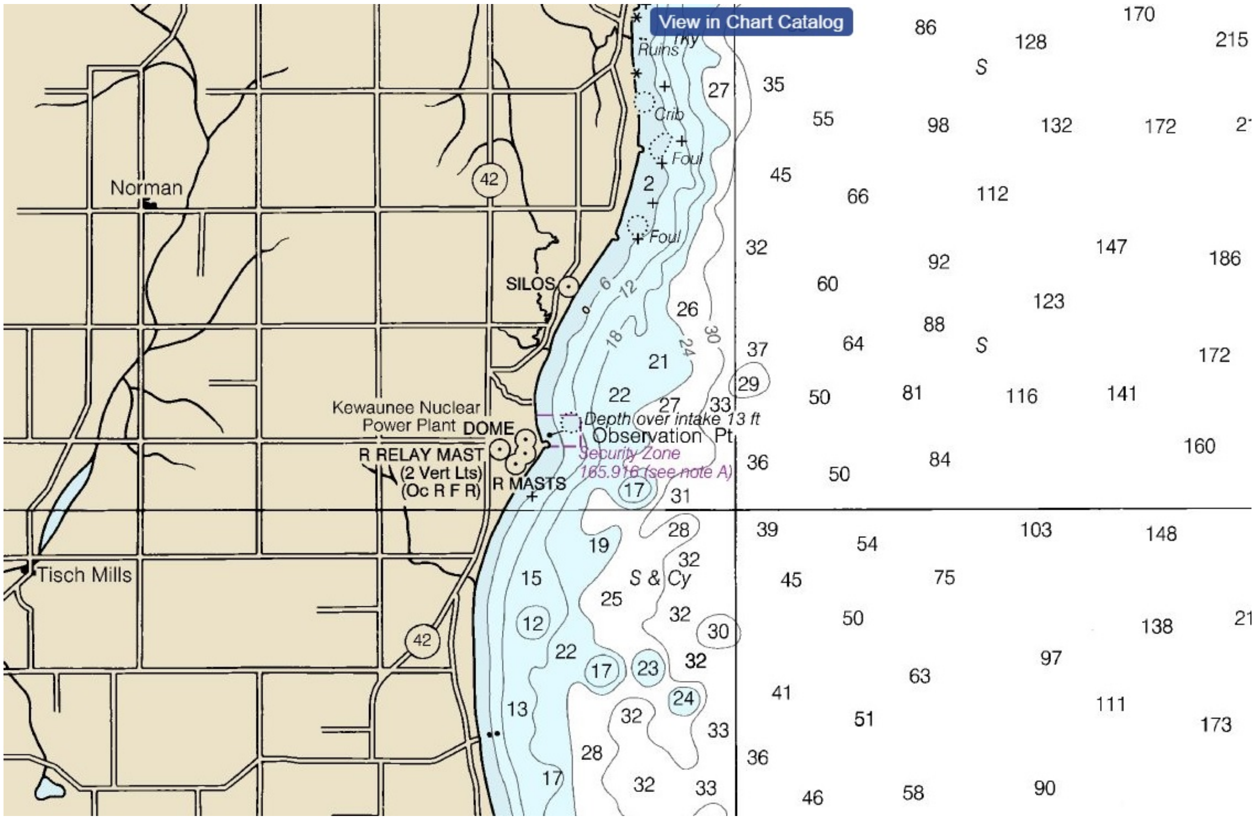
3.3 Barge Loading Locations

KPS is located on Lake Michigan. There is no existing barge slip. Previous indications are that at one time there was an active slip onsite during construction of the plant, but it was removed. The site is located on a beach, which is approximately 30 feet below the ISFSI. An existing road runs from the ISFSI to the beach at an approximate 9% grade (see **Figure 2-9**). According to NOAA depth charts from 2017, shown in **Figure 3-11**, the depth at the shoreline is approximately 6-13 feet deep, which is sufficient to conduct barge operations from the site. These operations would require grounding the barge, which is a common practice. Photos show rock formation barriers between the beach and the ISFSI. There are indications of barbed wire obstructions also located along the shoreline on the beach. No submerged barriers are shown on the NOAA maps. A physical site and marine survey must be conducted to ensure there are no submersed barriers to reaching the beach or obstacles on the beach to prevent landing the barge.

Weather conditions on Lake Michigan must be considered for any barge movements, as ice, wind, and tides are factors.

As the ISFSI is above the grade of the beach, removing the fence, performing grading, and laying crane mats as a foundation would allow for a smooth surface for the Goldhofer to transport the casks from the ISFSI to the barge in a safe manner. The beach access road appears to be sloping toward the beach. A detailed survey would be required to confirm its condition, grade, and possible use for access to the beach.

FIGURE 3-11: NOAA DEPTH CHART FOR THE KEWAUNEE SITE [54]



Visual and overhead photographs indicate barging would be possible using the previously mentioned existing "road" footprint, with some modifications to reduce the grade and with the addition of the aforementioned crane mats for the transition from the ISFSI to the beach.

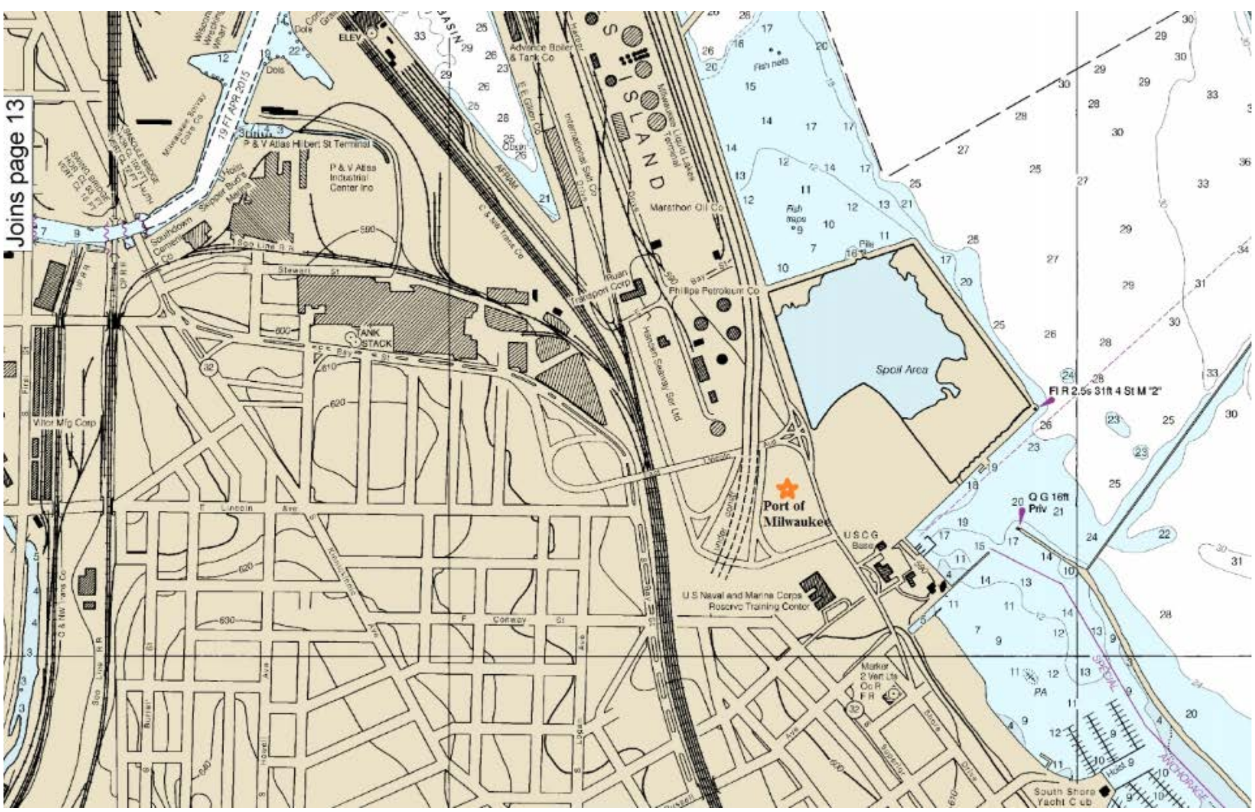
Prior shipments from KPS include several HHT-to-barge shipments. However, no direct barge shipments have occurred to/from the site since the plant was built. In 2001, two steam generators were trucked from KPS to the city pier and were transloaded onto barge for outbound transport. These shipments involved a HHT segment of approximately 10 miles from KPS to the city-owned pier where the two steam generator units were loaded onto a barge for movement to Memphis, TN for decontamination [22]. The same dock was also used to bring in the replacement steam generators with the movement taking place in reverse (ship to Kewaunee city pier, HHT to the site). These were both limited operations and not a continuous campaign. With the successful movements described above, use of Port of Kewaunee was considered; however, the nature of a continuous long-term campaign in a primarily recreational port area may be much more comprehensive and disruptive to the port than the prior, two-component shipments.

In July 2014, four steam generators were moved from Point Beach nuclear plant by HHT to Port of Kewaunee where they were loaded onto barges and moved on the Mississippi River to Houston, TX. In Houston, they were transloaded from barge to railcar for train movement into a Waste Control Specialists' facility for disposal. This type of movement involved three modes of transportation which increases the number of critical lifts. Frost depth and thaw were issues for the road portion of the transport to the Kewaunee city pier. In addition, the Wisconsin DOT required roadway improvements. Ice on Lake Michigan and water levels were challenges for the barge segment of the movement. Clearance restrictions were a consideration with the impact limiters for the rail segment of the movement. Some damage was caused to the barge staging area at the city pier, but it was restored after the units were loaded onto the barge. Specialized rigging and lifting devices were designed and used for this operation [46].

All of these barge shipments were successful. Since all the barge shipments were composed of much larger and heavier components than the casks, it is probable that the casks could also operationally be moved by barge from KPS or the Port of Kewaunee. However, there may be reporting requirements that may have implications for barging SNF on the Great Lakes, according to the Great Lakes Water Quality Agreement, Article 6(C) through The Great Lakes Executive Committee [55].

Other barge loading sites were considered including the Port of Milwaukee. This site could be reached by HHT or direct barge from the KPS ISFSI. HHT to this and other barge locations was considered and are identified in **Table 3-4**. The HHT movement to the Port of Milwaukee (or other port locations) will require additional permits associated with the over-the-road portion of the shipment versus a direct barge shipment from KPS. Using the Port of Milwaukee as an unloading site as opposed to a loading site (i.e., barge to the Port of Milwaukee as opposed to HHT to the Port of Milwaukee) would eliminate the associated HHT costs and permits to reach a suitable rail-served site. The Port of Milwaukee has 13.5 miles of track and service from two Class I carriers (Union Pacific Railroad and CPRS). It maintains a 26-foot depth so barge and ship traffic have easy access to the port. A professional commercial terminal operates here and has all required equipment (e.g., cranes, etc.) onsite to conduct the direct transfer from barge to railcar. It also has ample space and track to conduct a transfer from truck to railcar. The NOAA depth charts from 2017 for the Port of Milwaukee are shown in **Figure 3-12**.

FIGURE 3-12: NOAA DEPTH CHART FOR THE PORT OF MILWAUKEE [47]



The Port of Milwaukee is the only port facility with direct discharge capability and sufficient track proximal to KPS. It is a deep-water port and open to handling Class 7 commodities, but requires a current Material Safety Data Sheet (MSDS) to evaluate and make a final determination on handling the Class 7 commodity.

It should be noted that the use of any existing barge slip would need to be evaluated and a marine survey completed to determine if there are any submerged conditions that would present complications to the operation; if a pier were used, its condition to hold the combined weight of the cask, cradle, and Goldhofer would need to be evaluated.

3.4 Barge Unloading Locations

Several options for potential barge unloading locations were identified, including Port of Kewaunee, WI; the Port of Green Bay, WI; the Port of Milwaukee, WI; and the Port of Chicago, IL. **Table 3-3** lists the barge unloading locations reviewed. Additional lifts will be required with a barge shipment from the site to the identified ports for loading onto rail. The additional lifts add cost and time to the total transit.

TABLE 3-3: POSSIBLE BARGE UNLOADING PORTS

Port	Type of Facility	Owner	Rail Access	Rail Carrier Class	Usable for Transload onto Rail?
Port of Kewaunee (City Piers)	Recreational	City of Kewaunee	No	None	No rail track is available at this recreational port facility
Port of Green Bay	Commercial Port	City of Green Bay	Canadian National Railway	Class I	Not easily accessible. Coal and other unit train operations are present which would require interruption of service and be difficult to implement a continuing campaign without impacting ongoing businesses.
Port of Milwaukee	Commercial Port	City of Milwaukee	Union Pacific Railroad	Class I	Yes. 13.5 miles of track are located in the port. Established terminal with required equipment to conduct lifting and securing operations. Direct transfer from barge to railcar is available at this port.
Port of Chicago	Commerical Port	City of Chicago	Canadian National Railway, NS	Class I	Yes however due to the extreme congestion of the area this port is not considered a viable option. In addition, most dimensional traffic is not routed through Chicago to avoid delays and congestion.
Point Beach Nuclear Plant	Private Company with barge access	NextEra Energy Point Beach, LLC	No	None	No rail track is available here but Point Beach is on Lake Michigan and a temporary barge slip was used during construction, but was not maintained and would need to be dredged before use.

3.5 Down-Selected Transportation Routes

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

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

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 added to the screening criteria so that the unique criterion could be captured.

After applying the above screening criteria (see **Table 3-4**), a total of five possible routes (see **Figures 3-13** through **3-17**) were identified and are included for further evaluation in the MUA (Section 5.0):

1. HHT from KPS ISFSI to the Port of Kewaunee, WI, barge from Port of Kewaunee to Port of Milwaukee, WI, and rail to GCUS.
2. Barge from KPS ISFSI to Port of Milwaukee, WI, and rail to GCUS.

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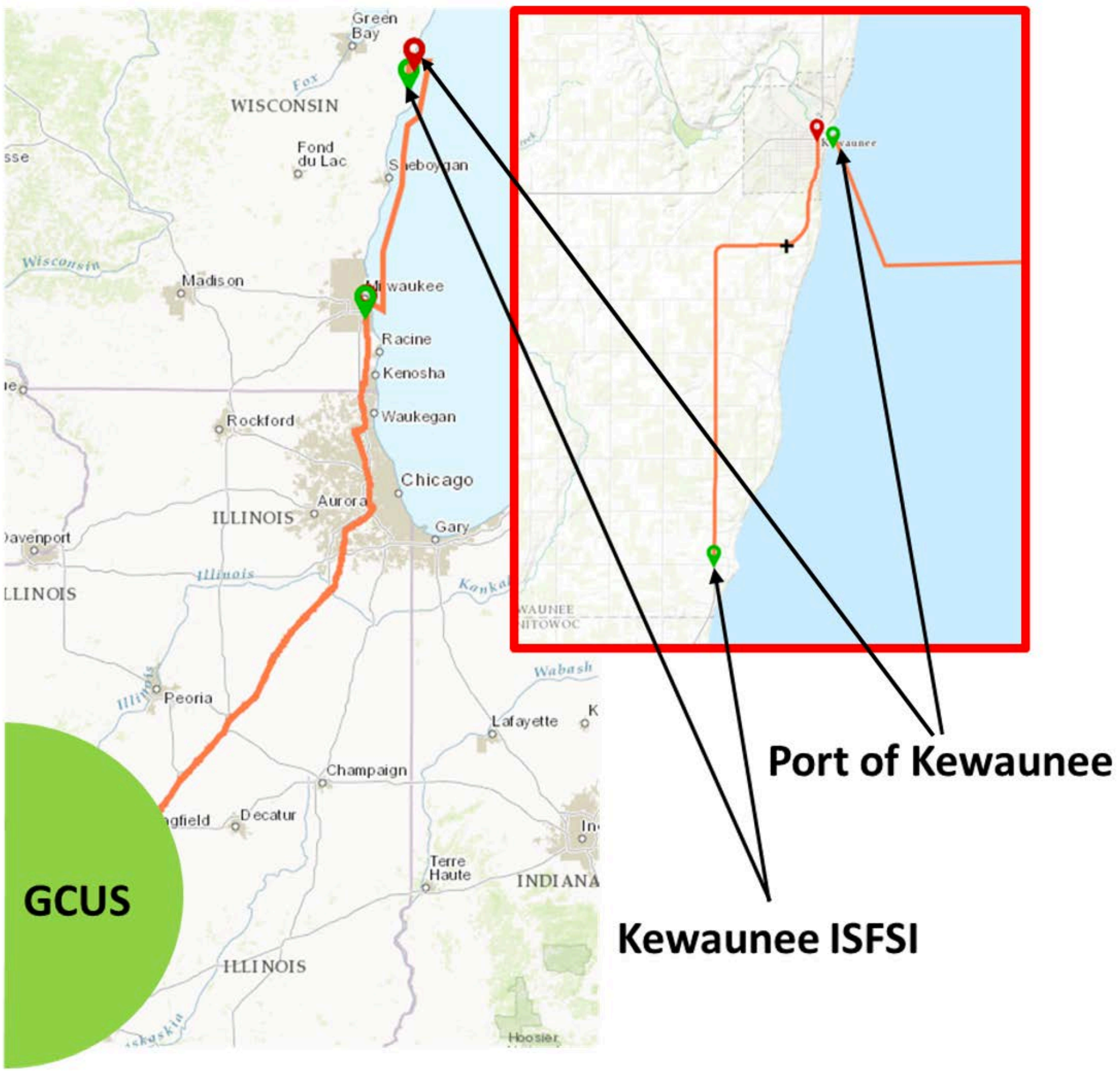
[4] For routes where HRCQ applies, screening may occur due to the more restrictive requirements of NRC approval of such a route and its associated requirements for armed security, disabling devices, secure communication, HAZMAT bill of laden, safe haven identification, safe-secure shipments, emergency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

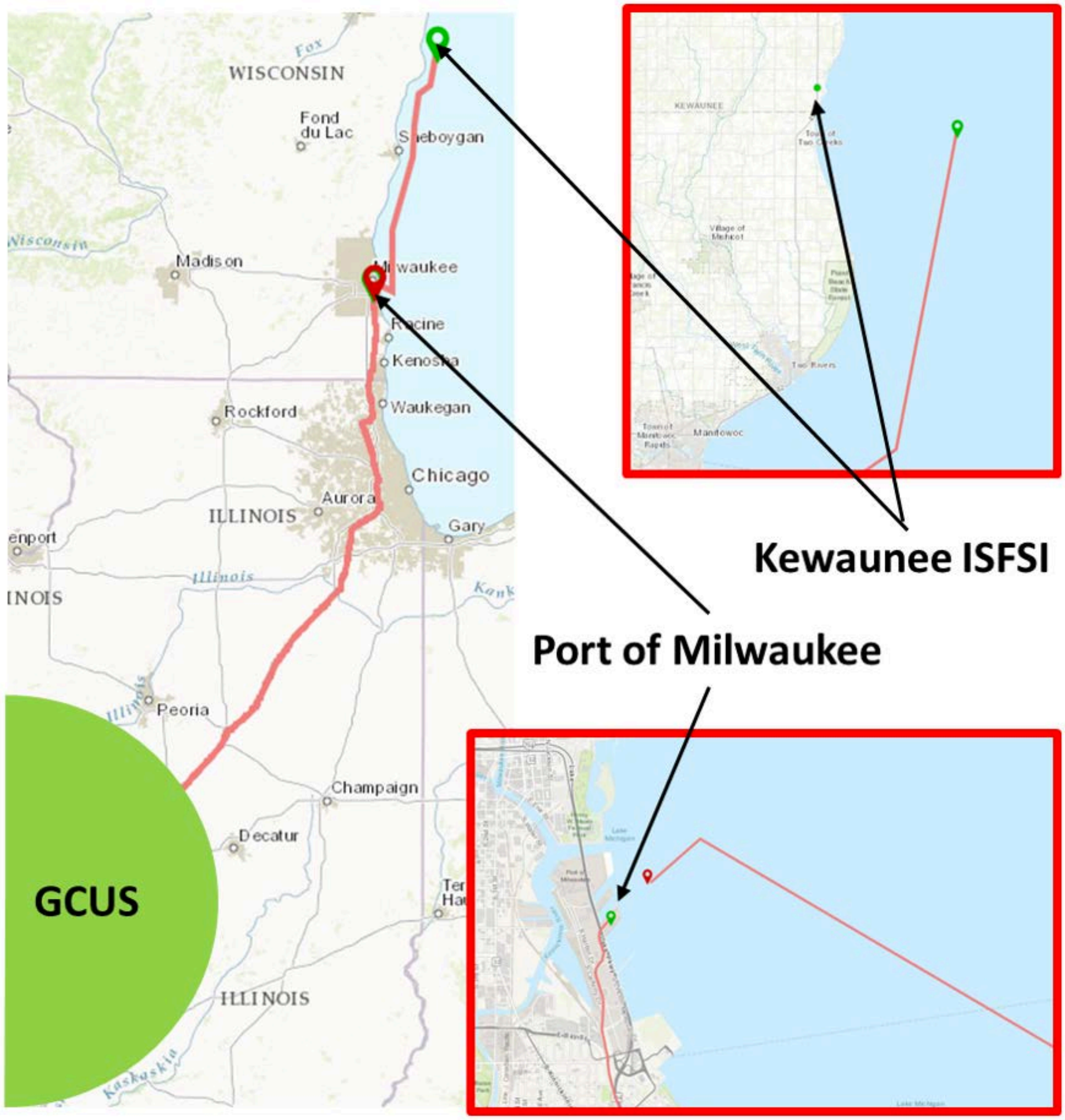
3. HHT from KPS ISFSI to Kohler, WI, and rail to GCUS.
4. HHT from KPS ISFSI to the Port of Milwaukee, WI, and rail to GCUS.
5. HHT from KPS ISFSI to Green Bay, WI, and rail to GCUS.

FIGURE 3-13: BARGE ROUTE FROM PORT OF KEWAUNEE TO PORT OF MILWAUKEE



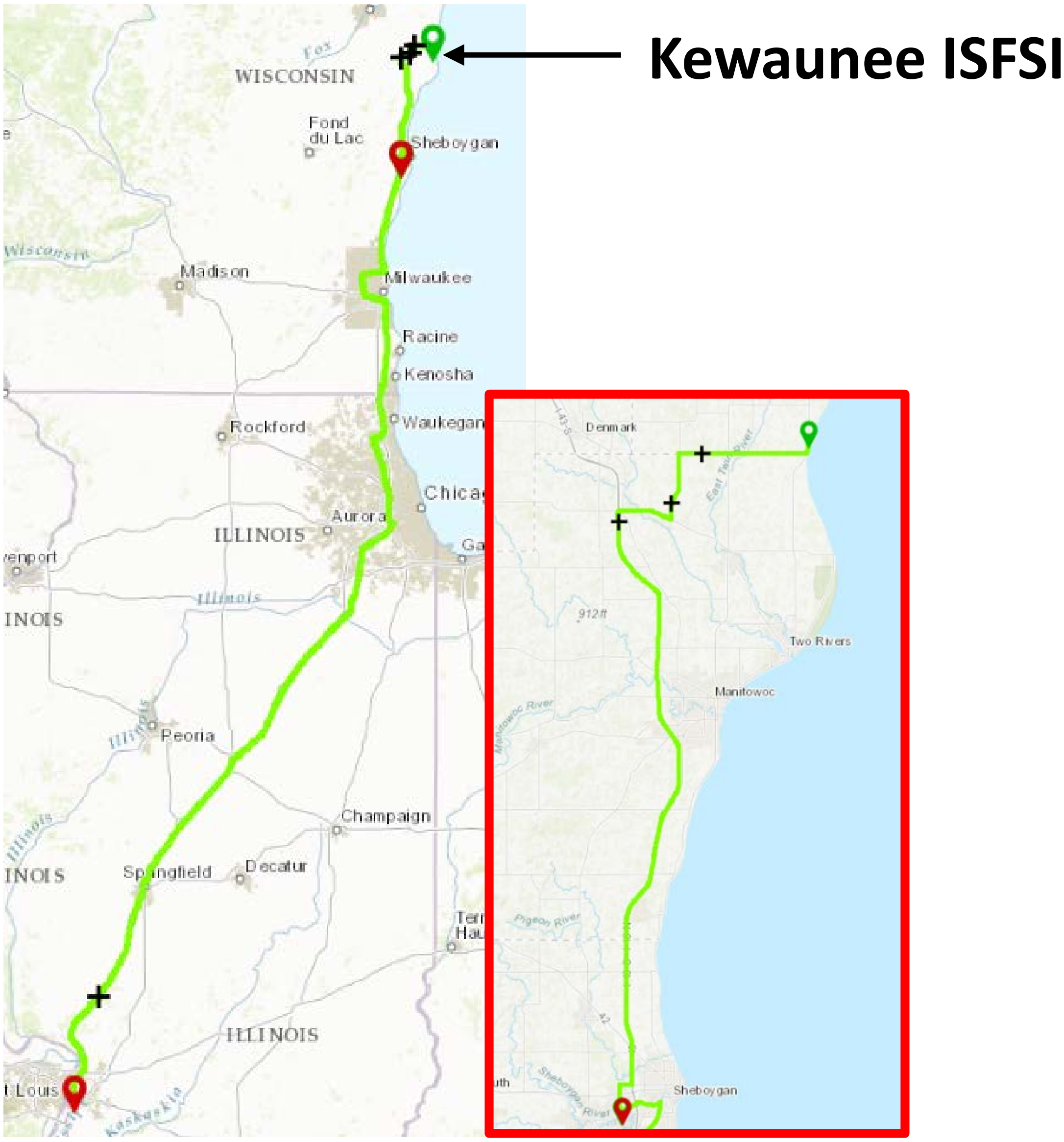
Note: This figure was produced by START[1]. The green and red pointers and the green semi-circle indicate transload, loading, and unloading locations (e.g., HHT to barge at the Port of Kewaunee or barge to rail at the Port of Milwaukee). The HHT route from the KPS ISFSI to the Port of Kewaunee is shown in the right inset. The cross represents a forced stop (actually a mandatory pass through point) on the HHT route to direct the HHT truck along the most appropriate route.

FIGURE 3-14: BARGE ROUTE FROM KPS ISFSI TO PORT OF MILWAUKEE



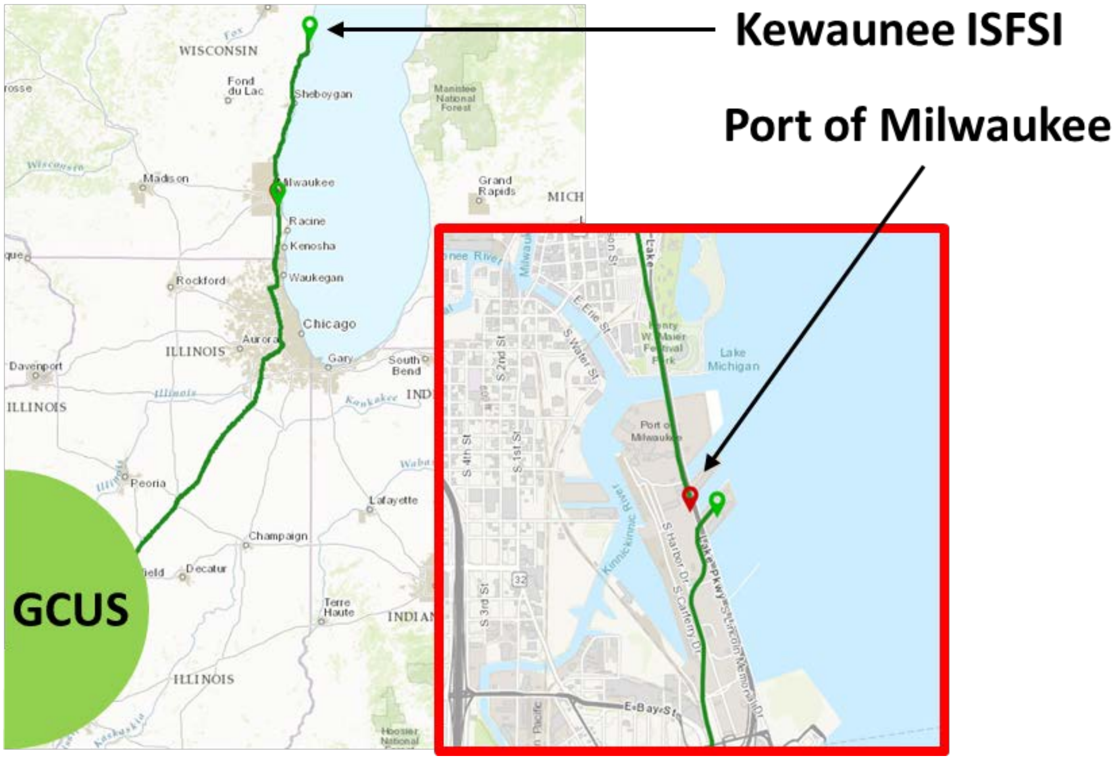
Note: This figure was produced by START[1]. The green and red pointers and the green semi-circle indicate transload, loading, and unloading locations (e.g., barge to rail at the Port of Milwaukee). The transfer from the Kewaunee site to the barge and the transload from the barge to rail at the Port of Milwaukee are shown in the upper and lower right inset (the gaps in the routes shown in the insets are an artifact of START[1]).

FIGURE 3-15: HHT ROUTE TO KOHLER, WI



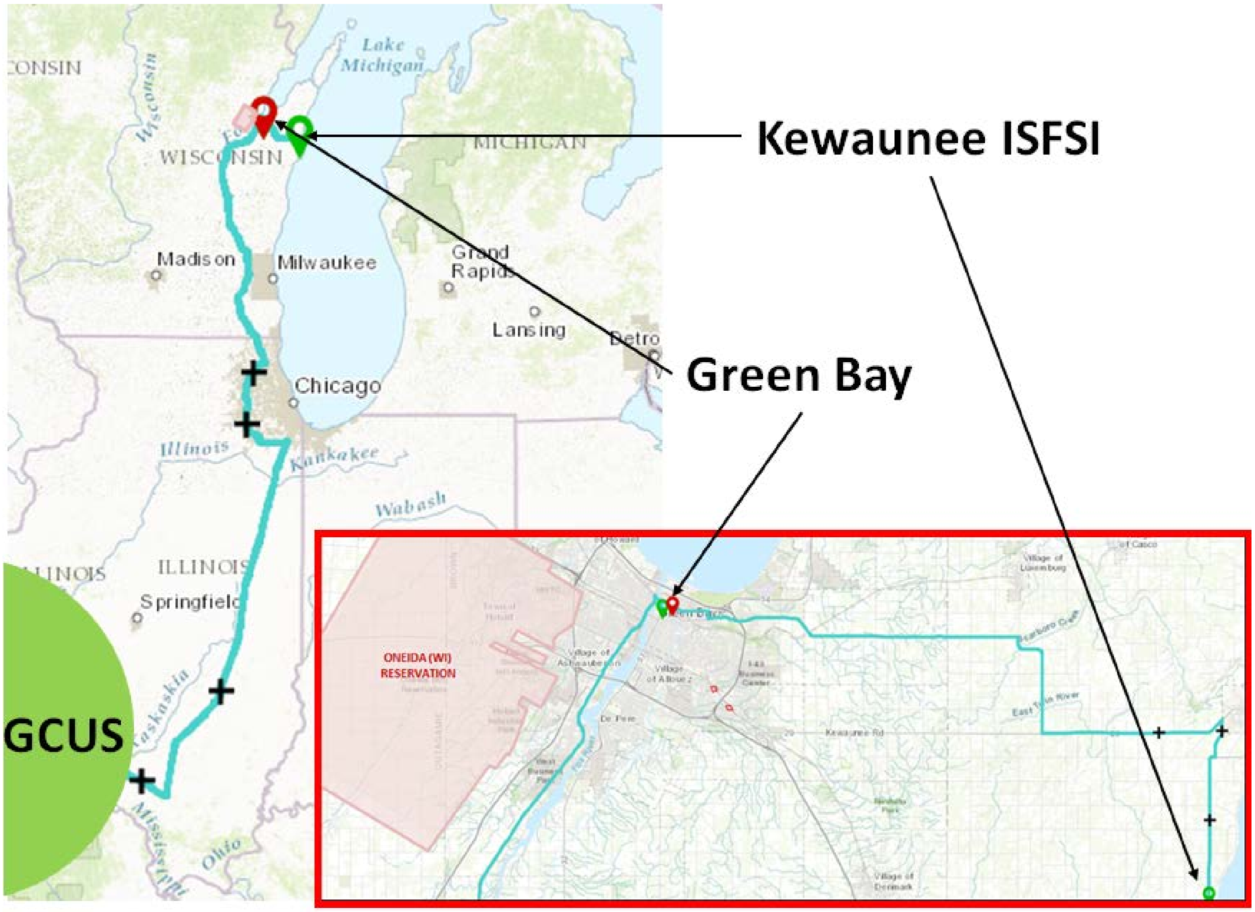
Note: This figure was produced by START[1]. The green and red pointers and the green semi-circle indicate transload, loading, and unloading locations (e.g., HHT to rail in Kohler, WI). The HHT route from the KPS ISFSI to Kohler, WI is shown in the right inset. The crosses represent forced stops (actually mandatory pass through points) on the HHT route to direct the HHT truck along the most appropriate route.

FIGURE 3-16: HHT ROUTE TO THE PORT OF MILWAUKEE, WI



Note: This figure was produced by START[1]. The green and red pointers and the green semi-circle indicate transload, loading, and unloading locations (e.g., HHT to the Port of Milwaukee). The transload from HHT to rail at the Port of Milwaukee is shown in the right inset.

FIGURE 3-17: HHT ROUTE TO GREEN BAY, WI



Note: This figure was produced by START[1]. The green and red pointers and the green semi-circle indicate transload, loading, and unloading locations (e.g., HHT to rail in Green Bay, WI). The HHT route from the KPS ISFSI to Green Bay, WI is shown in the right inset. The crosses represent forced stops (actually mandatory pass through points) on the HHT route to direct the HHT truck along the most appropriate route. Note the Oneida (WI) Reservation is located nearby the route as it leaves Green Bay, WI, but does not actually pass through the reservation.

TABLE 3-4: ROUTES VERSUS SCREENING CRITERIA

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT from Kewaunee to Luxemburg, WI (Cedar St)						X			X		
HHT from Kewaunee to Luxemburg, WI (Fourth St)						X					
HHT from Kewaunee to Luxemburg, WI (Frontier Rd)						X			X		
HHT from Kewaunee to Denmark, WI (Pine St)						X	X				Interferes with private business, used for food commodity
HHT from Kewaunee to Denmark, WI (Maple St)						X					Interferes with private business
HHT from Kewaunee to Bellevue, WI (Wall St)						X			X		
HHT from Kewaunee to Manitowoc, WI (Rockwood Rd)						X					Interferes with private business
HHT from Kewaunee to Manitowoc, WI (Freedom Way)						X	X				Active airport with no rail siding – would have to construct
HHT From Kewaunee to Manitowoc, WI (S Water St)						X					Insufficient track and loading operation space, interferes with private business
HHT from Kewaunee to Kohler, WI (Highland Dr)											
HHT from Kewaunee to Milwaukee, WI (S Lincoln Memorial Dr)											
HHT from Kewaunee to Green Bay, WI (Lombardi)	X										
HHT from Kewaunee to Green Bay, WI (Day St)											

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT from Kewaunee to sites further West than Green Bay, WI	X										
HHT from Kewaunee to sites further North than Luxemburg, WI	X					X					
HHT from Kewaunee to sites further South than Milwaukee, WI	X										
Barge from Port of Kewaunee to Port of Milwaukee											
Barge from Port of Kewaunee to Port of Green Bay	X										
Barge from Port of Kewaunee to Port of Chicago									X		
Barge from Port of Kewaunee to Chicago Sanitary & Ship Canal (CSSC) (via the Mississippi River)	X										
Barge from Kewaunee site to Port of Milwaukee											
Barge from Kewaunee site to Port of Green Bay	X										
Barge from Kewaunee site to Port of Chicago									X		
Barge from Kewaunee site to CSSC (via the Mississippi River)	X										

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

Screening Criteria Legend:

1. The time and/or distance to be traveled by the conveyance/barge will be significantly in excess
2. Clearance limits on routes
3. Sustained travel on routes with steep grades

4. Bridge(s)/overpass(s) weight limitation
5. Natural features make barge landings, overpack loading, etc., difficult
6. No available loading facility or insufficient track for performing loading of a full consist
7. Transloading and/or port facility does not permit receipt of Class 7 materials.
8. Number of interchanges between carriers
9. Avoidance of high-density transit areas
10. Characteristics of HHT Requiring Preapproval for HRCQ Shipments

4.0 PARTICIPATING ENTITIES

This section identifies participating entities in the overall de-inventory implementation for the KPS ISFSI and provides their current contact information. The list of participating entities includes:

- Employees
- Subcontractors: crane suppliers, riggers, etc.
- Transportation: trucker, railroad, 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 with participating entities (e.g., local authorities, escorts, etc.) in advance of movements as required in 10 CFR 73.37 and as recommended in NUREG-0561 Revision 2 [48].
- TRANSCOM or similar satellite and associated continuous in-transit communication service provider(s)
- Transportation emergency response resources

The participating entities 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 selected for the report. However, the Oneida Nation of Wisconsin's Reservation is located near the city of Green Bay, and if the HHT-to-Green Bay route were used, then information sharing and government-to-government consultation with the Oneida Tribe may be involved. This will need to be evaluated further once destination facilities are identified.

TABLE 4-1: PARTICIPATING ENTITY FUNCTIONAL IDENTIFICATION

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

Function Group	Entity
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. Coast Guard (USCG)
	U.S. Transportation Safety Administration (TSA)
	NRC
	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)(1) As specified in paragraphs (b), (c), and (d) of this section, each licensee shall provide advance notification to the governor of a State, or the governor's designee, of the shipment of licensed material, within or across the boundary of the State, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

(2) As specified in paragraphs (b), (c), and (d) of this section, … each licensee shall provide advance notification to the Tribal official of participating Tribes referenced in paragraph (c)(3)(iii) of this section, or the official's designee, of the shipment of licensed material, within or across the boundary of the Tribe's reservation, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage. …
(c) *Procedures for submitting advance notification*. (1) The notification must be made in writing to:
(i) The office of each appropriate governor or governor's designee;
(ii) The office of each appropriate Tribal official or Tribal official's designee; and
(iii) The Director, Division of Security Policy, Office of Nuclear Security and Incident Response."

Therefore, notification of government authorities is required to coordinate transport in an actual de-inventory campaign. For transport of radioactive material [48], the following government agencies issue regulations concerning the packaging and transport of radioactive materials:

- State authorities
- U.S. DOT
- NRC
- DOE
- USCG
- TSA
- PHMSA
- FRA

Listed in Sections 4.1 through 4.10 is contact information for the relevant state (Wisconsin) governing authorities and transportation services for the various modes of transport anticipated. During the development of this report, most information was obtained through public domain. However, during an actual de-inventory campaign these contacts would be instrumental in the execution of the work.

Caveat: Section 180(b) of the Nuclear Waste Policy Act (NWPA) of 1982, as amended, requires DOE to abide by NRC regulations regarding advance notification of State and local governments prior to transportation of SNF or HLW to an NWPA-authorized facility.

4.1 Wisconsin - Office of the Governor

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

https://www.walker.wi.gov
Wisconsin Governor Scott Walker
115 East, State Capitol
Madison, Wisconsin 53702
Phone: 608-266-1212

4.2 Wisconsin - Governor's Designee for Notification of SNF Shipments

Listed below is the contact information for the Wisconsin Governor's designee for notification of SNF shipments. [1]

Governor's Designee for Notification of SNF Shipments:
Brian Satula
Administrator
Wisconsin Emergency Management
P.O. Box 7865
2400 Wright Street
Madison, WI 53707-7865
Phone: 608-242-3210
Fax: 608-242-3313
24 hours: 800-943-0003
Brian.satula@wisconsin.gov

4.3 Wisconsin - Department of Transportation (DOT)

Listed below is the contact information for the Wisconsin DOT.

Wisconsin Department of Transportation
Hill Farms State Transportation Building
4802 Sheboygan Avenue
Madison, WI 53705
http://www.wisconsindot.gov/pages/home.aspx

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

Wisconsin Department of Transportation
Motor Carrier Services
P.O. Box 7980
Madison, WI 53707-7980
Phone: 608-266-7320
Fax: 608-264-7751

4.4 United States Coast Guard

KPS and the selected transload site in Green Bay, WI are both located along Lake Michigan. This body of water is under the supervision of the Lake Michigan sector of the Ninth District of the USCG.

Captain Stuhlreyer
USCG Sector Lake Michigan
2420 S Lincoln Memorial Dr.
Milwaukee, WI 53207
Phone: 414-747-7182

Lake Michigan Sector of the Ninth U.S. Coast Guard

https://www.uscg.mil/d9/units.asp
2420 S. Lincoln Memorial Drive
Milwaukee, WI 53207
Phone: 414-747-7100

4.5 Site Management Provider

Stuart Yuen
Plant Manager
Dominion Energy Kewaunee, Inc.
Phone: 920-388-8497

4.6 Heavy-Haul Transportation Service Providers

Ray Morgan
VP of Business Development and Government Affairs
Perkins Specialized Transport
1800 Riverview Drive
Northfield, MN 55057
Phone: 507-301-0704
Email: rmorgan@perkinsstc.com

Barnhart Crane and Rigging
Heavy Lift Terminal
12100 South Stony Island Ave.
Chicago, IL 60633
815-431-0078 Phone
815-431-0776 Fax
http://www.barnhartcrane.com/

4.7 Wisconsin - Department of Military Affairs Division of Emergency Management

Wisconsin Department of Military Affairs – Division of Emergency Management
2400 Wright Street
P.O. Box 7865
Madison, WI 53707-7865
Phone: 608-242-3000
Fax: 608-242-3247
24 hours: 800-943-0003
Email: wempio@wisconsin.gov

4.8 Railroad Transportation Contacts

Canadian National Railway Green Bay Rail Yard
729-, 749 Prairie Ave
Green Bay, WI 54303

4.9 Barge Operators

Although barge is not recommended for this project; if used, refer to the contact below:

Vincent Schu
Ceres Barge Line
3808 Cookson Rd.
East Saint Louis
Illinois 62201-2126
Phone: 314-602-5752
www.ceresbarge.com

Canal Barge
Mike Little
Main Office
835 Union Street
New Orleans, LA 70112-1469
Phone: 504-581-2424
Fax: 504-584-1505
http://www.canalbarge.com/

4.10 Cask Supplier

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

TN Americas LLC
www.us.areva.com/AREVATN
Chris Miller
Sales & Marketing
AREVA TN:
410-910-6810
AREVATNinformation@areva.com

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

5.0 MULTI-ATTRIBUTE UTILITY ANALYSIS

As noted in Section 3.0, there are several potential routes for shipping the NUHOMS 32PTs and TSC-37s from the KPS ISFSI to a railcar on a Class I railroad that can take the NUHOMS 32PTs and TSC-37s to their penultimate or ultimate destination (e.g., a consolidated interim storage site or a repository, respectively). The diversity of these routes reflects the multiple viable approaches to shipping the NUHOMS 32PTs and TSC-37s (i.e., by HHT or barge), and the access of KPS to these modes of transport. Furthermore, these routes present multiple attributes, many with a positive connotation (e.g., safe and secure transport), and some with a negative connotation (e.g., expense), which merit an assessment approach that can evaluate these attributes in a combined manner that may distinguish one route from another and/or provide a prioritized list of 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 to evaluate the viable modes and routes (options) for moving the NUHOMS 32PTs and TSC-37s containing SNF and GTCC LLW from the KPS 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 modes and routes from the KPS ISFSI.

5.1 Description of MUA Applied to the KPS ISFSI

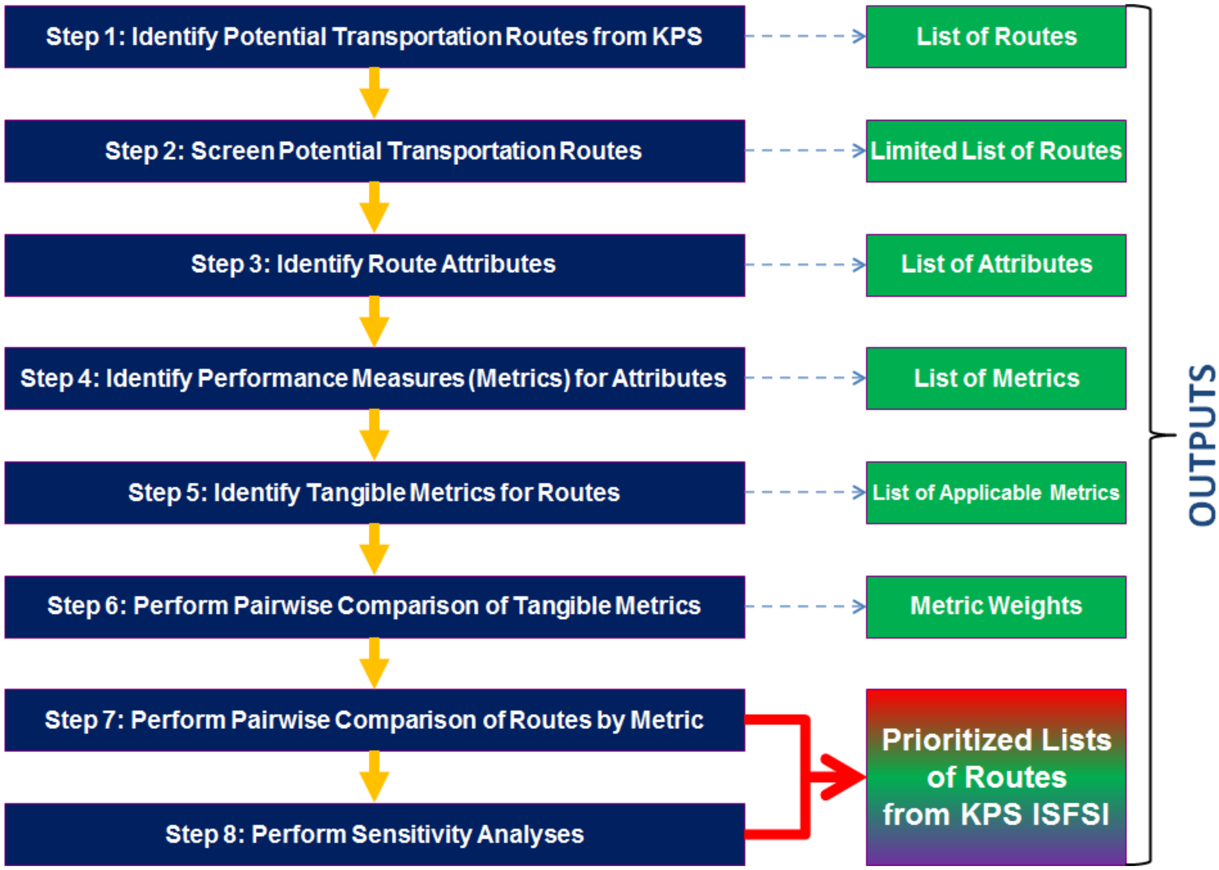
MUA is a straightforward concept. The three primary steps typically followed to frame the analysis are: (1) identify a set of objectives/attributes that an 'ideal' option will achieve; (2) define a set of performance measures (i.e., metrics) that provide a clear definition of each objective/attribute;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

1) Identified the potential modes and routes for transporting the NUHOMS 32PTs and TSC-37s from the KPS ISFSI, see Section 3.0.
2) Due to the larger number of potential routes identified in Step 1 from the KPS 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 cumbersome 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 NUHOMS 32PTs and TSC-37s from the KPS 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 Subject Matter Experts' (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 THE MUA APPLIED TO KPS ISFSI



5.2 Description of Evaluated Routes

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

- Transport by HHT directly to an existing rail transload facility (HHT to rail), or establish a private transload facility
- Transport to an onsite barge, barge transport to a port, and transfer directly from the barge to a railcar (barge to rail)
- Transport by HHT to a barge, barge transport to a port, and transfer directly from the barge to a railcar (HHT to barge to rail)

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

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

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

The reasons for the screening of potential routes identified in Section 3.0 are documented in **Table 3-4**. The routes unscreened and remaining to be evaluated by the MUA are as follows:

1) HHT from KPS ISFSI to the Port of Kewaunee, WI, barge from Port of Kewaunee to Port of Milwaukee, WI, and rail to GCUS on the Union Pacific Railroad.
2) Barge from KPS ISFSI to Port of Milwaukee, WI, and rail to GCUS on the Union Pacific Railroad.
3) HHT from KPS ISFSI to a potential transload site on Highland Drive in Kohler, WI, and rail to GCUS on the Union Pacific Railroad.
4) HHT from KPS ISFSI to the Port of Milwaukee, WI, and rail to GCUS on the Union Pacific Railroad.

---

[5] 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.

5) HHT from KPS ISFSI to a potential transload site on Day Street in Green Bay, WI, and rail to GCUS on the Canadian National Railway.

5.3 Evaluation of Routes

To evaluate each of these five routes, attributes used to define an 'ideal' route and associated shipping activities were identified, and for each attribute, metrics were identified that describe the performance measures and allow for the quantification of the assessment through pairwise comparisons. With these five routes in mind, the metrics were evaluated to identify those that are tangibly different between two or more routes. These tangibly different metrics were then pairwise compared against one another to identify a level of importance for each metric (i.e., a metric hierarchy) and provide a range of values against which sensitivity analyses were performed. An additional pairwise comparison was performed between the tangible metrics for each route, and using the metric hierarchy, a hierarchy for the routes was established. Finally, sensitivity analyses were performed to examine the impact 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 and also based on the large body of past MUA activities having been performed on nuclear waste management evaluations [56-59].

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

To minimize the number of evaluations performed in the next set of MUA activities, the team was surveyed to establish which metrics identify a potentially tangible difference between one or more of the remaining five routes (Step 5). **Table 5-1** shows the results of this survey and some subsequent team discussions. Those metrics identified as having the potential to differentiate between one or more of the routes are identified in **Table 5-1** with a "Y" (yes). Comments are provided in the last column of the table to indicate how the "applicable metric" assessment was performed/concluded. The results of this assessment identified at least one metric for each attribute, with the exception of the Resource Requirements and Waste Generation attributes, for which no tangible differences in the resources 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 14 metrics will be evaluated for each route and contrasted against the other routes.

TABLE 5-1: ATTRIBUTES AND ASSOCIATED METRICS

Attribute	Metric	Y/N	Comments
Cost[6]	ISFSI Rental Equipment Costs (e.g., mobile cranes)	N	No significant differences are expected at the ISFSI as all casks will be shipped from the ISFSI by HHT and all operations for the transfer of the canister to the transportation cask will be required regardless of route taken. A Goldhofer will be required regardless of the mode of transportation.
	ISFSI Hardware Procurement Costs (e.g., transfer cask)	N	No differences are expected at the ISFSI as all casks will be shipped from the ISFSI by HHT to either the onsite barge or the off-site rail.
	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	Y	Improvements, such as preparing a barge landing site and upgrading an onsite and/or off-site road(s), may be necessary and may pose measurable differences.
	Labor and Permitting Costs	N	Neglibile differences are expected between routes as activities are essentially considered the same and permitting costs are expected to be negligible to overall costs.
	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	Y	The different modes of transport from the site of HHT or barge will result in different shipment costs and different transload costs.
	Cost of Rail Transport (e.g., costs associated with interchange activities)	N	No significant difference between the rail portions of the routes is expected, with a minimal number of rail interchanges expected to take place.
	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 and barge 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.

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

Attribute	Metric	Y/N	Comments
	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.)	N	Evaluated routes are not expected to traverse steep grades and/or use tunnels that may pose a challenge to the shipments of the material from KPS.
	Impact of Weather to Route (e.g., limited availability of route or instability of weather)	Y	Weather may impact HHT and barge shipments from KPS.
	Number of Water Areas Nearby Route (e.g., number of bridges crossed)	N	Mileage over water shows neglible differences.
	Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)	N	Identified routes show neglibile differences between sensitive areas traversed.
Insitutional Considerations	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)	N	Based on results from START[1], these mass gathering places along the evaluated routes is fairly consistent for each route and not really distiguishable between the routes.
	Number of Tribal Lands Crossed	N	Evaluated routes do not cross tribal lands per information provided by START[1].
	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	All permit pulling is expected to be difficult to perform and hence, no real means for distinguishing between the routes, especially since many of the routes have some precedence for making prior shipments.
	Number of Permits	Y	For the longer HHT routes, the number of local permits expected to be needed is higher.
	Insurability of Route	N	Not considered an issue between these routes.
Resource Requirements	Number of Personnel involved in Transfer	Y	Barge routes are expected to have a higher number of personel involved.
	Quantity of Hardware Needed	N	Hardware is expected to be relatively the same for all routes, with stands for barging being negligible exception.

Attribute	Metric	Y/N	Comments
	Availability of Specialty Equipment (e.g., rigging, transfer cask)	N	Speciality equipment such as a transfer cask, rigging, and an HHT (Goldhofer) will be required for each route. Barges and tugs will only be needed for barge routes, but their inclusion will be captured in the transport to rail costs identified above.
Safety	Cumulative Worker Exposure (α handling time & number of workers)	Y	Some routes will involve greater cumulative worker exposure as a result of an additional transload activity (for barge routes) and/or the longer transient duration associated with some routes.
	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	Y	Risks associated with lifting activities will vary between modes of transportation.
	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	The number of fire stations and trained personnel nearby the route will be proportional to the population density and hence the population desnity metric will accounted for this metric.
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	Only potential significant infrastructure improvements are expected to be the clearing of a landing area for a barge and maybe the fortifying of the road system. These are expected to be performed in advanced of any SNF handling and hence are not expected to adversly impact the schedule.
	Ease of Access to Transload Site (e.g., consider usage of existing site)	Y	The ease of access varies between each transload location, as access to the Green Bay site will depend on a private entity whereas onsite barge access will be easy.

Attribute	Metric	Y/N	Comments
	Immediacy of Ability to Perform Transfer (e.g., ability to train crew)	N	The team decided there was no tangible difference between the HHT routes and since a beach landing was possible, all routes were deemed equally immediately ready for performing a transfer.
	Size of conveyance (# of casks per shipment)	Y	Only one cask per HHT shipment will be made, whereas barges will be able to transport 5 casks per shipment.
Security/ Vulnerability	Security Vulnerability of Route	Y	Some routes may transit urban areas viewed as a higher risk, where as other routes may remain in mostly lower risk 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 the route will be proportional to the population density and hence the population density metric will accounted for this metric.
Waste Generation	Quantity of Radiological Waste Produced from Normal Ops	N	A minimum amount of rad 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-rad 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 11 members of the AREVA-led team to establish a relative weighting of the metrics and a range for the metric weight over which a sensitivity analyses was performed (Step 6). In a pairwise comparison, each metric is evaluated for its favorability against the other metrics. This exercise was performed by each of the 11 individuals of the AREVA-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 **Figure 5-2**. In this example, the “Infrastructure Improvement Costs” metric is pairwise compared against the other metrics on a favorability scale. For example, the “Infrastructure Improvement Costs” metric is rated mildly favorable against the “Transport to Rail Class I Costs,” but is rated mildly unfavorable against “Security Vulnerability of Route.” These ratings are interpreted to mean that there is a slight benefit seen to reducing the monies spent on improving the infrastructure on the route at the expense of increasing the costs spent on transportation to Class 1 Rail (i.e., if there are some additional transportation to Class 1 Rail costs that can be performed which reduce the costs of improving infrastructure for a route, then this evaluator would slightly favor performing these activities). However, if an infrastructure improvement could be performed that improves the security/vulnerability of the route (e.g., adding security fences or walls), then this will be a more favored/encouraged outcome.

FIGURE 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
Infrastructure Improvement Costs			X					Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Infrastructure Improvement Costs			X					Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Infrastructure Improvement Costs						X		Public Acceptability of Route
Infrastructure Improvement Costs			X					Number of Permits
Infrastructure Improvement Costs					X			Number of Personnel involved in Transfer
Infrastructure Improvement Costs						X		Cumulative Worker Exposure (α handling time & # of workers)
Infrastructure Improvement Costs						X		Cumulative Population Dose along Route (α population density)
Infrastructure Improvement Costs						X		Risks Associated with Number of Lifting Activities
Infrastructure Improvement Costs					X			Average Accident Frequency on Route
Infrastructure Improvement Costs		X						Transit Duration per Conveyance and Consist

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
Infrastructure Improvement Costs						X		Ease of Access to Transload Site (e.g., consider usage of existing site)
Infrastructure Improvement Costs		X						Size of conveyance (# of casks per shipment)
Infrastructure Improvement Costs					X			Security Vulnerability of Route

With 14 tangible metrics to be evaluated, 91 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 **Figure 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 5-3** shows the results for the relative weighting of the tangible metrics as established from the evaluation of eleven individual pairwise comparisons. **Table 5-2** 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).

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

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.

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).

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

where B = averaged biased relative weight.

The "Maximum" value as established from the 11 individual assessments.

Results from all 11 of the individual assessments are shown in Attachment B.

As shown in **Figure 5-3** and **Table 5-2**, the tangible metrics with the highest preferences (based on average weighting method) are Security Vulnerability of Route, Cumulative Worker Exposure, and Cumulative Population Dose which rated at about 9.1%, 8.9%, and 8.7% of the total weight, respectively. The tangible metrics with the least preferences (based on average weighting method) are Impact of Weather/Tides to Route, Number of Personnel involved in Transfer, and Labor and Permitting Costs which rated at about 5.9%, 5.7%, and 5.4% 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 5-2**.

These results also show negligible differences between the average weighting method and the biased weighting method, which indicates a fairly uniform assessment by the 11 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 5th overall, was ranked highest overall by an individual at 12.5% (as clearly seen in **Figure 5-3**) 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 5.2% giving it the largest range between maximum and minimum.
- The Cumulative Worker Exposure metric, which ranked 2nd overall, had the second highest favorable ranking by an individual at 12.3%, but was also ranked fairly low by another individual at 5.5% (having the second highest range between the minimum and maximum).
- Overall, the safety and security metrics ranked near the top in preference for everyone’s assessment.
- The metrics with the least difference between minimum and maximum values were the Number of Personnel involved in a Transfer metric and the Number of Permits metric, which ranked at the bottom of importance of all the metrics and hence, showing a fairly robust rating.

Finally, the minimum and maximum values listed in **Table 5-2** provide ranges of values to be used in the sensitivity analyses performed in Section 5.5.

FIGURE 5-3: WEIGHTING OF THE TANGIBLE METRICS BASED ON PAIRWISE COMPARISONS

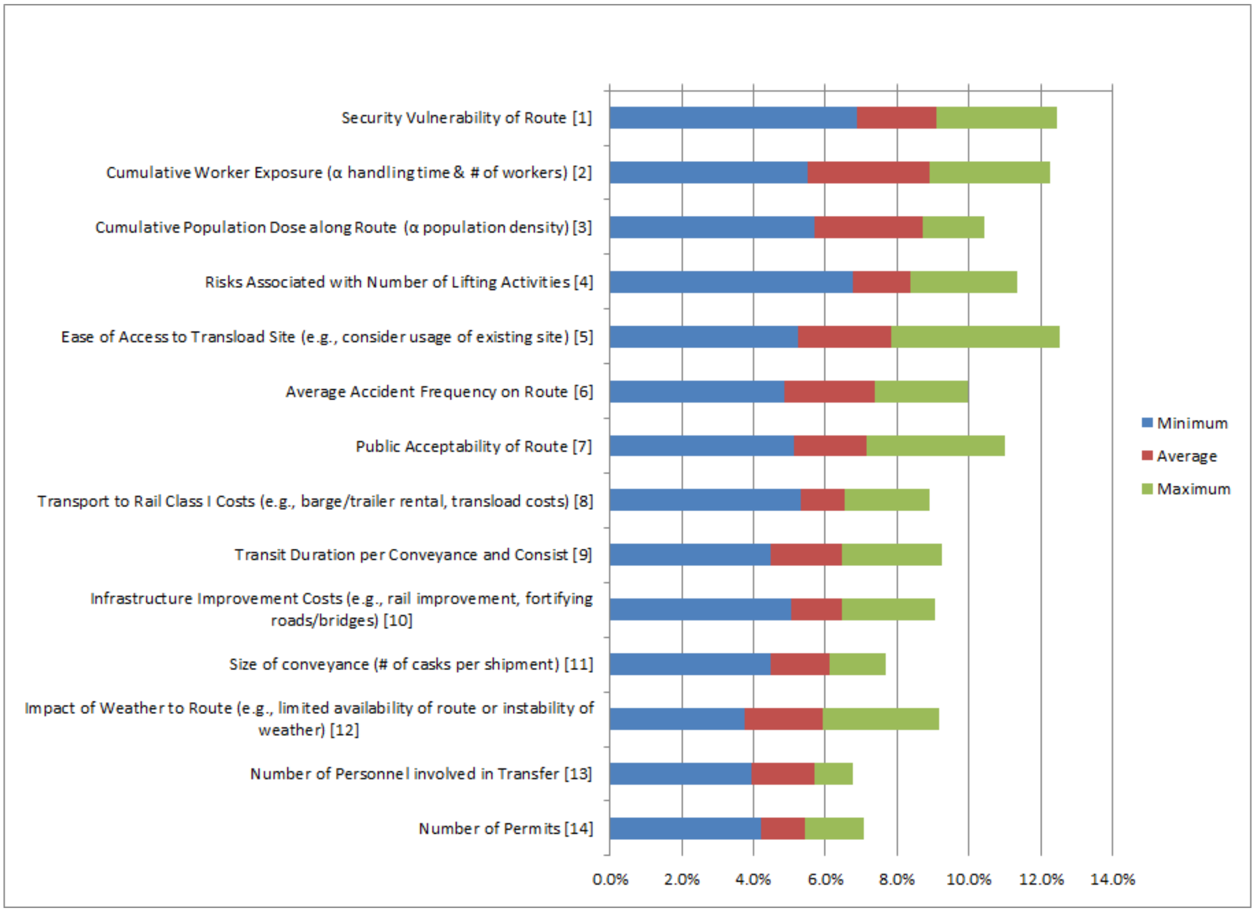


TABLE 5-2: WEIGHTING OF TANGIBLE METRICS

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
1	6.9%	9.09%	9.09%	12.5%	Security Vulnerability of Route
2	5.5%	8.88%	8.88%	12.3%	Cumulative Worker Exposure (α handling time & # of workers)
3	5.7%	8.72%	8.72%	10.4%	Cumulative Population Dose along Route (α population density)
4	6.8%	8.35%	8.35%	11.4%	Risks Associated with Number of Lifting Activities
5	5.2%	7.85%	7.85%	12.5%	Ease of Access to Transload Site (e.g., consider usage of existing site)
6	4.9%	7.39%	7.39%	10.0%	Average Accident Frequency on Route
7	5.1%	7.13%	7.13%	11.0%	Public Acceptability of Route
8	5.3%	6.54%	6.54%	8.9%	Transport to Rail Class 1 Costs (e.g., barge/trailer rental, transload costs)
9	4.5%	6.45%	6.45%	9.2%	Transit Duration per Conveyance and Consist
10	4.5%	6.45%	6.45%	9.2%	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)
11	4.5%	6.11%	6.11%	7.7%	Size of conveyance (# of casks per shipment)
12	3.8%	5.92%	5.92%	9.2%	Impact of Weather to Route (e.g., limited availability of route or instability of weather)
13	3.9%	5.69%	5.69%	6.8%	Number of Personnel involved in Transfer
14	4.2%	5.41%	5.41%	7.1%	Number of Permits

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 Infrastructure Improvement Costs

For the infrastructure improvement costs, each of the five routes to be evaluated had unique infrastructure improvement needs, which equated to costs. The barge from the site was considered to require the most infrastructure improvements as some grading to the beach is likely required and some temporary covering (e.g., crane plates/mats) will be required for the casks to be transferred by trailer to the beach landing site. However, dredging is not foreseen to be required to land the barge on the beach and to leave the beach loaded with five cask systems. Nevertheless, the barge from the site is considered to be the most expensive of the five routes for infrastructure improvements. The HHT to Kohler route will require the setting up of a transload to rail facility and may also require some infrastructure modifications to work around some round-abouts found on its route. Hence, this route was considered the second most expensive of the five routes. The HHT to the Port of Kewaunee route will require the setting up of a transload to barge facility, which the team deemed would be more expensive than the setting up of a transload to rail facility (even though there is some recent experience for having sent the Point Beach steam generators from this port). Thus, this route was deemed the third most expensive of the five routes. The HHT routes to Green Bay and Milwaukee were deemed to be approximately the same in infrastructure costs, which would be related to the setting up of a transload-to-rail facility at these sites. Note each of the HHT routes may also require infrastructure improvements to allow the HHT to move on the onsite roads. So, in addition to the assessment of the onsite roads, each of the HHT routes require clearance assessments of the off-site routes prior to their use to verify this assessment, considering this assessment is temporal.

5.3.3.2 Transport to Rail Class I Costs

For the transport to rail costs, each of the five routes were evaluated by the team to have a cost benefit or cost penalty relative to the other routes based primarily on composite costs associated with rental of barges, tugs, and HHTs and number of transload activities. For barge routes, the costs are associated with: (1) an HHT to move one transportation cask from the ISFSI to the barge transload facility/site; (2) the rental of a barge and tugs to ship five transportation casks at a time placed on specialty racks on the barge or left on the HHT (rolled on); and (3) the rental of a crane(s) to move the transportation cask from the trailer onto a stand on a barge (if applicable) or to move the transportation cask from the barge or trailer (rolled off) to a railcar. For HHT routes, the costs are 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. In addition to these rental costs, costs associated with the distance required to be covered for each route and the number of shipments required to be performed for each route will impact this assessment. The HHT route to the Port of Kewaunee followed by barging to the Port of Milwaukee was deemed to be the most expensive route due to the equipment rental costs, distance traveled, and the need to perform two transload activities. The remaining routes were only mildly different from one another, with the HHT route to Milwaukee deemed to the most expensive of these routes for two principal reasons: the distance traveled by the HHT and the number of times this distance had to be traveled (once per cask). The Kohler and Green Bay HHT routes were deemed to have essentially equivalent costs and slightly higher costs than the barge route from the site, which was deemed to have the cheapest transport-to-rail costs due to the short distance to travel to the barge site and the barge moving five casks at a time.

5.3.3.3 Impact of Weather to Route

The impact of weather and tides/seiches in this area of the country is considered to be either directly impacting on the routes (e.g., rough waters and snow on the roads in the winter) or indirectly impacting on the routes (e.g., vacationer traffic in the summer on the roads and waterways). For example, the HHT to Green Bay route may be more impacted by vacationer traffic not only during the summer, but also during the fall with the added traffic associated with the Green Bay Packers football season (limited mainly to about ten Sundays). The HHT routes may be impacted adversely by the winter weather and the heavy traffic in the summer/fall, but are favored over barge routes, which can be impacted by the rough winter lake weather and the summer lake traffic to a larger degree than the impact of the weather to travel on the roads (can be overcome by plows and/or traffic control).

5.3.3.4 Public Acceptability of Route

The public acceptability of the five routes to be evaluated varied between each of the routes. The HHT routes were judged to be more favorable over the barge route evaluated in the MUA based on several factors including the recent attempted shipments of radioactive materials on the Great Lakes [60]. In addition, the HHT-to-rail routes traveling through higher population density areas are normally less favored over the lighter populated HHT-to-rail routes, but for this region of the country, the population density is relatively constant and low compared to the Northeast, so population densities were not a strong factor in the assessment of this metric. Finally, the actual distances traveled also impacted the public acceptance metric evaluation, as shorter routes are likely to have fewer stakeholders involved. The combination of these elements led to the final evaluations of this metric, which strongly favored the HHT routes over the barge routes with only mild differences between the HHT routes.

5.3.3.5 Number of Permits

The number of permits required for each of the five routes to be evaluated varied based on the number of local jurisdictions crossed by the HHT route, which was simply associated with the distance traveled by the route with consideration given to what portion of the distance traveled was state highway miles versus interstate miles, which require fewer permits. Between the HHT routes and the barge route, barge requires fewer permits and was judged to be more favorable over all the evaluated HHT routes, although permitting of barging is expected to be more challenging, but this metric is simply based on the number of permits required.

5.3.3.6 Number of Personnel involved in Transfer

Upon initial assessment of this metric, the number of personnel involved with barge routes was considered to exceed the number of personnel involved with the HHT routes based on the need to perform two transload activities: from HHT to barge and from barge to railcar. However, this difference is deemed to only mildly favor HHT routes since the barge routes are capable of handling five transportation casks per shipment, whereas the HHT routes only handle one cask per shipment; hence, the number of full time equivalent personnel are expected to be similar between the routes.

5.3.3.7 Cumulative Worker Exposure

The cumulative worker exposure metric assessment relies heavily on the number of handling events (e.g., transloads) involving the transportation casks outside of the KPS ISFSI (activities within the ISFSI are identical or nearly identical for each route) and, to a lesser degree, on the distance traveled for each route. These handling events are outlined below and result in the HHT routes (equivalent of two transload sites) having a mild advantage over the barge routes (equivalent of three transload sites). Worker exposure levels will also not approach regulatory limits as the shielding afforded by the transportation casks and the remote operations involved with these handling activities will result in low exposure levels. Furthermore, the larger fraction of the cumulative worker exposure will occur at the KPS ISFSI where the transfer operations to move the canisters to the transportation casks take place and apply to each route.

- Transfer to HHT then to rail (two lifts):
    - Lift of MAGNATRAN transport cask (loaded with the TSC) or the MP197HB (loaded with the NUHOMS 32PT) in their cradle onto the HHT.
    - Lift of transportation cask and cradle from HHT to cask railcar at transload site (*Note: a single lift is assumed at the HHT-to-rail transload site*).
- Transfer to HHT then to barge to rail (two to three lifts):
    - Lift of MAGNATRAN transport cask (loaded with the TSC) or the MP197HB (loaded with the NUHOMS 32PT) in their cradle onto the HHT (*Note: the MP197HB may not have to be removed from the transfer trailer if the transfer to barge remains on the site*).
- Two options for loading onto barge:

- Lowering of Goldhofer that has been rolled onto barge to allow beams holding transportation cask and cradle to rest on stands and subsequently roll off Goldhofer from barge (*Note: this lowering activity may not be necessary if the Goldhofer is to be left loaded with the transportation cask and cradle on the barge and another option is to use a crane to lift the transportation cask from the HHT and place it onto the stands on the barge*).
- Lift of transportation cask and cradle located on beams off stand/Goldhofer onto cask railcar (*Note: a direct transfer from barge to rail is assumed available*).

Based on these assessments and the duration of transport on each of the individual routes, the HHT routes are mildly favored over the barge routes, the onsite barge route is mildly favored over the barge route from the Port of Kewaunee due to the additional distance traveled by HHT, and the Green Bay route is mildly favored over the other HHT routes due to the shorter distance traveled.

5.3.3.8 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 is 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 5-3**. Those routes with the lowest total exposed populations are favored over the other routes.

TABLE 5-3: ROUTE AVERAGED POPULATION DENSITY ALONG EACH ROUTE

#	Route Description	Average Population Density (Persons/Square Mile)[1]	Total Exposed Population Estimate[2] (Thousands)
1	Truck to Port of Kewaunee, Barge and Rail on Union Pacific Railroad	842	418
2	Barge from Site to Milwaukee, Rail on Union Pacific Railroad	863	412
3	Truck to Kohler, Rail on Union Pacific Railroad	1,098	544
4	Truck to Milwaukee, Rail on Union Pacific Railroad	1,061	499
5	Truck to Green Bay, Rail on Canadian National Railway	813	528

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).

5.3.3.9 Risks Associated with Number of Lifting Activities

Risks associated with lifting activities are dependent on the number of lifts made of a transportation cask, which have been identified in Section 5.3.3.7. Based on this assessment, the HHT routes are deemed more favorable over the barge routes. These are minimized by: the protection afforded the transportation casks by the impact limiters, the design of the lifting equipment (includes multiple safety factors and avoidance of single-failure points), and the robustness of the transportation cask systems. Hence, although this parameter provides some preference to HHT routes, the overall risk associated with a lifting device is deemed negligible.

5.3.3.10 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 5-4**), 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 5-4** provides the average accident rate by mode of transport on the route and the cumulative accident rate for the entire route, which was used to perform this evaluation.

TABLE 5-4: AVERAGE ACCIDENT FREQUENCY OVER EACH ROUTE [1]

Accident Rate (per mi per yr)	Route				
	HHT to Port of Kewaunee, Barge and Rail on Union Pacific Railroad	Barge from Site to Milwaukee, Rail on Union Pacific Railroad	HHT to Kohler, Rail on Union Pacific Railroad	HHT to Milwaukee, Rail on Union Pacific Railroad	HHT to Green Bay, Rail on Canadian National Railway
Water Accident Rate	0.003	0.003	N/A	N/A	N/A
Truck Accident Rate	0.117	N/A	0.351	0.211	0.347
Rail Accident Rate	0.005	0.005	0.005	0.005	0.005
Average Accident Rate	0.007	0.005	0.045	0.050	0.023
Factor Increase Over Lowest Rate	1.4 x	1 x	9 x	10 x	4.6 x

5.3.3.11 Transit Duration per Conveyance and Consist

For purposes of this report, a second trailer is planned for the campaign and will be loaded at the KPS ISFSI, while the first transportation cask is being unloaded at the transload site. The transit duration for each route was roughly estimated during the team meeting and arrived at the following estimates:

1) HHT to the Port of Kewaunee, barge to Port of Milwaukee, and rail to GCUS
   a) Loading Cask: load canister into cask, load cask on Goldhofer, and attach truck to Goldhofer (2 to 4 days per cask)
   b) Transportation: transport by HHT to Port of Kewaunee (1 day per cask)
   c) Load Barge: roll on to barge and off load transportation cask and roll off (1 day per cask)
   d) Barging: pre-barge briefings for procedures, quality, and safety reviews; assemble crew; transport 119 miles to Port of Milwaukee, WI (1 to 2 days for 5 casks)
   e) Unloading Barge: transload operations from barge to rail (2½ days for 5 casks)
   f) Thus, approximately **23½ to 34½ days** for 5 casks to load onto cask railcar
2) Barge from KPS ISFSI to Port of Milwaukee and rail to GCUS
   a) Loading Cask: load canister into cask, load cask on Goldhofer, and attach truck to Goldhofer (2 to 4 days per cask)
   b) Transportation: transport by HHT to onsite barge (1 day per cask)
   c) Load Barge: roll on to barge and off load transportation cask and roll off (½ day per cask)

d) Barging: pre-barge briefings for procedures, quality, and safety reviews; assemble crew; transport 111 miles to Port of Milwaukee, WI (1 to 2 days for 5 casks)

e) Unloading Barge: transload operations from barge to rail (2½ days for 5 casks)

f) Thus, approximately **21 to 32 days** for 5 casks to load onto cask railcar

3) HHT to Kohler and rail to GCUS

a) Loading Cask: load canister into cask, load cask on Goldhofer, and attach truck to Goldhofer (2 to 4 days per cask)

b) Transportation: pre-road briefings for procedures, quality, and safety reviews; assemble crew; transport at ~20-30 mph for 57 miles to Kohler, WI rail transload facility (1 day per cask)

c) Load Rail: lift transportation cask from HHT and place onto railcar (1 day per cask)

d) Thus, approximately **20 to 30 days** for 5 casks (or approximately 4 to 6 days per cask) to load onto cask railcar

4) HHT to the Port of Milwaukee and rail to GCUS

a) Approximately the same as Kohler except the road mileage is longer (103 miles) and hence, Kohler is more favorable over this route.

5) HHT to Green Bay and rail to GCUS

a) Approximately the same as Kohler except the road mileage is shorter (35 miles) and hence, Green Bay is more favorable over both the other HHT routes.

In addition to these handling times, there are also the total route transit durations on the HHTs, barges, and rails. START[1] provides these times and **Table 5-5** provides a breakdown by route.

TABLE 5-5: ROUTE TRANSIT DURATIONS [1]

Time (minutes)	Route				
	HHT to Port of Kewaunee, Barge and Rail on Union Pacific Railroad	Barge from Site to Milwaukee, Rail on Union Pacific Railroad	HHT to Kohler, Rail on Union Pacific Railroad	HHT to Milwaukee, Rail on Union Pacific Railroad	HHT to Green Bay, Rail on Canadian National Railway
HHT	11	N/A	54	104	43
Barge	1,022	953	N/A	N/A	N/A
Rail	717	709	912	717	924

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

Using the data in Table 5-5 from START[1] and the above handling times, the pairwise comparisons were performed between the various routes.

5.3.3.12 Ease of Access to Transload Site

This metric has been added to the evaluation for KPS due to the majority of transload locations available near this site considering the use of tracks that may already be significantly used by commercial enterprises. Loading the transportation casks at locations involved with commercial operations may require an interruption to their day-to-day business activities and hence, make it less favorable than other locations which do not require such interruptions. Furthermore, ongoing commercial operations may also make it difficult to perform any required infrastructure improvements, such as adding security features (e.g., fencing). Therefore, the current length of track siding considered "available" (e.g., not part of an apparent active rail line) was used in part to evaluate this metric. **Table 5-6** provides the track siding length as measured from Google Maps [5]. In addition, the level of cooperation currently afforded by the rail line owner for the potential transport of this category of materials was considered in the evaluation of this metric, which essentially can be summarized as: Union Pacific Railroad has an agreement with the DOE [69] and Canadian National Railway does not.

TABLE 5-6: TRACK SIDING LENGTH [5]

	Route				
	HHT to Port of Kewaunee, Barge and Rail Union Pacific Railroad	Barge from Site to Milwaukee, Rail on Union Pacific Railroad	HHT to Kohler, Rail on Union Pacific Railroad	HHT to Milwaukee, Rail on Union Pacific Railroad	HHT to Green Bay, Rail on Canadian National Railway
Track Siding Length (ft)	N/A*	N/A*	2,265	1,396	1,145 (3,630 of track within the plant)

Note: the track siding length is only applicable for loading from HHT to rail and therefore not applicable for barge routes.

5.3.3.13 Size of Conveyance

For this metric, the routes can be divided into three groups: HHT routes to a rail transload facility/site, HHT route to a barge transload facility/site, and the route direct to barge. The route direct to the barge onsite results in the transfer of five transportation casks conveyed on the barge to the transload to rail facility/site at a time, which is the more favored route. The HHT route to a barge transload facility/site results in the transfer of single transportation cask conveyed to the barge, followed by the conveying of five transportation casks to the transload-to-rail facility/site. This route is more favored over the remaining HHT routes, which only transport a single transportation cask per conveyance.

5.3.3.14 Security Vulnerability of Route

For the metric on security vulnerability of the route, all routes were considered to be capable of being secured; however, some minor advantages of one route over another were identified and these advantages are related to a combination of duration of the shipment, distance traversing urban versus rural regions, number of transload activities, and the lower vulnerability associated with barge routes over HHT routes. The barge route from the site was judged to be the more favored security route over the HHT routes due primarily to the security associated with the barging activity over the HHT activity. The short HHT distance to the Port of Kewaunee and its following barging activity were mildly favored over the longer HHT distance routes to Milwaukee, Kohler, and Green Bay. Similarly, the shorter HHT distance from the site to Green Bay and Kohler relative to Milwaukee makes these routes more favored over the Milwaukee HHT route.

5.4 Route Recommendations

Using the metric information identified for the routes listed in the previous section, the AREVA-led team held a conference call to perform a pairwise comparison of each of the tangible metrics for each of the routes identified in Section 5.2 (Step 7). This team evaluation, unlike the individual assessments performed for the tangible metrics, ensured SMEs' 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 5-4 provides an example of the pairwise comparison performed by the de-inventory team for the metric related to the Infrastructure Improvement Costs (as denoted on the far-left column). "Column A Routes" (2^{nd} column on left) are subsequently compared against "Column B Routes" (last column on right) for the Infrastructure Improvement Costs metric. The favorability scale listed in this figure is the same as identified for the pairwise comparison of the tangible metrics (see **Figure 5-2**). As an example, the fourth row of the evaluation (excluding the header row) shows that the HHT to the Port of Kewaunee, then barge and rail to GCUS on Union Pacific Railroad route is mildly unfavored when compared to the HHT to Green Bay on Canadian National Railway route for the metric related to the infrastructure improvement costs, which is reflective of the information provided in Section 5.3.3.1.

With 14 tangible metrics and 5 routes to be evaluated, the team performed 140 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 5-2**, **Figure 5-5** shows the resulting relative weighting of the routes in order of the highest rated (HHT to Green Bay, Rail on Canadian National Railway) to the least rated (HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad). **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 5-2.
3) The "Biased Weight" results, which are based on the metric weights associated with the "Biased Weights" from Table 5-2.
4) The "No Safety or Security Metric" results, which are based on zeroing out the weights associated with the safety and security metrics and re-normalizing the "Average Weights" from Table 5-2.
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, Security, or Public Acceptability Metric” results, which are based on zeroing out the weights for the safety, security, and public acceptability metrics and re-normalizing the “Average Weights” from Table 5-2.

FIGURE 5-4: 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
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP					X			3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN

As shown in **Figure 5-5** and **Table 5-8**, the routes with the highest ratings (based on average weighting method) are: HHT to Green Bay, Rail on Canadian National Railway, and Barge from the site to the Port of Milwaukee, Rail on Union Pacific Railroad. The route with the least favored rating (based on average weighting method) is the HHT to the Port of Kewaunee, Barge and Rail on Union Pacific Railroad. Aside from the least favored route, the difference between the top four favored routes is approximately 2.4%. The slight difference between the top routes indicate that there are multiple viable and closely aligned routes from the KPS ISFSI and an actual selection will depend on the conditions of these routes and transload sites when the time to ship grows near.

FIGURE 5-5: RESULTING LIST OF PRIORITIZED ROUTES FROM THE KPS ISFSI SITE

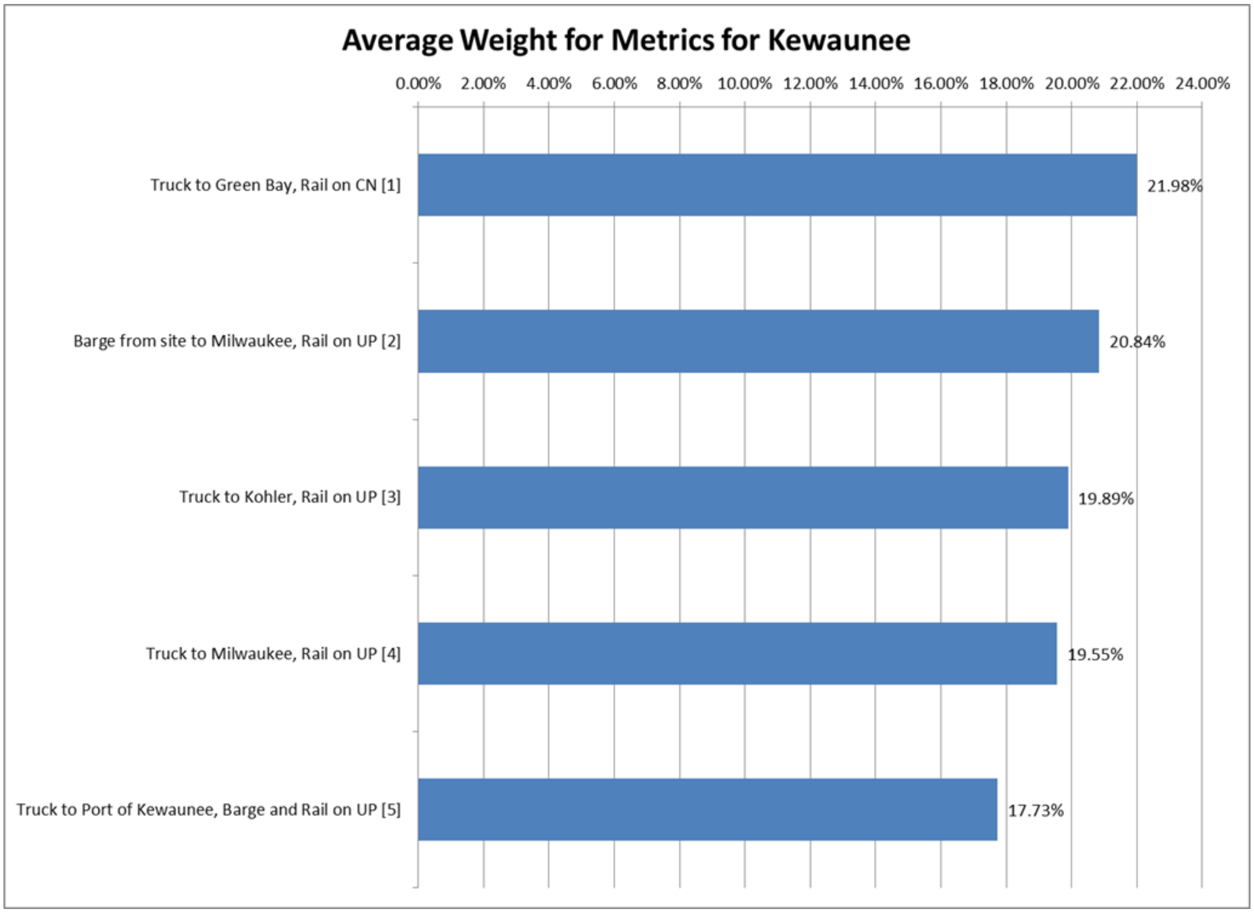


Figure 5-6 shows the impact each tangible metric had on the overall scoring of each route. There is no single dominant metric identified in this figure; however, this figure does show the two most favored routes based on significant contributions from different tangible metrics. The HHT-to-Green Bay route received significant contributions from the following tangible metrics: infrastructure improvement costs, public acceptability of routes, cumulative worker exposure, cumulative population dose along route, risks associated with lifting devices, and transit duration per conveyance and consist. Whereas the barge from the site route received significant contributions from the following tangible metrics: cumulative population dose along route, average accident frequency on route, ease of access to transload site, size of conveyance, and security vulnerability of route. Essentially only one metric is common to both routes (cumulative

population dose along route), indicating these two routes each provide a unique (and diverse) approach to the shipment of the transportation casks from the KPS ISFSI.

Since the safety and security 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 security or safety metrics. As shown in **Table 5-8**, the highest-scored route changes depending on which of the metrics are removed from the assessment. The removal of the safety and security metrics results in the HHT route to Milwaukee rising to highest scored route over the HHT to Green Bay route, with the barge route dropping to near the bottom of the rankings. The removal of only the public acceptability metric results in the barge from site route rising to the highest scored route over the HHT to Green Bay route. The removal of the public acceptability, security, and safety metrics results in the HHT route to Milwaukee rising to highest-scored route again. Thus, 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, in general, to the alternative weighting schemes. To further examine the impact to the ranking/scores of the routes to changes in the weighting of the metrics, a sensitivity analysis was performed using the range of the metrics identified in **Table 5-2** (Step 8).

Tables 5-9, **5-10**, and **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 5-2**. For example, under the metric column labeled "Infrastructure Improvement Costs" in **Table 5-9**, results are presented using a weight of 4.5% for the "Infrastructure Improvement Costs" (instead of the 6.45% in **Table 5-2**) with the other metrics proportionally re-normalized. The results indicate that the HHT route to Green Bay is ranked first for each minimized metric. **Figure 5-7** summarizes the minimum, average, and maximum results presented in **Tables 5-9**, **5-10**, and **5-11** for the minimization of individual metrics. As can be seen from these results, the HHT route to Green Bay remains robustly ranked as the most favored route for the removal of the SNF from the KPS ISFSI (at this time).

Tables 5-12, **5-13**, and **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 5-2**. For example, under the metric column labeled "Public Acceptability of Route" in **Table 5-12**, results are presented using a weight of 11.0% for the "Public Acceptability of Route" (instead of the 7.13%), with the other metrics proportionally re-normalized. The results indicate that the HHT route to Green Bay is ranked first for each maximized metric. **Figure 5-8** summarizes the minimum, average, and maximum results presented in **Tables 5-12**, **5-13**, and **5-14** for the maximization of individual metrics. As can be seen from these results, the HHT route to Green Bay remains robustly ranked as the most favored route for the removal of the SNF and GTCC LLW from the KPS ISFSI.

A final assessment of the results was performed by taking the results for each individual from the pairwise comparison on the metrics and using them to establish a route ranking per individual. These results also established, for each individual, the HHT route to Green Bay as the favored route for the removal of the SNF and GTCC LLW from the KPS ISFSI.

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

TABLE 5-7: PRIORITIZED LIST OF ROUTES FROM KPS ISFSI

Rank	Prioritized Route
1	Truck to Green Bay, Rail on Canadian National Railway
2	Barge from site to Milwaukee, Rail on Union Pacific Railroad
3	Truck to Kohler, Rail on Union Pacific Railroad
4	Truck to Milwaukee, Rail on Union Pacific Railroad
5	Truck to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad

FIGURE 5-6: IMPACT OF EACH TANGIBLE METRIC ON EACH ROUTE'S "SCORE"

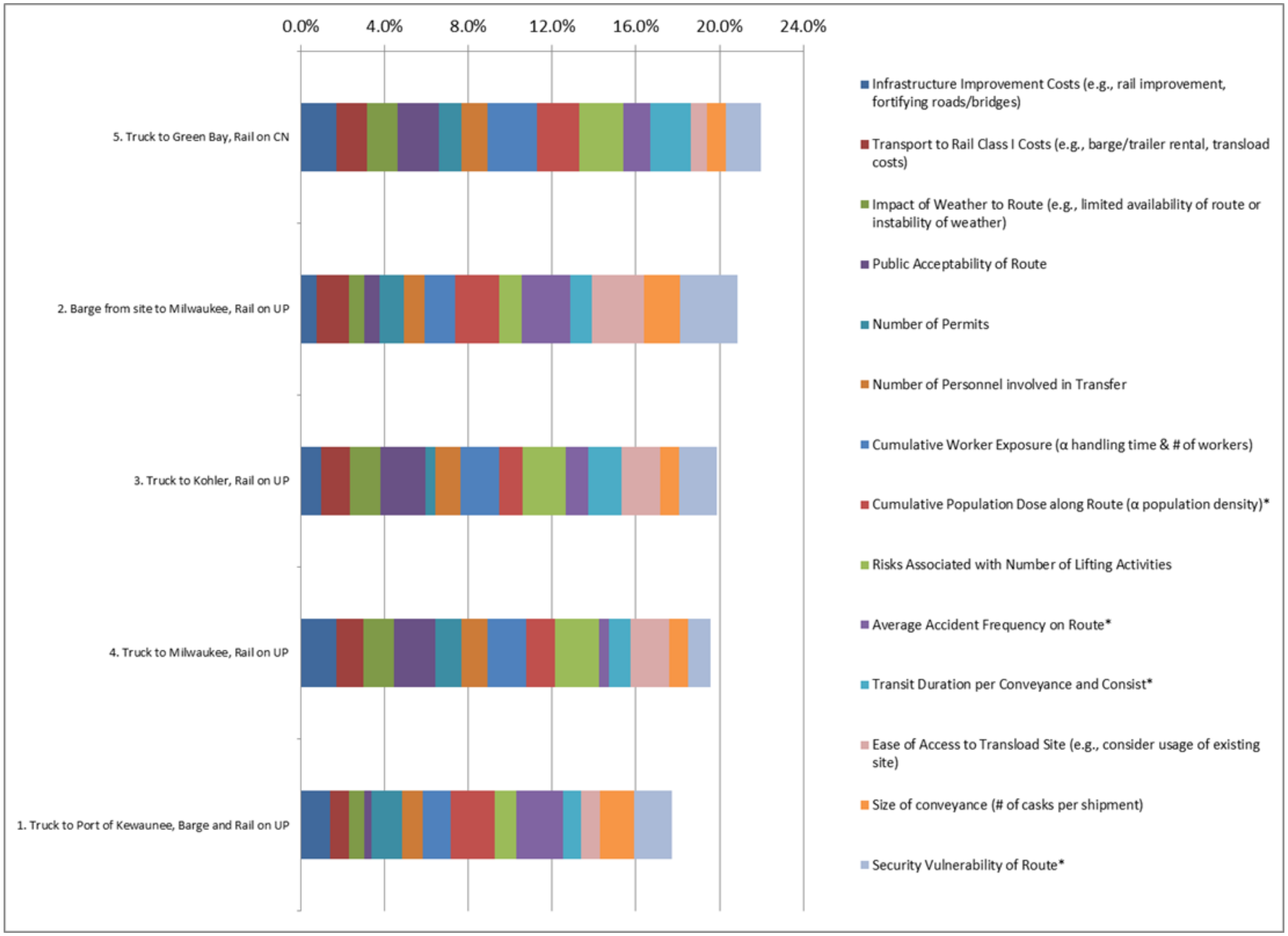


TABLE 5-8: WEIGHTING OF ROUTES

Nominal Results:	Unweighted		Average Weight		Biased Weight		No Safety or Security Metric		No Public Acceptability Metric		No Safety, Security, or Public Acceptability Metric	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.86%	5	17.73%	5	17.73%	5	16.00%	5	18.71%	5	17.56%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.54%	2	20.84%	2	20.84%	4	19.35%	1	21.67%	3	20.67%
3. HHT to Kohler, Rail on Union Pacific Railroad	4	19.76%	3	19.89%	3	19.89%	3	20.84%	3	19.11%	4	19.54%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	3	19.82%	4	19.55%	4	19.55%	1	22.03%	4	18.94%	1	21.26%
5. HHT to Green Bay, Rail on Canadian National Railway	1	22.02%	1	21.98%	1	21.98%	2	21.77%	2	21.56%	2	20.96%

TABLE 5-9: WEIGHTING OF ROUTES AT MINIMUM METRIC VALUE (PART 1 OF 3)

Metric Minimized:	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)		Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)		Impact of Weather to Route (e.g., limited availability of route or instability of weather)		Public Acceptability of Route		Number of Permits	
Route	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.68%	5	17.79%	5	17.85%	5	17.99 %	5	17.62 %
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.97%	2	20.81%	2	21.02%	2	21.06 %	2	20.83 %
3. HHT to Kohler, Rail on Union Pacific Railroad	3	19.96%	3	19.88%	3	19.78%	3	19.68 %	3	20.03 %
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.46%	4	19.55%	4	19.43%	4	19.39 %	4	19.51 %
5. HHT to Green Bay, Rail on Canadian National Railway	1	21.93%	1	21.98%	1	21.92%	1	21.87 %	1	22.01 %

TABLE 5-10: WEIGHTING OF ROUTES AT MINIMUM METRIC VALUE (PART 2 OF 3)

Metric Minimized:	Number of Personnel involved in Transfer		Cumulative Worker Exposure (α handling time & # of workers)		Cumulative Population Dose along Route (α population density)*		Risks Associated with Number of Lifting Activities		Average Accident Frequency on Route*	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.74%	5	17.83%	5	17.53%	5	17.82%	5	17.41%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.90%	2	20.99%	2	20.74%	2	20.97%	2	20.56%
3. HHT to Kohler, Rail on Union Pacific Railroad	3	19.86%	3	19.86%	3	20.12%	3	19.81%	3	20.04%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.52%	4	19.51%	4	19.67%	4	19.47%	4	19.89%
5. HHT to Green Bay, Rail on Canadian National Railway	1	21.99%	1	21.82%	1	21.94%	1	21.94%	1	22.10%

TABLE 5-11: WEIGHTING OF ROUTES AT MINIMUM METRIC VALUE (PART 3 OF 3)

Metric Minimized:	Transit Duration per Conveyance and Consist*		Ease of Access to Transload Site (e.g., consider usage of existing site)		Size of conveyance (# of casks per shipment)		Security Vulnerability of Route*	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.82%	5	17.90%	5	17.58 %	5	17.68%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.94%	2	20.55%	2	20.72 %	2	20.63%
3. HHT to Kohler, Rail on Union Pacific Railroad	3	19.79%	3	19.80%	3	19.97 %	3	19.89%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.63%	4	19.45%	4	19.63 %	4	19.73%
5. HHT to Green Bay, Rail on Canadian National Railway	1	21.82%	1	22.31%	1	22.10 %	1	22.07%

TABLE 5-12: WEIGHTING OF ROUTES AT MAXIMIZED METRIC VALUE (PART 1 OF 3)

Metric Maximized:	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)		Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)		Impact of Weather to Route (e.g., limited availability of route or instability of weather)		Public Acceptability of Route		Number of Permits	
Route	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.83%	5	17.63%	5	17.57%	5	17.26%	5	17.88%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.61%	2	20.90%	2	20.58%	2	20.44%	2	20.85%
3. HHT to Kohler, Rail on Union Pacific Railroad	3	19.76%	3	19.91%	3	20.05%	3	20.26%	3	19.70%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.71%	4	19.56%	4	19.73%	4	19.85%	4	19.62%
5. HHT to Green Bay, Rail on Canadian National Railway	1	22.08%	1	22.00%	1	22.08%	1	22.19%	1	21.95%

TABLE 5-13: WEIGHTING OF ROUTES AT MAXIMIZED METRIC VALUE (PART 2 OF 3)

Metric Maximized:	Number of Personnel involved in Transfer		Cumulative Worker Exposure (α handling time & # of workers)		Cumulative Population Dose along Route (α population density)*		Risks Associated with Number of Lifting Activities		Average Accident Frequency on Route*	
Route	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.73%	5	17.64%	5	17.84%	5	17.58%	5	18.04%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.80%	2	20.70%	2	20.90%	2	20.60%	2	21.11%
3. HHT to Kohler, Rail on Union Pacific Railroad	3	19.91%	3	19.92%	3	19.76%	3	20.04%	3	19.75%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.58%	4	19.60%	4	19.49%	4	19.71%	4	19.23%
5. HHT to Green Bay, Rail on Canadian National Railway	1	21.98%	1	22.14%	1	22.01%	1	22.07%	1	21.87%

TABLE 5-14: WEIGHTING OF ROUTES AT MAXIMIZED METRIC VALUE (PART 3 OF 3)

Metric Maximized:	Transit Duration per Conveyance and Consist*		Ease of Access to Transload Site (e.g., consider usage of existing site)		Size of conveyance (# of casks per shipment)		Security Vulnerability of Route*	
Route	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**	**Rank**	**Result**
1. HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad	5	17.61%	5	17.46%	5	17.87%	5	17.81%
2. Barge from site to Milwaukee, Rail on Union Pacific Railroad	2	20.70%	2	21.33%	2	20.96%	2	21.14%
3. HHT to Kohler, Rail on Union Pacific Railroad	3	20.03%	3	20.04%	3	19.81%	3	19.89%
4. HHT to Milwaukee, Rail on Union Pacific Railroad	4	19.45%	4	19.72%	4	19.48%	4	19.30%
5. HHT to Green Bay, Rail on Canadian National Railway	1	22.20%	1	21.45%	1	21.88%	1	21.87%

FIGURE 5-7: MINIMUM, AVERAGE, AND MAXIMUM RESULTS FROM SENSITIVITY ANALYSIS FOR MINIMIZATION OF EACH METRIC

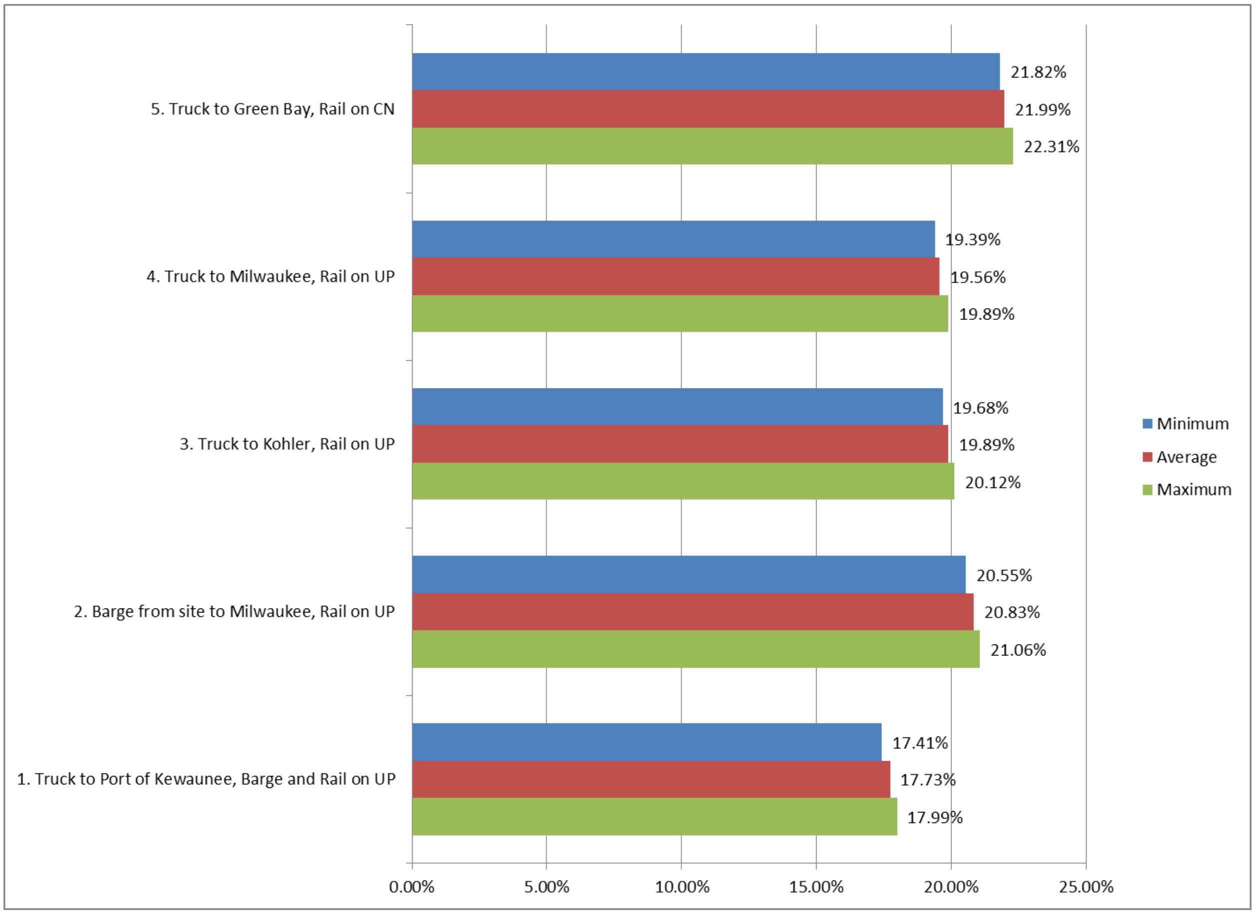
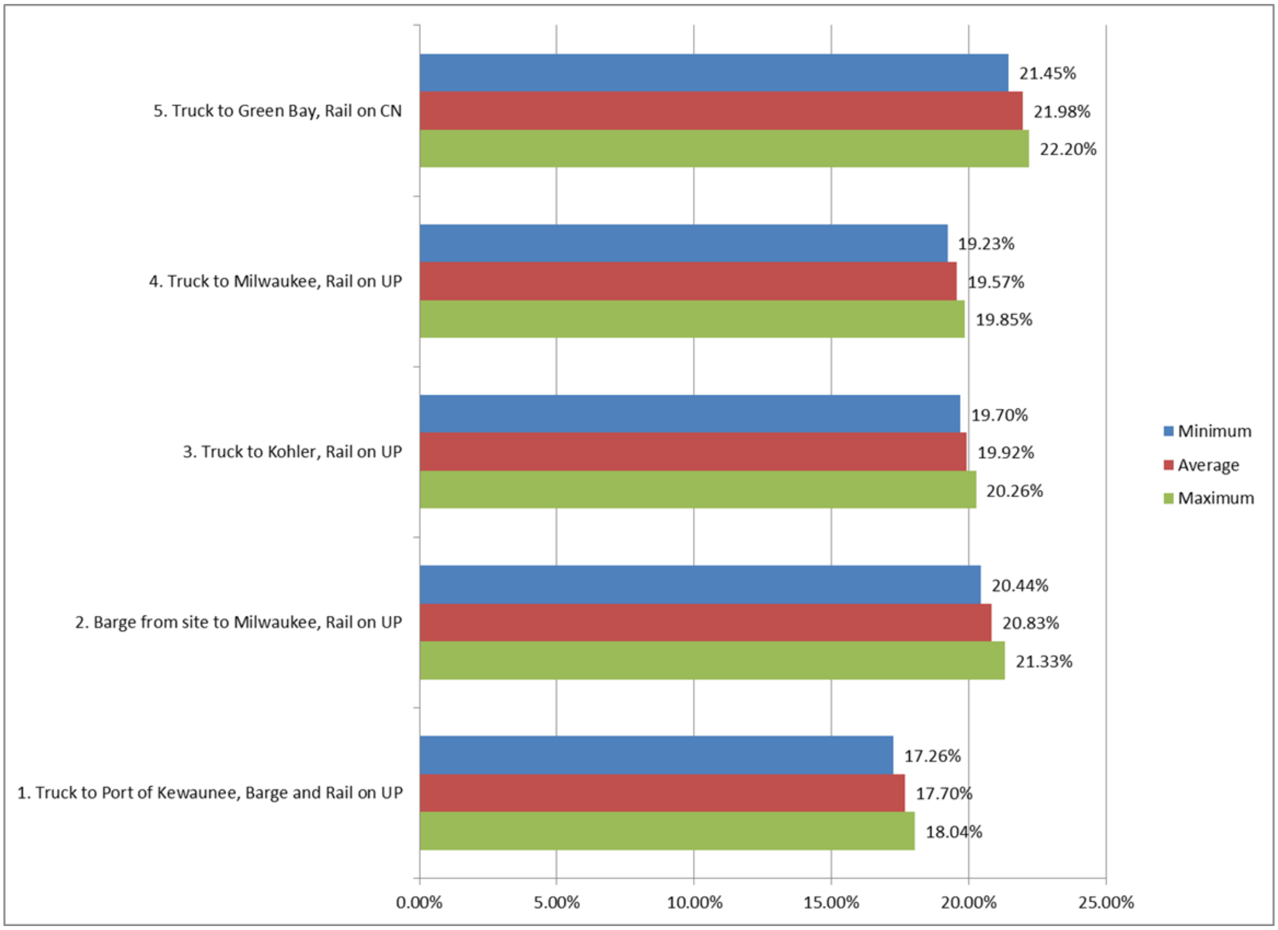


FIGURE 5-8: MINIMUM, AVERAGE, AND MAXIMUM RESULTS FROM SENSITIVITY ANALYSIS FOR MAXIMIZATION OF EACH METRIC



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 best route scenarios. Sometimes, however, the subjective opinions of team members can span a larger range then may be necessary to distinguish between routes and may over emphasize the difference between routes. For example, as noted in Section 5.3.3.8 the dose along the route to individuals is expected to be below background levels (i.e., essentially negligible), but nevertheless cumulative population doses along the routes were still ranked from being neutral to more favorable against one another, when in fact they should have at most spanned from neutral to mildly favorable over one another. Additional sensitivity analyses were performed which examined the impact of suppressing the range of assessments for metrics whose material results are acceptable (e.g., through regulatory requirements). Additionally, more detailed analyses of the sensitivity results presented in **Table 5-8** 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 realistically only vary slightly between each route, as the results will always be acceptable for regulatory reasons. The purpose of this sensitivity analyses is to examine the impact to the route rankings as a result of limiting the span select metrics can be evaluated over. These select metrics include:

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

These specific safety and security 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 5-9**, was examined. Since these five metrics were ranked, by average, in the top six metrics from the pairwise comparison by individual team members, the suppression of the span of the pairwise comparison will impact the route rankings.

FIGURE 5-9: EXAMPLE OF SUPPRESSION OF SPAN FOR CUMULATIVE WORKER EXPOSURE

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Worker Exposure (α handling time & # of workers)	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP				X				3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP					X			5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN

In **Figure 5-9**, assessments originally identified as "Strongly 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 5-10 shows the modified rankings with the security and safety metrics evaluation range suppressed. **Figure 5-11** shows the contribution each tangible metric makes to the scoring for each route. **Table 5-15** compares the results from the original assessment and the modified results using the suppressed span. These results show the barge routes are more dependent on these safety and security metrics than the HHT routes, and hence, the barge routes drop to the bottom of the list of prioritized routes when the span of evaluation for these metrics are suppressed. These results indicate the HHT routes are likely the better alternatives for the removal of the SNF from the KPS ISFSI. This result is consistent with the results identified by the other sensitivity analyses included in this report.

FIGURE 5-10: RESULTING LIST OF PRIORITIZED ROUTES FROM THE KPS ISFSI FOR THE SUPPRESSION OF SPAN FOR SAFETY AND SECURITY METRICS

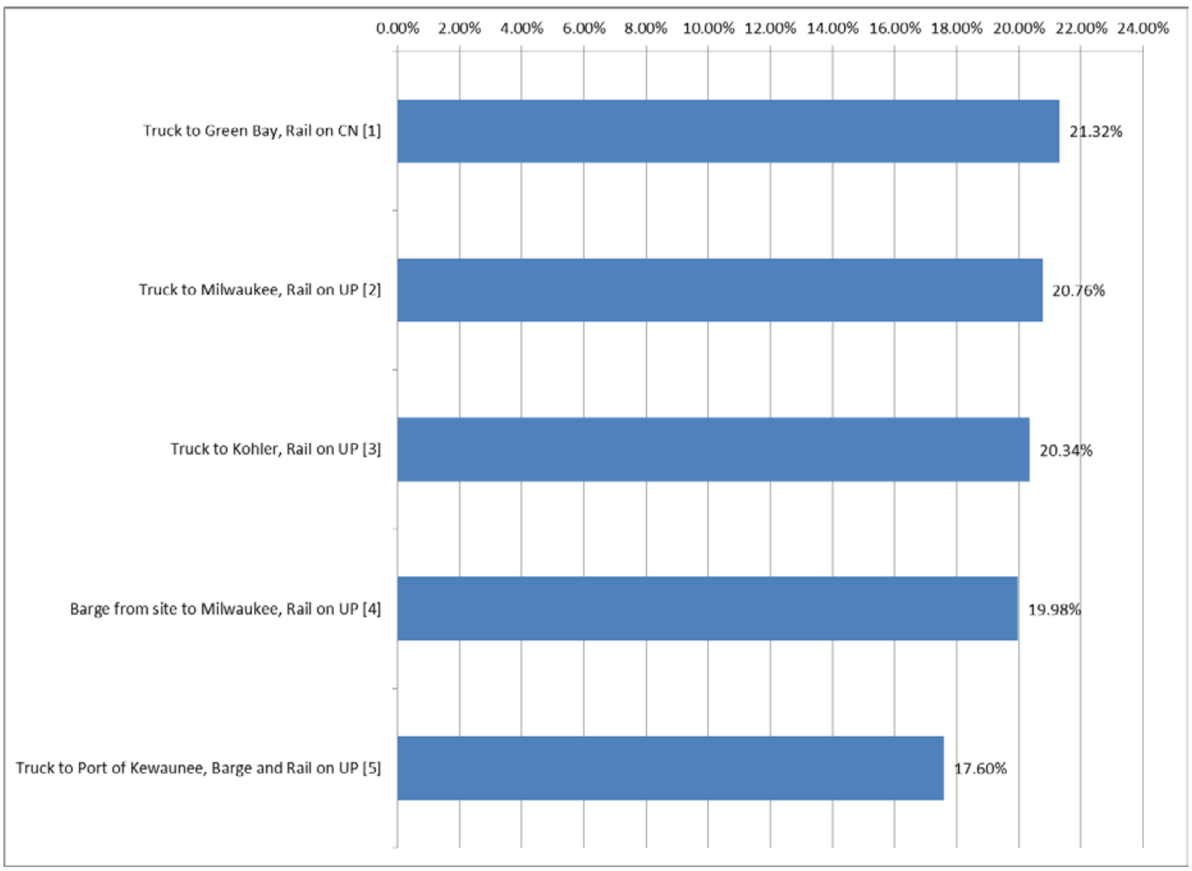


FIGURE 5-11: IMPACT OF EACH TANGIBLE METRIC ON EACH ROUTE'S SCORING FOR THE SUPPRESSION OF SPAN FOR SAFETY AND SECURITY METRICS

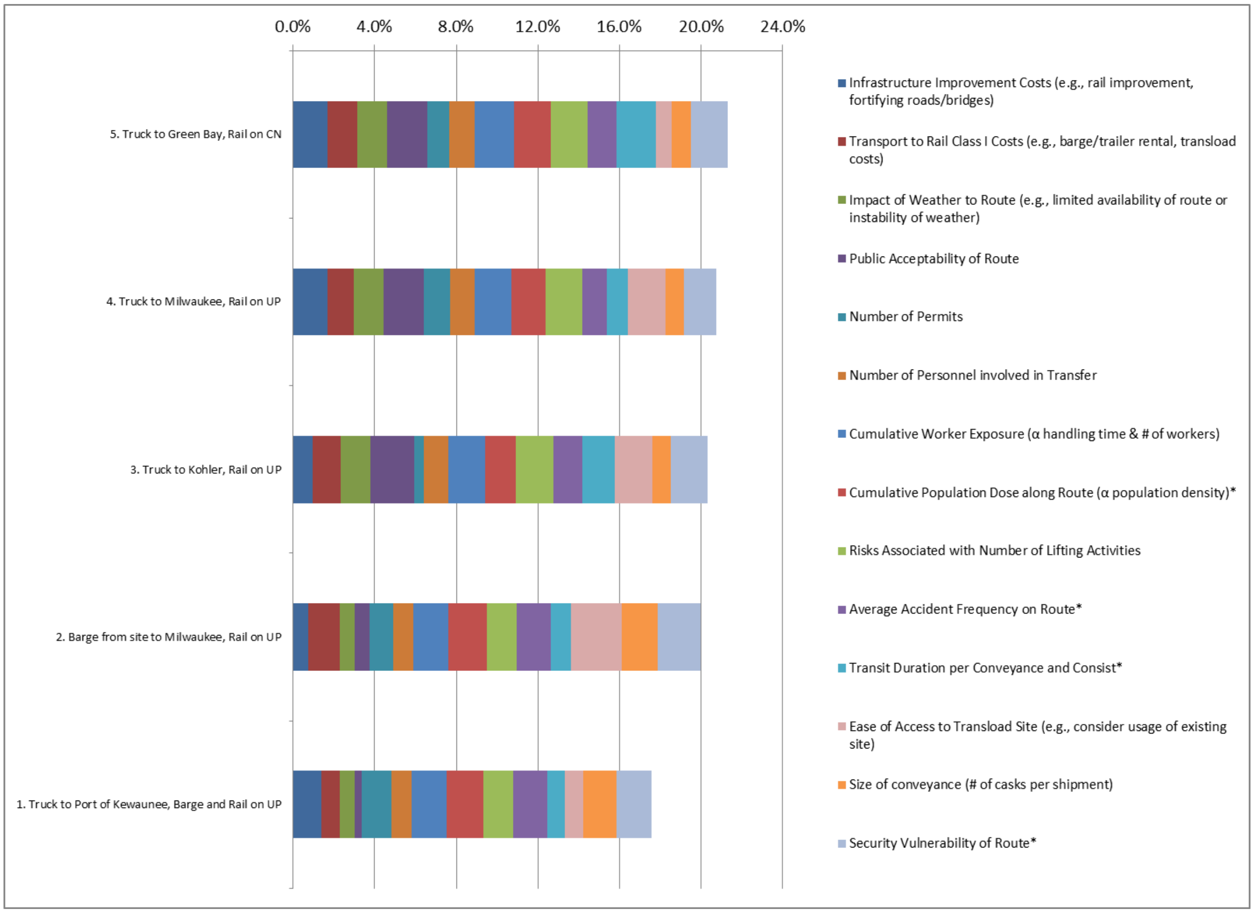


TABLE 5-15: COMPARISON OF ORIGINAL MUA RESULTS TO THE SUPPRESSED SPAN MUA RESULTS

	Suppression Results		Original Results	
Rank	Avg	Results	Avg	Results
1	21.32%	HHT to Green Bay, Rail on Canadian National Railway [1]	21.98%	HHT to Green Bay, Rail on Canadian National Railway [1]
2	20.76%	HHT to Milwaukee, Rail on Union Pacific Railroad [2]	20.84%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [2]
3	20.34%	HHT to Kohler, Rail on Union Pacific Railroad [3]	19.89%	HHT to Kohler, Rail on Union Pacific Railroad [3]
4	19.98%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [4]	19.55%	HHT to Milwaukee, Rail on Union Pacific Railroad [4]
5	17.60%	HHT to Port of Kewaunee, Barge and Rail on Union Pacific Railroad [5]	17.73%	HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad [5]

5.5.2 Details of Select Sensitivity Results

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

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

Results shown in **Figure 5-12** and **Table 5-16** for the removal of the safety metrics show the original rankings remain intact, but the resulting ranking values are separated by less than 1% for the top four routes, essentially indicating no difference between the routes. Results shown in **Figure 5-13** and **Table 5-17** for the removal of the security metric show a slight change from the original rankings, with the HHT-to-Milwaukee route moving up one position over the barge from the site route. Thus, the security metric providing the barge route from the site some advantage over the HHT route to Milwaukee. Results shown in **Figure 5-14** and **Table 5-18** for the removal of the public acceptability metric show the barge route from the site swapping positions with the HHT-to-Green Bay route, indicating the penalizing nature of this metric towards the barge routes. Although the top-ranked route changes, its advantage over the HHT route to Green Bay is less than 0.2%, and hence, essentially identically ranked. The final sensitivity analysis performed involved removing both the public acceptability and security metrics at the same time. **Figure 5-15** and **Table 5-19** show the results of this assessment with only the third- and fourth-ranked routes exchanging positions relative to the original ranking.

Overall, the HHT route from Green Bay 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: DOE signing an agreement with Canadian National Railway to make these types of shipments, an agreement can be arranged with the transload site owner, the rail line at the transload site remaining viable for use, and the HHT and rail routes meet the required clearances.

FIGURE 5-12: IMPACT OF REMOVING THE SAFETY METRICS

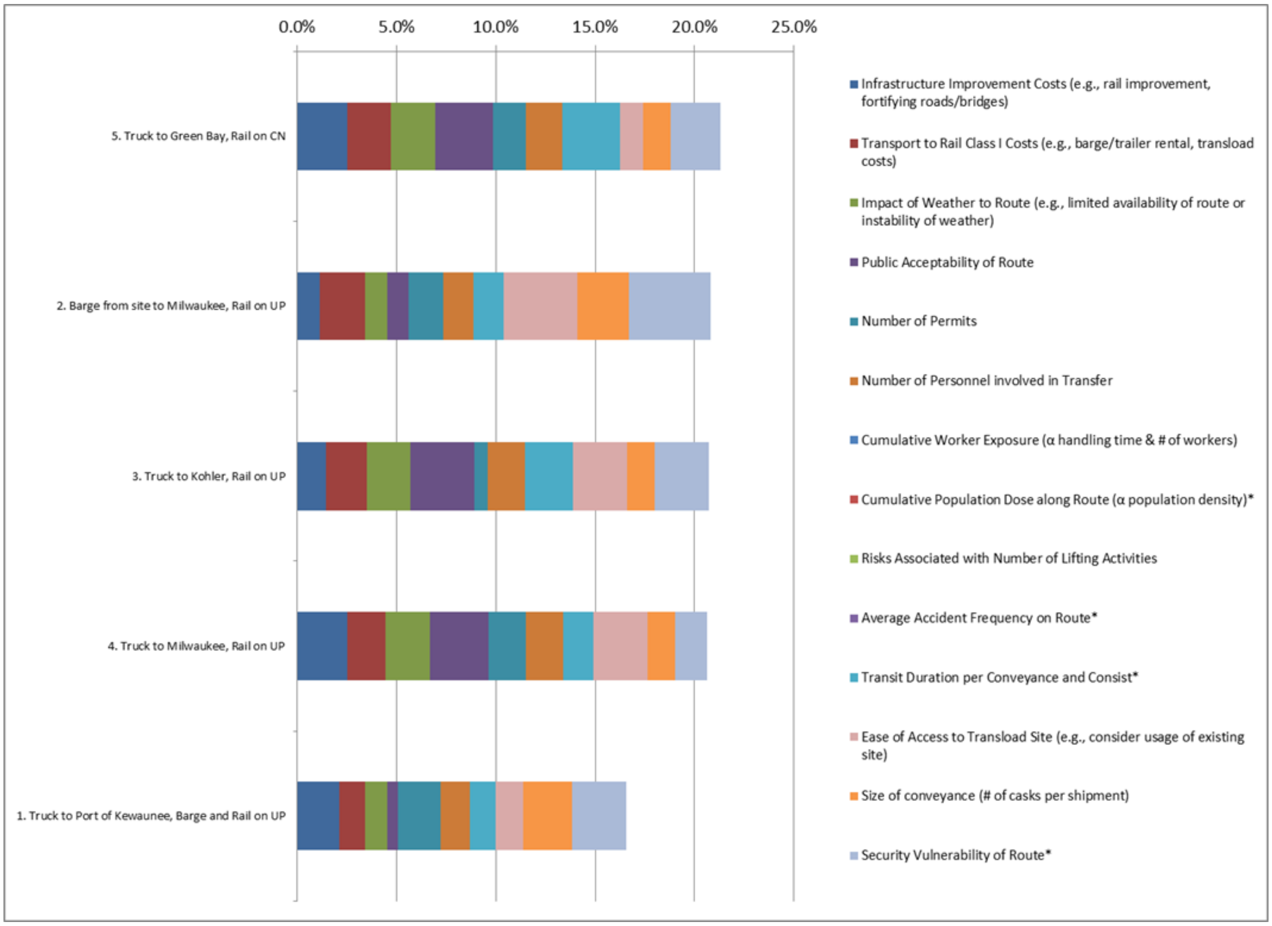


TABLE 5-16: RESULTS FROM THE DELETION OF THE SAFETY METRICS

Rank	Norm Points	Results
1	21.30%	HHT to Green Bay, Rail on Canadian National Railway [1]
2	20.80%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [2]
3	20.73%	HHT to Kohler, Rail on Union Pacific Railroad [3]
4	20.62%	HHT to Milwaukee, Rail on Union Pacific Railroad [4]
5	16.55%	HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad [5]

FIGURE 5-13: IMPACT OF REMOVING THE SECURITY METRIC

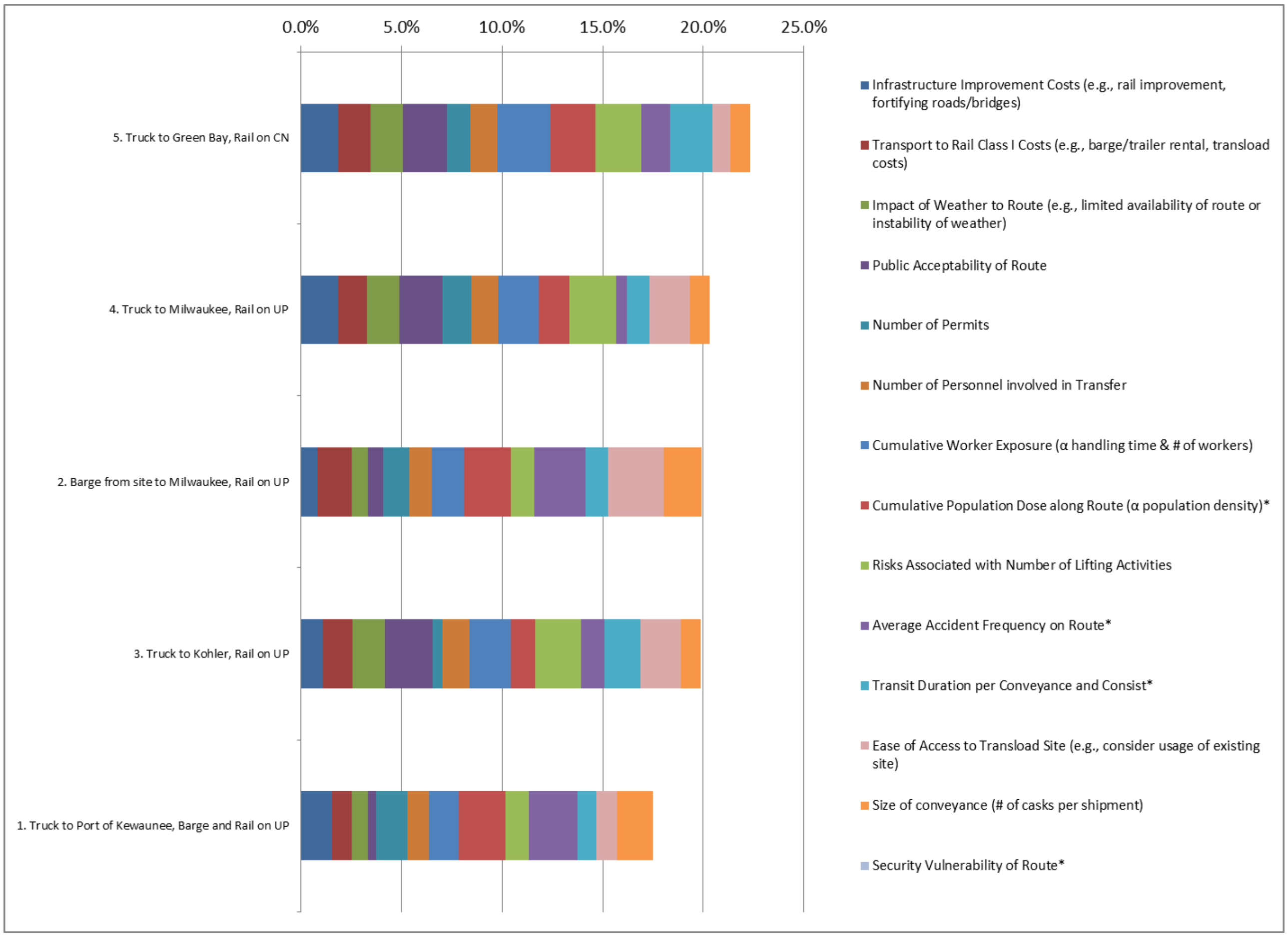


TABLE 5-17: RESULTS FROM THE DELETION OF THE SECURITY METRIC

Rank	Average	Results
1	22.35%	HHT to Green Bay, Rail on Canadian National Railway [1]
2	20.34%	HHT to Milwaukee, Rail on Union Pacific Railroad [2]
3	19.92%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [3]
4	19.88%	HHT to Kohler, Rail on Union Pacific Railroad [4]
5	17.50%	HHT to Port of Kewaunee, Barge and Rail on Union Pacific Railroad [5]

FIGURE 5-14: IMPACT OF REMOVING THE PUBLIC ACCEPTABILITY METRIC

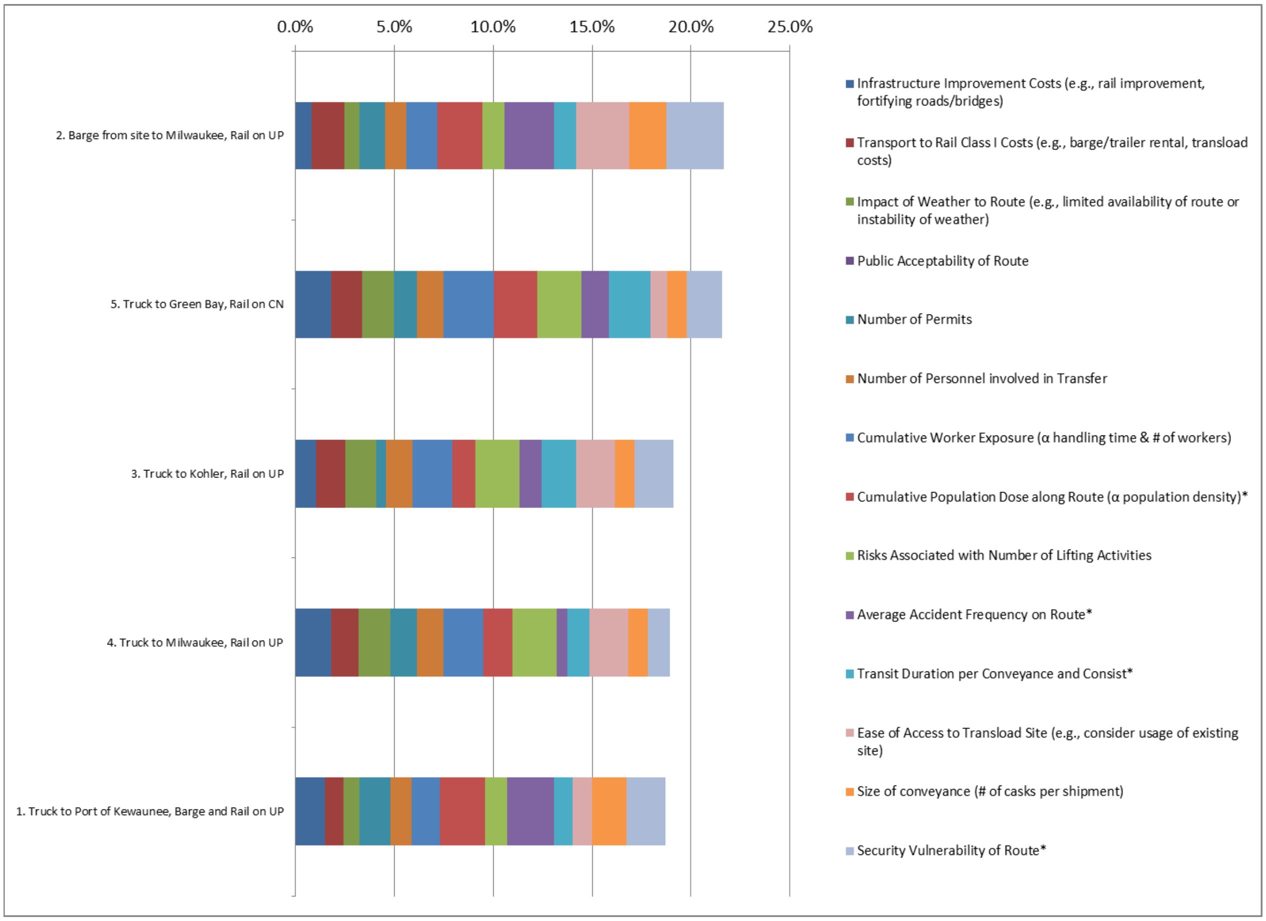


TABLE 5-18: RESULTS FROM THE DELETION OF THE PUBLIC ACCEPTABILITY METRIC

Rank	Norm Points	Results
1	21.67%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [1]
2	21.56%	HHT to Green Bay, Rail on Canadian National Railway [2]
3	19.11%	HHT to Kohler, Rail on Union Pacific Railroad [3]
4	18.94%	HHT to Milwaukee, Rail on Union Pacific Railroad [4]
5	18.71%	HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad [5]

FIGURE 5-15: IMPACT OF REMOVING THE PUBLIC ACCEPTABILITY AND SECURITY METRICS

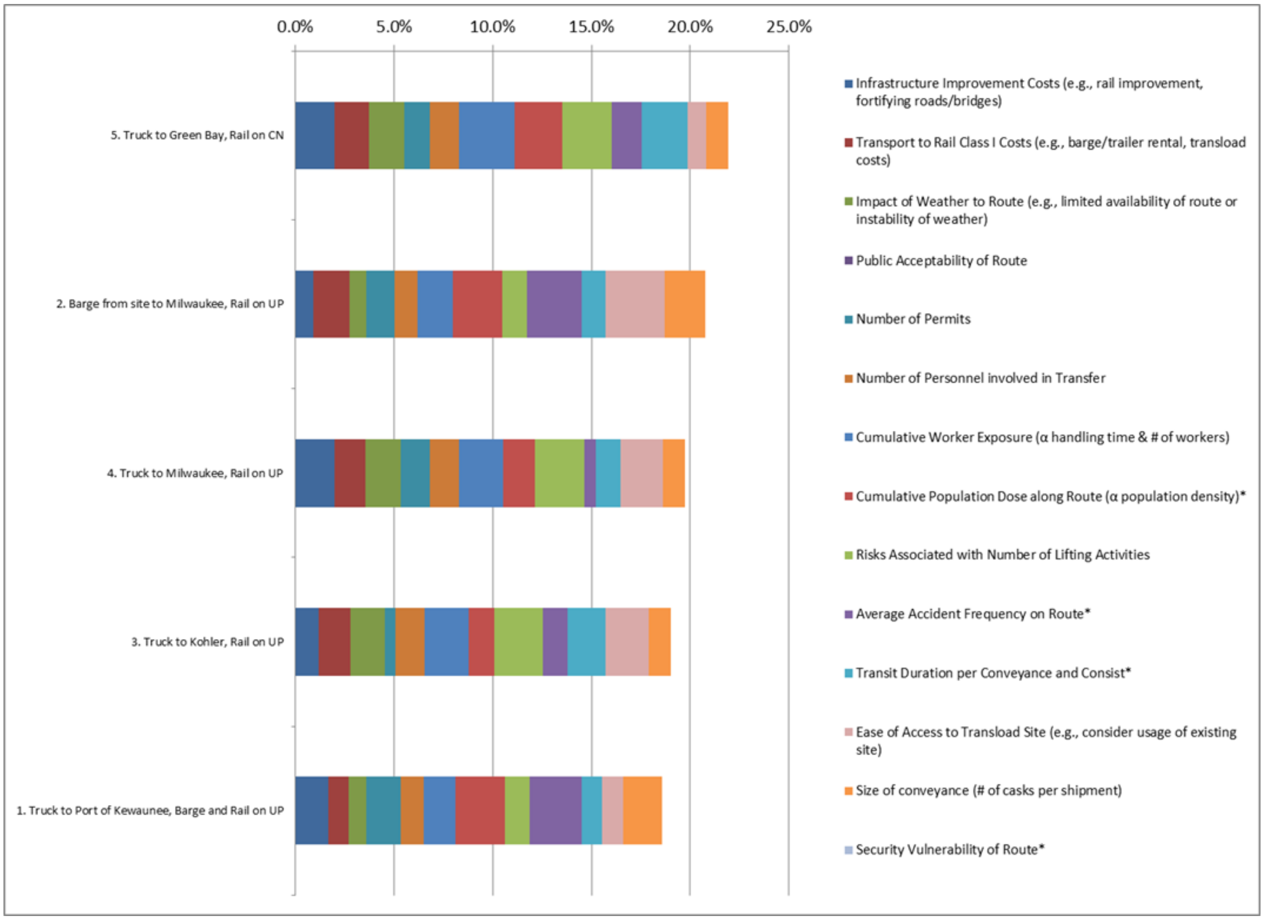


TABLE 5-19: RESULTS FROM THE DELETION OF THE PUBLIC ACCEPTABILITY AND SECURITY METRICS

Rank	Norm Points	Results
1	21.91%	HHT to Green Bay, Rail on Canadian National Railway [1]
2	20.77%	Barge from site to Milwaukee, Rail on Union Pacific Railroad [2]
3	19.73%	HHT to Milwaukee, Rail on Union Pacific Railroad [3]
4	19.02%	HHT to Kohler, Rail on Union Pacific Railroad [4]
5	18.57%	HHT to Port of Kewaunee, Barge, and Rail on Union Pacific Railroad [5]

6.0 CONCEPT OF OPERATIONS FOR RECOMMENDED APPROACH

6.1 Overview of Operations and Assumptions for NAC MAGNASTOR and TN Americas MP197HB Systems

The operations associated with the de-inventory of Kewaunee fuel stored in MAGNASTOR and NUHOMS systems at KPS would consist of lease or purchase of transportation casks, onsite transport equipment, auxiliary equipment and ancillary systems including mobile crane(s) and lifting equipment, identification of Transfer Station location on the ISFSI pad, development/confirmation of training program materials, training of operating personnel and supervisors, preparation and approval of site operating procedure for both systems, 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 is divided into five groups:

1) Mobilization operations: procurement/lease and delivery of required equipment to the site
2) Operational readiness: operating procedure preparation and approval, training program development, operator training, equipment checkouts, dry run(s), and operational readiness review(s)
3) Site operations: performance of canister transfer operations from MAGNASTOR storage cask and NUHOMS HSM to the MAGNATRAN and MP197HB transport casks respectively, for offsite transports
4) Heavy haul road and rail transport operations
5) Demobilization of equipment and personnel from the KPS site

Based on the number of canisters to be loaded and shipped from the KPS ISFSI (i.e., 38 canisters with SNF), it is recommended to load and ship five transport casks for each offsite transport campaign by road and rail transport with a total of five transport cask systems each committed to the de-inventory shipping campaign. Shipment of the empty casks from GCUS will be transported on a "special train" and the duration will be the same as for a loaded cask shipment.

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

1) Five MAGNATRAN casks, including impact limiters, MAGNASTOR cask cavity spacers, and 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.
2) A Transfer Station will be located at the north end of the MAGNASTOR ISFSI pad for off-loading of the TSC from the VCC into the MTC, and subsequent loading of the TSCs into the MAGNATRAN transport cask. The unloading, transfer, and loading of the TSCs would be performed in a vertical orientation at the Transfer Station.
3) The Transfer Station will use a mobile crane meeting the requirements of the MAGNASTOR Technical Specification Appendix A, Section 4.4.
4) The intermodal transport cradle mounted on the over-the-road HHT or positioned on the pad surface will be used to upright the MAGNATRAN casks using the MAGNATRAN

vertical lift yoke. A horizontal lift beam would be required to lift the loaded intermodal transport cradles off and on the over-the-road HHT and railcar.

5) The MAGNATRAN intermodal transport cradle could also be transferred with the MAGNATRAN transport cask positioned on the cradle with the impact limiters and personnel barrier installed from the ground to the HHT and railcar.
6) The MAGNATRAN packages would be provided with CoCs with the USNRC CoC No. 71-9356 (when issued) maintenance program as specified in Table 8.2.1 "Maintenance and Inspection Program Schedule" and Chapter 8.2 of the MAGNATRAN SAR (see **Table 6-2**).
7) New sets of inner metallic O-ring seals and outer EPDM O-rings will be required to be installed for the transport lid and vent port coverplate. After replacement and re-installation following TSC loading, the transport lid and vent port coverplate would require helium leakage testing to ANSI N14.5 leaktight criteria using a helium MSLD. Additional sets of containment seals will be required in case of seal leakage test failure.
8) 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.
9) A mobile crane would be required to lift the MTC, to remove the TSC from the VCC and load the TSC into the MAGNATRAN transport cask, to lift and load the MAGNATRAN cask on the intermodal transport cradle, and to lift and load the intermodal transport cradle to and from the off-site HHT or onsite HHT. Mobile crane(s) are required to meet MAGNASTOR CoC TS Appendix A, Section 4.4 requirements.
10) Fuel/TSC is assumed transportable for these activities (e.g., 10 CFR 71 dose and thermal limits are met).

The following assumptions were used in planning this NUHOMS 32PT canister transfer, loading, and off-site shipment campaign:

- Five MP197HB casks including impact limiters, cask cavity spacers, and intermodal transport cradle with integral tie-downs and personnel barrier.
- One cradle (transport cradle) will be used for loading and shipping. The cradle will be designed such that it can be used for the cask loading on an onsite transfer trailer and for transportation of the cask.
- Impact limiters will be removed and installed onto the cask while the cask is positioned on the transfer trailer.
- The maintenance activities required to be performed in Chapter 8 of the SAR will be completed and up-to date (see Table 6-2).
    - Trunnions (as applicable).
    - The MP197HB cask lid bolts are within the 250 shipments requirement or have been replaced.
    - The five-year test of the impact limiter to ensure that water has not entered the impact limiters is current.
- Canister integrity has been evaluated and is compliant with the cask SAR.

- Fuel/canister is assumed transportable for these activities (e.g., 10 CFR 71 dose and thermal limits are met).

6.1.1 Pre-Mobilization/Mobilization

Table 6-1 lists the activities required to prepare for and remove SNF from the KPS ISFSI.

TABLE 6-1: ACTIVITIES TO PREPARE FOR AND REMOVE SNF FROM KPS ISFSI IN MAGNASTOR / MAGNATRAN AND MP197HB SYSTEMS

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 transportation cask, Hardware, Railcars, Off-Site HHT, and Transport Services	Develop specifications, solicit bids, issue contracts, and initiate preparations for shipping campaigns; includes procurement of transport packagings including impact limiters, personnel barriers, intermodal transport cradles, MAGNATRAN Cask Lift Yoke and Horizontal Lift Beam; revisions to transport casks Part 71 CoC and MAGNASTOR/NUHOMS Storage CoC, if required; procurement of AAR Standard S-2043 railcars; and procurement of off-site transportation services including rail and HHT as applicable.
3	Acquire/Lease Required Auxiliary Equipment including Refurbished MAGNASTOR, Transfer Adapter, Suitable HHT(s) and Prime Mover(s), onsite Transfer Trailer and Remaining Required Auxiliary Equipment	The KPS site does not have any major components or auxiliary systems available following completion of the MAGNASTOR/ NUHOMS loading campaigns. Essentially all equipment will need to be acquired/refurbished/leased and shipped to site for setup and checkout prior to start of the training program and performance of the dry run(s). In addition, there is limited staffing at the KPS decommissioned site, so outside contractor crews will need to be assembled, trained, and evaluated to perform all transfer operations.
4	Prepare Transfer Station Area(s) and Equipment in accordance with the Requirements of the MAGNASTOR and NUHOMS CoC TSs	There is area of approximately 35 feet x 53 feet on the north end of the MAGNASTOR ISFSI pad available for the placement of the Transfer Station and positioning of the required auxiliary equipment. The NUHOMS transfers will occur at the door of each HSM with a transfer trailer loaded with a MP197HB aligned to make the transfer.
5	Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport for decommissioned site.
6	Coordinate with Stakeholders	Coordinates with carriers and makes notifications to federal, state, and applicable tribal nations.

Task		Task Activity Description
7	Develop Campaign Plans/Procedures (e.g., prepare, review, and approve all required site operating procedures for the TSC unloading from the VCCs and transfer/loading into the MAGNATRAN/ MP197HB casks, preparation and testing of the casks, 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, MTC handling, VCC/MTC 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 VCT operations, transfer adapter hydraulic system operation, diesel powered air compressor, etc. New site procedures will be required for the handling of the transport casks, Transfer Station operations, Goldhofer HHT operations, proper tie-down and securing of the casks packages to the railcar/intermodal transport cradle, evacuation and backfilling of the cask cavity with helium, helium leakage testing of the cask containment boundary seals, etc. All approved procedures will require review and approval by KPS Independent Safety Review (ISR).
Operational Activities to Prepare, Accept, and Transport from KPS		
8	Conduct Readiness Activities (e.g., In-Processing, Badging, Training, and Dry Run(s) of All Personnel, Procedures, and Operations)	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 Quality Assurance (QA)/Quality Control (QC) personnel would need to be trained and qualified to perform the operating procedures in accordance with KPS's Systemic Approach to Training (SAT) Programs. Training would require classroom, on-the-job training (OJT) (operating required equipment), and formal Training Program Evaluation (TPE) effectiveness. All de-inventory project personnel would require training commensurate with their responsibilities and work scope on the project.
9	Load for Off-site Transport	Unload storage systems and transfer TSCs to transport casks, install loaded casks onto intermodal transport cradles, installing impact limiters and personnel barrier, and lift onto off-site HHT to rail transloading facility.
10	Accept for Off-site Transport	Accept loaded casks onto trailer for offsite transportation and shipment to the designated destination.

6.1.2 Operational Readiness

Prior to the performance of an Operational Readiness Review and Assessment, the assembled de-inventory project team is 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 executed safely. It also ensures that the project team and procedures comply with the applicable regulations, permits, authorizations, and agreements that are in effect for the shipment to meet regulatory, contract, and stakeholder requirements prior to commencing operations as part of a de-inventory of the KPS ISFSI. The following subsection will discuss the operational readiness required to ensure operations at KPS are ready to commence and can be performed in a safe and regulatory compliant manner.

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

Operations management would ensure readiness from a quality, safety, and operational perspective. Management assessments of these processes 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 assumption in this report that DOE shipments would follow the same requirements as any 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. Once route approval is granted (e.g., by the NRC), notification would be provided prior to each shipment, since the campaign is longer in duration than one train movement.

As required by the MAGNASTOR/NUHOMS 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 as specified in the TSs. The training program would require a qualified trainer to oversee and conduct the training on the MAGNASTOR and NUHOMS systems with 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 – MAGNASTOR, MAGNATRAN, NUHOMS HSM, and MP197HB Systems Overview
- Module 2 – MAGNASTOR Transfer Cask and Transfer Adapter Operations
- Module 3 – MAGNASTOR VCC Handling and Movement
- Module 4 – Onsite HHT Operations (including prime mover) if required
- Module 5 – Off-site HHT (Goldhofer) Operations including Prime Mover
- Module 6 – TSC Unloading Operations from MAGNASTOR VCC
- Module 7 – Canister Unloading Operations from NUHOMS HSM
- Module 8 – MAGNATRAN Transport Cask Handling and Loading Operations
- Module 9 – MP197HB Transport Cask Handling and Loading Operations

- Module 10 – MAGNATRAN/MP197HB Transport Cask Intermodal Transport Cradle Tie-Down and Transloading Operations
- Module 11 – Preparation of MAGNATRAN Transport Cask for Transport
- Module 12 – Preparation of MP197HB Transport Cask for Transport
- Module 13 – MAGNATRAN Transport Cask Containment O-Ring Helium Leakage Testing
- Module 14 – MP197HB Transport Cask Containment O-Ring Helium Leakage Testing
- Module 15 – Use of Measuring and Test Equipment (M&TE)
- Module 16 – Radiological Concerns and ALARA Planning
- Module 17 – Regulatory Requirements
- Module 18 – Supervisor Training
- Module 19 – Contingency KPS Procedures
- Module 20 – Operation of the NAC Secure-Lift Yoke and Integrated Chain Hoist System
- Module 21 – Use and Operation of MAGNASTOR TSC Lift Adapter Plate

OJT:

- OJT-1 – Perform Pre-Use Inspections (VCC, MTC, MAGNATRAN/MP197HB casks, Lift Yoke(s), Chain Hoist, and other support equipment)
- OJT-2 – Perform Periodic Inspections (VCC, MTC, MAGNATRAN/MP197HB casks, Lift Yoke(s), Chain Hoist, and other support equipment)
- OJT-3 – Prepare a MAGNASTOR VCC and MTC for Stackup and TSC Transfer
- OJT-4 – Prepare an HSM for Canister Transfer
- OJT-5 – Off-Load Empty MAGNATRAN Transport Cask from Intermodal Transport Cradle
- OJT-6 – Off-Load Empty MP197HB Transport Cask from Intermodal Transport Cradle
- OJT-7 – Perform MP197HB Setup for Canister Transfer from HSM
- OJT-8 – Perform MTC Stackup and TSC Unloading from VCC
- OJT-9 – Perform MAGNATRAN Transport Cask and MTC Stackup for TSC Transfer
- OJT-10 – TSC Loading into MAGNATRAN Transport Cask
- OJT-11 – TSC Loading into MP197HB Transport Cask
- OJT-12 – Movement of VCC to/from ISFSI to Transfer Station
- OJT-13 – Movement of MP197HB transfer trailer to/from ISFSI/HSM
- OJT-14 – MAGNATRAN Transport Cask Lid Installation and Torqueing, and Cavity Evacuation, Backfill, and Helium Leakage Testing

- OJT-15 – MP197HB Transport Cask Lid Installation and Torqueing, and Cavity Evacuation, Backfill, and Helium Leakage Testing
- OJT-16 – Perform Loaded MAGNATRAN Package Downending and Preparation for Transport
- OJT-17 – Onsite and Off-site HHT Operations
- OJT-18 – Operate Diesel Air Compressor, Air-Powered Chain Hoist System
- OJT-19 – Onsite and Off-site Intermodal Transport Cradle Handling Operations

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

Operational dry runs with a DSC mock up to perform the transport cask loading operation would be conducted at KPS for the MP197HB if the remaining two HSMs are not loaded with rad waste. Due to a lack of an empty MAGNASTOR VCC and mock-up TSC onsite, 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 withdrawing a TSC to confirm procedures, training, and equipment interfaces, fit-up and function. Alternatively, a MAGNASTOR TSC mock-up modified to full length with struts can be used in the MTC to dry run the TSC transfer from the MTC to the MAGNATRAN transport cask. This component was used during the KPS MAGNASTOR dry runs to confirm the functions of the TSC Lift Adapter Plate, Secure-Lift Yoke and Chain Hoist System, and transfer and retrieval of a TSC from a VCC. The modified mock-up is currently in storage at the KPS storage building on the ISFSI, and it is expected that this component would be available for use for the de-inventory project.

Communication and interfacing with the applicable stakeholders would be needed to ensure readiness. This would include, but would not be limited to, KPS, DOE, State, and local authorities. In addition, the NRC onsite and Region III inspectors would observe and provide regulatory oversight throughout the entire preparation, construction, operating procedure and approval process, and training/dry run program. Some entities 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 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 will be performed as specified in the MAGNASTOR CoC TSs and NUHOMS training program and witnessed by DOE, NRC, and stakeholders. Additionally, and as applicable, these entities would be involved in event response planning and mitigation, including contingency KPS emergency event training, to ensure that any event is well managed and mitigated prior to the first shipment of the campaign. This would encompass approvals to start work, training, and interaction with State and local authorities. It is assumed that KPS, NRC, and DOE would participate as observer/regulator/participant for each shipment.

Transportation-related Operational Readiness Items

Equipment Readiness Determined through Review of the Following:

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

Transportation Personnel Readiness:

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

Transportation Readiness Notifications:

- Proper notifications have been made to the Tribes, NRC, State and local governments, DOT, USCG, and DOE, as applicable, and copies are provided. Any water served or adjacent facility is required to have an active and updated safety and security plan, which must be reviewed and approved by the USCG.
    - If a plan exists, it should be confirmed by the shipper and updated as to the actual operations designed to take place on the site during the campaign.

- All required permits to transport SNF are prepared and/or in place.
- Proper notification requirements are being met for the receiving facility.
- Scheduled meetings and briefings that would be conducted for all phases of the shipments are identified.

6.1.3 Site Operations NAC System

Each MAGNASTOR TSC transfer sequence will encompass the following major evolutions:

- Removal of the personnel barrier, impact limiters, and cask tie-downs
- Uprighting the empty MAGNATRAN transport cask from the transport cradle
- Movement and positioning of the vertical MAGNATRAN transport cask at the Transfer Station
- Removal of the MAGNATRAN transport cask lid
- Placement of the MAGNATRAN transport cask transfer shield ring and MTC transfer adapter on the MAGNATRAN transport cask
- Loaded VCC retrieval and movement to the Transfer Station
- Removal of the VCC lid and installation of the TSC lift adapter plate and MTC transfer adapter
- VCC/MTC stackup and TSC extraction into the MTC using the Secure-Lift Yoke and Chain Hoist System
- Lifting and movement of the loaded MTC from the VCC to the MAGNATRAN transport cask
- Transfer of the loaded TSC into the MAGNATRAN transport cask using the Secure-Lift Yoke and Chain Hoist System
- Removal of the MTC, TSC lift adapter plate, MTC transfer adapter, and adapter ring from the MAGNATRAN transport cask
- Installation of transport lid with new metallic containment O-ring seal
- Installation and torqueing of the transport lid bolts
- Evacuation and helium backfill of MAGNATRAN transport cask cavity
- Installation of vent port coverplate with new metallic containment O-ring seal
- Performance of the transport lid and vent port coverplate containment O-ring helium leakage tests
- Movement and downending of the loaded MAGNATRAN transport cask on the intermodal transport cradle
- Installation of cask tie-downs, personnel barrier, and impact limiters

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 KPS and as noted in Section 2.3.2, it is planned to locate the Transfer Station at the north end of the ISFSI Pad. The free area is approximately 35 x 53 feet. At the Transfer Station, the Secure-Lift Yoke and Chain Hoist System would be positioned on its storage stand as shown in **Figure 2-33**. A mobile crane of sufficient capacity utilized to lift and handle the loaded MTC and MAGNATRAN transport cask must meet the requirements of MAGNASTOR TS 4.4, "TSC Handling and Transfer Facility".

Prior to the start of any MAGNASTOR TSC transfer operation or MAGNATRAN transport 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, RWP requirements, dose and dose rate expectations, planned RP coverage, As Low As Reasonably Achievable (ALARA) practices, and 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 MAGNATRAN transport cask has a certification of conformance with all required cask maintenance and testing as specified in **Table 6-2**.

Prior to commencing MAGNASTOR TSC Transfer operations, the primary and auxiliary equipment and services would be configured and positioned as follows:

- Disconnect the temperature monitoring equipment from the VCC to be unloaded.
- Install the two VCC lifting lugs and torque attachment bolts.
- Position the primary mobile crane located such that it would be able to reach the MAGNASTOR transport cask downending area and the intermodal transport cradle.
- Locate the intermodal transport cradle, with securement straps removed, in the downending area either on the off-site HHT (Goldhofer) or on the ground.
- Locate the secondary mobile crane intended to be used for lifting the MTC transfer adapters, transfer shield ring, and VCC and transport cask lids adjacent to the Transfer Station.
- Position the vacuum pump, leak test system, and helium supply at the Transfer Station. Also position temporary storage stands for the placement of the VCC lid and MAGNATRAN transport cask lid on the pad or directly adjacent to the pad.
- Position the diesel air compressor adjacent to the ISFSI pad to supply air to the Secure-Lift Yoke's Chain Hoist System. (*Note: a second redundant air compressor should also be available in case of equipment failure contingency during lifting or lowering of the TSC).*

Once the transfer equipment is staged and ready, operations would be initiated to off-load an empty MAGNATRAN transport cask from the off-site HHT (Goldhofer). 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. The two trunnion plugs are removed, and the two lifting trunnions inspected, installed, and bolted into position. Any road dirt and previous labels would be removed from the cask's surfaces. The primary mobile crane would then be connected to the

MAGNATRAN transport cask lift yoke and the lift yoke engaged to the two lifting trunnions. The crane and lift yoke would then upend the MAGNATRAN transport cask by lifting from the front to rear while maintaining the crane and yoke above the centerline of the front trunnions 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 MAGNATRAN transport cask on the intermodal transport cradle with the impact limiters and tie-downs still installed. Once positioned on the ground, the detailed uprighting operations described above will be performed to prepare and upright the MAGNATRAN transport cask in preparation for movement to the Transfer Station. Once in a vertical orientation, the MAGNATRAN transport cask would be lifted from the intermodal transport cradle and placed in position at the Transfer Station. Appropriate work platforms to access the cask lid area would be positioned around the cask. As an alternative to the primary mobile crane, a specially designed VCT may be used to perform the upending, down ending, and onsite vertical transport of the MAGNATRAN transport cask.

The VCT would engage the VCC lifting trunnions and raise the VCC approximately 6 inches off the surface. The VCT would move the VCC from its storage position on the ISFSI pad to the Transfer Station where it would be positioned adjacent to the MAGNATRAN transport cask. The work platform(s) would be placed around the VCC, and the VCC lid bolts removed.

Once the MAGNATRAN transport cask is in position at the Transfer Station 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 transport lid, lid bolts, and vent port coverplate, bolting, and leak test port plugs.

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 the 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 stored to prevent loss or damage. Prior to re-installation, a new metallic containment O-ring would be installed in the vent port coverplate. The transport lid bolts would then be de-torqued in the numbered sequence of the bolts as stamped on the cask lid. The transport lid bolts would be inspected for any damage and damaged bolts replaced with authorized spares, and stored to prevent loss or damage. The transport 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 lid is lifted, removed, and stored in a location to protect the O-ring grooves. Prior to lid re-installation, the transport lid metallic containment O-ring seal will be replaced.

Following the lid removal, a visual inspection of the lid containment boundary seating surface and cask cavity is performed to observe for any foreign material or damage. The transfer shield ring is lifted, installed in the lid recess / seating surface, and bolted in place. The transfer shield ring is provided to interface with the MTC transfer adapter plate and to provide additional shielding during the loading of the TSC into the MAGNATRAN transport cask. The MTC transfer adapter is positioned on the transfer shield ring and bolted in place. The adapter plate is connected to the shield door auxiliary hydraulic system and the female connectors are positioned to the engagement position.

The secondary mobile crane is then positioned for removal of the VCC lid and installation of the second MTC transfer adapter on the top of the VCC. Once the VCC lid 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 adapter plate is installed in the six lifting threaded holes on the MAGNASTOR TSC closure lid. If installed, threaded hole plugs would be removed. The primary mobile crane connected to the Secure-Lift Yoke and Chain Hoist System would then be used to lift and place the empty MTC with retaining blocks in the engaged position on the transfer adapter positioned on the top of the VCC.

The Secure-Lift Yoke and Chain Hoist System is ready to remove the shield door lock pins, allowing for the opening of the shield doors using the auxiliary hydraulic unit, followed by the lowering and engagement of the chain hoist's sister hook and connection to the TSC lift adapter plate. The next operational sequence is the lifting of the MAGNASTOR TSC from the VCC using the air-powered chain hoist system into the MTC cavity until the top of the MAGNASTOR TSC is lifted to just below the retaining blocks. The retaining blocks are designed to prevent the unauthorized extraction of a loaded TSC from the MTC, and the retaining blocks are structurally designed to take the entire weight of the loaded MAGNASTOR TSC and MTC without failure. However, caution should be used to ensure that the top of the TSC does not engage the retaining blocks. Once the MAGNASTOR TSC is in the MTC cavity, the auxiliary hydraulic system is used to close the shield doors and the MAGNASTOR TSC is lowered to rest on the doors.

During the TSC transfer operation, radiation dose rates are expected to be high at the MTC-to-adapter-plate interface and through gaps in the shield door to MTC openings. Also, once the MAGNASTOR TSC is in the MTC, dose rates on the MTC surfaces 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 MAGNASTOR TSC as allowed by MAGNASTOR TS Limiting Condition of Operation (LCO) 3.3.2, 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 expected to be significantly lower because of using clean demineralized water in the MTC/TSC annulus during in-pool and annulus cooling operations. Although the TS establishes maximum limits, a significant majority of the MAGNASTOR TSCs had less than 1,000 dpm/100 cm^2 beta/gamma contamination in surveys performed during TSC closure and transfer to VCC for storage. However, contamination control practices will be required to be observed during MAGNASTOR TSC handling and transfer operations to the MAGNATRAN transport cask. It is expected that interior surfaces of the MAGNATRAN transport cask and MTC may potentially pick up minimal contamination during the MAGNASTOR TSC transfer and loading operations. The potential contamination of the interior of the MAGNATRAN transport cask 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 crane would then be used to lift the loaded MTC from the top of the VCC and position it on the MTC transfer adapter on top of the MAGNATRAN transport cask using the Secure-Lift Yoke ensuring the transfer adapter's female connectors engage with the male connectors of the shield doors. The Secure-Lift's chain hoist is then used to lift the TSC off the shield doors, the shield door lock pins are removed, and the shield doors opened. The Secure-Lift's chain hoist is then used to slowly lower the

MAGNASTOR TSC into the MAGNATRAN transport cask cavity. During the MAGNASTOR TSC transfer operation, radiation dose rates are expected to be high at the MTC openings and MTC-to-MAGNATRAN interfaces. Once the TSC is fully down in the MAGNATRAN cavity, the hydraulic system is used to disconnect the chain hoist system's sister hook from the TSC lift adapter plate. The MTC shield doors are then closed, the door locks installed, and the crane and Secure-Lift Yoke is used to lift the MTC off the MAGNATRAN cask. The MTC is then set down and disengaged from the Secure-Lift Yoke system and staged for the next MAGNASTOR TSC unloading sequence from the next loaded VCC. The Secure-Lift Yoke and Chain Hoist System would be placed on the storage stand and disengaged from the primary mobile crane.

Operators would then access the top of the MAGNATRAN transport cask to remove the TSC lift adapter plate from the TSC closure lid. Then, using the transfer adapter sling set and the secondary mobile crane, the MTC transfer adapter is unbolted, lifted, and placed in storage for the next TSC loading sequence. Next, the transfer shield 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. Verify that the transport lid has the cask cavity spacer installed. If the cask cavity spacer is not installed to the underside of the lid, position the spacer under the lid and install the four bolts and lock washers and torque to 300 ± 20 in-lbs. As the transport cask cavity spacer is bolted to the transport lid, there is not a requirement to remove the spacer for empty cask return shipment. The cask transport lid and cask cavity spacer installed with a new metallic containment O-ring seal is lifted using the secondary crane and transport lid sling set, installed in the lid recess, and aligned to the lid bolt holes. Once the lid is fully seated, the 48 lid bolts lubricated with Never-Seez or equivalent are installed, and using the bolt torqueing device, the lid bolts are torqued in the indicated numbered sequence stamped on the lid in complete three passes to a final torque of 4,600 ± 200 ft-lbs.

After the transport 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, the vent recess is flushed with helium gas, and the vent port coverplate installed with a new metallic containment O-ring seal. The four coverplate bolts lubricated with Never-Seez or equivalent are torqued to a final torque of 120 ± 20 in-lb.

Final helium leakage testing of the transport lid cask containment boundaries (e.g., transport lid seals and vent port coverplate seals) is then performed using a helium MSLD system to confirm that each containment boundary closure is leaktight in accordance with ANSI N14.5-1997 to a leakage rate of $\leq 2 \times 10^{-7}$ cm^3/s, helium with a minimum sensitivity of 1×10^{-7} cm^3/s, helium. Following successful leakage testing, the MSLD will be removed from each component and the leak test port plugs will be re-installed with a new metallic O-ring seal and tightened to the designated torque of 120 ± 5 in-lbs. The MAGNATRAN transport cask containment boundary provided by the lid closures are 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 front and rear trunnions for general condition and lubrication would be performed, with corrective actions as required. Using the primary mobile crane connected to the MAGNATRAN Lift Yoke will be engaged and the loaded cask removed from the Transfer Station. 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 MAGNATRAN cask lowered until the rear trunnions are seated into the cradle's rear supports and fully engaged. Taking precaution to maintain the lift yoke and crane over the centerline of the lifting trunnions, slowly lower and rotate the MAGNATRAN cask into a horizontal position on the intermodal transport cradle. (*Note that the rear trunnions are off-set from the cask centerline to assist in correct downending*).

Once the cask is in the horizontal position, the front trunnions are removed and replaced by the trunnion plugs. Next, final removable contamination surveys are taken for areas to be covered by the front and rear impact limiters. The cask tie-down assembly is installed between the top of the neutron shield and the trunnion plugs and engaged to restrain the cask in a vertical direction. 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 35 ± 2 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., and installed safety wire between adjacent impact limiter rods. To provide evidence of tampering during transport, a security seal wire and TID is installed between two of the front impact limiter rods. The crane and sling set are then disengaged from the front impact limiter, and the impact limiter installation operation is repeated for the rear/lower impact limiter. Finally, the personnel barrier is installed over the center of the cask enclosing the open area between the front and rear impact limiters and bolted to the intermodal transport cradle. The personnel barrier and access panel are locked to prevent unauthorized access to the cask surfaces.

If required, the intermodal transport cradle horizontal lift beam is used to lift and place the loaded intermodal transport cradle containing the assembled MAGNATRAN package on the final transport conveyance.

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 (TI). All dose rates and contamination surveys must comply with applicable DOT and NRC regulations. The appropriate Criticality Safety Index (CSI) assigned to the package contents should be determined in accordance with the CoC and indicated on the Fissile Material labels applied to the package. 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 Site Operations TN Americas System

Each NUHOMS canister transfer sequence and loading into the MP197HB cask will encompass the following major evolutions:

Receiving the Cask and Preparation for Canister Loading

An inspection of the empty cask system and cradle will be performed to verify no damage has occurred to the cask and cradle during transport. Additionally, radiation and contamination surveys will be performed to the cask system to verify acceptable levels.

Once the inspections and surveys have been completed and verification that all equipment needed to perform the cask loading is in place, the crane will attach to the transportation cradle lifting lugs.

The transport cradle tie down pins/bolts will be removed from the transportation trailer and inspected for damage and stored. The onsite transfer trailer will be positioned at a location for loading the empty cask and cradle.

The crane will slowly lift the cask from the transport trailer and swing the cask into position over the onsite transfer trailer with the cask lid facing to the back of the transfer trailer. At this point the crane operator will slowly lower the cask and cradle onto the onsite transfer trailer and into the cradle positioning system on the transfer trailer. The crane will be disconnected from the cask cradle and the cradle pins/bolts will be attached to secure the cradle to the transfer trailer. The crane will attach to the personnel barrier on the cask. The bolts that secure the personnel barrier to the cask cradle will be removed. The personnel barrier will be removed from the cradle/cask and positioned at a location for storage. The personnel barrier and associated hardware will be inspected for damage and additional surveys of the exposed cask surfaces will be performed to verify levels are acceptable.

The three impact limiter hoist rings will be inspected, the impact limiter hoist ring plugs/bolts removed, and the hoist rings installed to the front impact limiter. The tamper indicator will be removed. The crane operator will apply a slight load to the impact limiter to aid in removal of the 12 impact limiter bolts. Operations will remove the impact limiter bolts from the cask and store them. Each bolt will be inspected for damage and surveys of the bolts will be performed as needed.

Once all the bolts have been removed from the impact limiter, the crane operator, with support from riggers, will swing the front impact limiter from the cask body and store. The impact limiter and cask lid area exposed surfaces will be surveyed for contamination. Additional inspections will be performed of the impact limiter shell for any dents or penetrations or any evidence of weld cracking or other damage which could result in water in-leakage.

Once the front impact limiter has been removed the crane operator and riggers will attach to the rear impact limiter. This operation for removal of the rear impact limiter is the same process as discussed above for the front impact limiter.

Once both impact limiters have been removed and the cask has been surveyed for contamination and levels are acceptable, operations with support from a radiological control technician (RCT) will obtain a sample of the atmosphere on the inside of the cask cavity. During the operation of removing the vent plug and bolt, RCT coverage will be needed to verify contamination levels are within the acceptable levels. If contamination levels are not acceptable, operations will be stopped, the cask will be placed in a safe configuration, and management notified.

Once the cask surveys have been completed and levels confirmed, operations will remove the front cradle tie down strap and the front trunnion covers from the cask and perform an inspection of the two front cask trunnions including bolts and thread area, seals, mounting blocks, bolt holes on the cask body, and trunnion lifting surfaces for damage that would cause an unsafe condition during docking and transfer operations. Once the inspections are completed the front trunnions will be installed onto the cask body and the trunnion bolts torqued as required in the cask SAR.

It should be noted that only the front cask trunnions will be installed on the cask body to allow an anchor point to secure the cask to the HSM for docking purposes and loading of a canister into the cask.

Canister Loading into the Cask

In preparation for canister loading, the port plugs and port plug bolts will be removed from the vent, drain, and test ports. RCT will survey the plugs and port areas for contamination. Plugs and bolts will be inspected for damage and new O-ring seals installed.

Concurrently, the cask ram access closure plate will be removed by removing the 12 cover bolts and RCT will survey bolts, as needed. As the cover is removed, RCT coverage would be needed during the coverplate removal. Using the crane, the cover is removed. Once the cover is removed and surveyed, the metal seal will be removed and an inspection for damage performed on the coverplate and cask body seal surface area and the coverplate bolts. Operations staff will install a new seal on the coverplate and store.

A cask lid-handling device will be attached to the cask lid and a slight load will be applied to the rigging to aid in the removal of the cask lid bolts. Operations staff will loosen all bolts and then remove the bolts and store, and RCT will survey bolts as needed. Once the bolts are all removed and with support from RCT, the cask lid will be removed, surveyed, and stored in a location for inspection.

Operations staff will remove and discard the cask lid seals and perform an inspection on the cask lid, the lid/body seal surfaces for damage, cask lid bolts, and the cask body bolt holes for any damage. Once the inspection is completed, new lid seals will be installed onto the cask lid. The cask lid will be placed in a storage location.

RCT will perform a survey of the internal cask cavity for contamination and direct any decontamination if required. The cask canister sleeve is verified as present in the cask and the canister sleeve spacer ring is removed from the cask and stored. Operations staff will inspect the canister sleeve and verify the sleeve is in good condition including the canister guide rails.

The canister spacer is installed into the cask, the unloading flange installed in the cask opening area, and the cask prepared for docking to the HSM.

Using the target aligning system on the cask, trailer, HSM, and using a transit, the transfer trailer will be positioned in front of the HSM to be discharged.

The HSM door-lift fixture will be positioned to the HSM door and the fixture mounting bolts and torque installed. Operations staff will raise the crane slightly to preload the door to aid in the HSM door bolt removal. With support from RCTs, the HSM door bolts will be removed. Operations staff will continue to remove the HSM door while RCT continues radiation and contamination monitoring during the operation. At any time, if the radiation or contamination levels exceed the approved limits, the operation will be stopped, equipment placed in a safe configuration, and management notified. Once the HSM door is removed, it will be placed in a storage location.

RCT will conduct additional surveys and monitoring of the canister and verify the levels are acceptable. Operations will inspect the canister and canister grapple for any signs of degradation from storage and remove the seismic restraints. Once the inspection has been completed, the transfer trailer and cask will be positioned, aligned, leveled, and docked to the HSM using the cradle positioning system.

Once the cask is docked with the HSM and the alignment verified, the cask will be connected to HSM restraints and secured to the HSM. Concurrently, the hydraulic ram will be installed and aligned for connecting the grapple to the canister.

Using the ram system hydraulics, the ram will be connected to the canister via the canister grapple. The canister will be pulled into the cask. Operations staff will monitor the progress to ensure the alignment and canister transfer into the cask is achieved. RCT will continue to monitor the radiation as this operation is conducted. In the event the canister becomes wedged or is not able to be transferred into the cask, operations staff will stop and place the equipment in a safe configuration and notify management.

Once the canister is fully inserted into the cask, operations will disconnect the grapple from the canister and position the ram for the installation of the cask ram closure plate. RCT will continue to monitor radiation/contamination levels. Operations will rig to the ram access closure plate and install it onto the cask. The 12 bolts will be installed and torqued as required by the cask SAR.

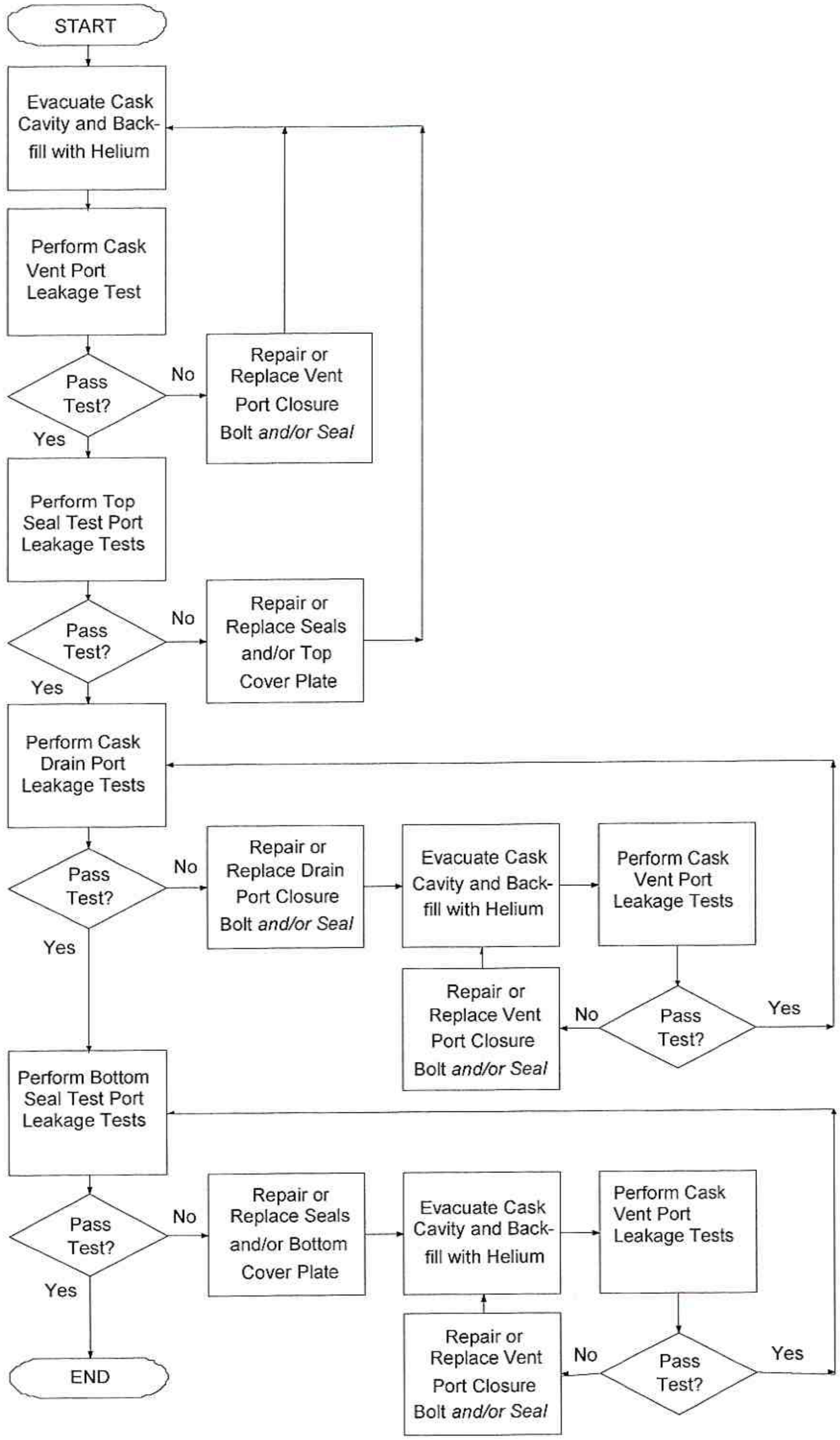
Concurrently, operations will remove the cask to HSM restraints and prepare the transfer trailer to un-dock from the HSM. Operations staff will rig the cask lid and position the lid for installation onto the cask. The transfer trailer will be moved away from the HSM far enough for the installation of the cask lid. RCT will monitor radiation and contamination during this operation to verify the levels are acceptable. Once the trailer is in position and surveys completed, the canister unloading flange will be removed from the cask and the canister sleeve spacer ring will be installed in the cask opening. The cask lid will then be positioned and installed onto the cask. The cask lid bolts will be installed and torqued between 950 and 1,040 ft-lbs. The crane will disconnect from the lid and operations will torque the lid bolts as required in the cask SAR.

RCT will perform additional contamination surveys on the cask and area to verify acceptable levels.

The transfer trailer will be positioned as required for leak testing of the cask. Concurrently, the HSM door will be reinstalled, if required.

Operations staff will remove the vent port plug and connect the leak test system to the vent port. The cask cavity will be evacuated and then backfilled with helium. Helium leak tests will then be performed to verify the containment boundary seals are acceptable. These tests include checking the port plug bolt seals of the vent and drain ports and the interspace between the lid and ram access cover seals. **Figure 6-1** depicts the process flow for cask assembly leak testing verification. Concurrently, the cask front trunnions will be removed from the cask and the cask trunnion covers installed. After installation of the front trunnion covers, the front tie-down strap will be reinstalled over the cask and secured to the cradle.

FIGURE 6-1: MP197HB ASSEMBLY VERIFICATION LEAK TEST FLOW CHART



Cask Final Assembly and Preparation for Shipment

Once the cask leak test has been completed, the transfer trailer will be positioned as needed for installation of the impact limiters.

The crane will be attached to the front impact limiter and the impact limiter positioned onto the cask body. Once the impact limiter is fully engaged onto the cask body, the 12 bolts are snugged (hand tight). Once all the bolts have been snugged, the bolts will be continually torqued as required in the SAR. This same evolution will be used to position the rear impact limiter to the cask. The hoisting rings will be removed and the impact limiter hoist ring plugs/bolts installed on both impact limiters

Operations staff will install the required security seal to the cask front impact limiter.

Final inspections will be conducted on the cradle, cradle tie down straps, and cradle tie down hardware for any loose components and damage. Any issues noted will be brought to the attention of management and resolved prior to release to the cask for shipment.

If needed, RCT will perform additional surveys of the cask prior to installation of the personnel barrier. Once the surveys have been completed, the personnel barrier will be rigged, loaded, and the frame secured to the cradle. The rigging will be disconnected and preparations will be made to transfer the cask from the transfer trailer to the transportation trailer.

Operations staff will verify that the temperature on all accessible surfaces is <185°F.

The crane will be positioned for the cask transfer and the rigging connected to the cradle lifting points. The cradle securement pins/bolts will be removed from the transfer trailer and stored. Operations staff will slowly lift the cask and transfer the cask and cradle to the transport trailer and lower the cradle onto the trailer. Once the cradle is lowered onto the transportation trailer, the cradle-to-trailer pins/bolts will be installed to secure the cradle to the trailer.

The RCT will perform the additional survey required to release the cask system for transport. 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 TI. All dose rates and contamination surveys must comply with applicable DOT and NRC regulations. The appropriate CSI assigned to the package contents should be determined in accordance with the CoC and indicated on the Fissile Material labels applied to the package. 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.

TABLE 6-2: MAINTENANCE PROGRAM SCHEDULE

Maintenance Program Schedule for MAGNATRAN	
Task/Activity	**Frequency**
Visual inspection of cavity	Prior to loading
Visual inspection of O-rings	Prior to loading
Visual inspection of neutron shield shell segments for structural or penetration damage	Prior to loading
Visual inspection of cask lid bolts and lid port coverplate bolts	Prior to installation (each use)
Visual and proper function inspection of cask	Prior to and during each use
Visual inspection of lifting trunnions and rotation trunnions	Prior to and during each use
Pre-shipment leakage rate test of cask lid and lid port coverplate containment O-rings	Prior to each loaded transport
Maintenance leakage rate test of containment system	After replacement or repair of containment boundary components
Replacement of lid and lid port coverplate metallic O-rings	Prior to each loaded transport
Visual inspection of impact limiters for structural or penetration damage	Prior to each loaded transport
Inspection of quick disconnect for proper function	Each cask use
Replacement of non-containment O-ring	Annually, or as required by inspection during operations
Maintenance Program Schedule MP197HB	
Task/Activity	**Frequency**
Visual inspection of cavity	Prior to loading
Visual inspection of O-rings	Prior to loading
Visual inspection of neutron shield shell segments for structural or penetration damage	Prior to loading
Visual inspection of cask lid bolts and lid port coverplate bolts	Prior to installation (each use)
Visual and Proper Function Inspection of Cask	Prior to and during each use
Visual inspection of lifting trunnions and rotation trunnions	Prior to and during each use
Periodic leakage rate test of cask lid and lid port coverplate containment O-rings	Annually during use
Pre-shipment leakage rate test of cask lid and lid port coverplate containment O-rings	Prior to each loaded transport
Maintenance leakage rate test of containment system	After replacement or repair of containment boundary components
Replacement of lid and lid port coverplate metallic O-rings	Prior to each loaded transport
Visual inspection of impact limiters for structural or penetration damage	Prior to each loaded transport
Impact Limiters Leak Test	Once every five years
Inspection of quick disconnect for proper function	Each cask use
Cask Ram Access Cover Plate	Seal replacement each shipment
Replacement of cask lid bolts	Every 250 round-trip shipments, or as required due to thread damage

6.1.5 Transport Operations

Special Permit Requirements

The following permits for transporting the loaded transportation casks from the KPS ISFSI would have to 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 KPS site to the Class I railroad, Canadian National Railway, which would clear the entire route with all participating railroads.
- DOE Manual 460.2-1A states "For shipments not subject to an NRC license, DOE will be responsible for stakeholder interactions, final route approval, and other applicable safeguards and security requirements. DOE will meet or exceed the requirements prescribed by DOT and NRC for comparable commercial transportation."
- The shipper, for the purposes of this report, would be DOE, and the shipments are assumed conducted like comparable commercial shipments. Therefore, although typically not required for DOE shipments, it is assumed that DOE would file an application with the NRC for an approved rail and HHT route from the KPS site to the identified destination.

Note: a formal clearance submission is required for all dimensional shipments on all railroads involved in the full route. With loading at the recommended site in Green Bay, since the shipment will originate on a Class I carrier, the clearance will be submitted to Canadian National Railway for the rail movement and it will clear the entire route to the final destination, in this case to the GCUS.

At this time, it is acknowledged that shipments by DOE would not be subject to NRC oversight, because DOE would not be an NRC licensee. However, the status of a future Management and Disposal Organization is unknown at this time. DOE policy is to meet or exceed the requirements of the DOT and the NRC for comparable commercial shipments, unless national security or another critical interest requires different action. Thus, this report recommends and assumes that the same rules would be followed as for commercial shipments. In this report, DOE is treated as though it is subject to NRC regulations just as any commercial shipper.

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

1) Identification of the origin, the destination, the standard transportation commodity code, the shipper, receiver, and associated serving carriers, and the route (including interchange locations for the requested route).
2) Identification of the specific railcar to be used for the shipment.
3) All dimensions of the loaded unit on the railcar, which depict a profile of the loaded unit and car together. 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 Rules (OTR) 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 Hazardous Material (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 superload permits for movements of similar weight and dimensions and HAZMAT (Class 7). Once the route is approved, 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 final destination). The minimum amount of time to submit routes to the NRC for approval is 90 days; however, they 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 would need to be resubmitted after 6 months to ensure no changes have taken place on the rail route that would affect the ability for the dimensional load to pass the route safely without striking anything (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.

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 KPS for the loaded transportation casks. The permits will also dictate the requirement for private escorts (not the security team) and State Police escorts for both the mobilization and demobilization efforts of the equipment. These escorts are in addition to those required by the regulations for LLEA for safety and security purposes.

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 KPS 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 and operating the pilot 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: ACTIVITIES TO PREPARE FOR AND REMOVE SNF AND GTCC LLW FROM KEWAUNEE ISFSI [49]

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 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 Off-site Transport	Load and prepare casks and place on transporter's trailer for off-site transportation.
8	Accept for Off-site Transport	Accept loaded casks on transporter's trailer for off-site transportation.
9	Transport	Ship shutdown site casks.

Additional Coordination Efforts

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

- All diagrams, including dimensions, center of gravity, and weights must be obtained, preferably in Computer Aided Drawing (CAD) format[7] and provided to both the heavy-haul truckers and riggers for use in planning the HHT movement (and securement on the trailer) and the lift and rigging arrangements.
- Any lift diagrams or transport diagrams from the manufacturer should be provided to both the heavy-haul truckers and riggers for use in planning the lift and rigging arrangements at both the ISFSI and at the rail transload site.
- This information is used by the trucking company and rigger to develop accurate engineering drawings of the transportation cask and cradle on the specific piece of equipment being used for the movement (e.g. Goldhofer, trailer, and crane equipment).
- The drawings developed by the trucking company of the transportation cask and cradle on its trailer will be submitted with the road permit applications. These diagrams would be shared with the team, including coordination with the crane company and riggers.
- Load securement information, including weights of the components in transport configuration, plus the weights of the trailers, would be used to determine and verify vehicle axle weights to meet all safety requirements for the short haul from the ISFSI to the rail transload track in Green Bay, WI.
- The local utilities must be brought into the work plan for overhead and underground clearances, if any are impacted. While there are overhead wires in the vicinity, they do not appear to be over the rail track or within reach of the crane's boom at the rail transload site. The location of any obstructions will be identified in the formal truck and transload site surveys.
- The transportation plan must include: State of Wisconsin DOT inspections, securements, routing issues (obstructions, bridge reinforcement, weight restrictions on road or rail track, etc.), document checks, notifications, and briefings.
- Wisconsin DOT is expected to inspect the empty truck equipment upon arrival at the ISFSI before loading and again once the transportation cask has been loaded onto the trailer to ensure the loaded dimensions and weights fall within the approved trucking permits for the movement from the ISFSI to the rail transload location.

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

[7] CAD diagrams are used to place the unit onto a CAD of the railcar to take all final measurements of the loaded and secured unit for the formal clearance submission. Clearance is granted based on dimension and weight information presented to it, including the specifics of the identified railcar.

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 Railroad (in this case the same as the Class I railroad):

The private rail siding at the recommended site in Green Bay is served by the Canadian National Railway. 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. 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 operations, planning for the placement, inspection of the loaded train, and all other operations including establishing the mechanics for pulling the released train from the site and obtaining the transit schedule for delivery to the GCUS.

- Develop safety and security plan for the rail transload site and notify serving carrier, Canadian National Railway, of the plan in place and provide a contact name and number for the site. Provide proper notification that the transload site will be designated as a "rail secure area".
    - The recommended site is a paper products manufacturer and probably has not been designated as a rail secure site with the railroad, so this must be established.
    - 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.
- Determine if railroad police will be present during the manned interchange and any other stops along the route on the way to the destination. 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.

- Hold initial meetings with the Class I carrier to explain the movement, provide estimated number of trains to ship, discuss the dedicated train requirement, and begin rate negotiations for the trains.
- Mention current safety and security measures for the site to ensure the railroad is aware of special considerations and operating procedures in case they have no familiarity with these requirements:
    - Note and discuss safety features that will be added to the site: fence, lights, defined perimeter, etc.
    - 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 on 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 Following:

- 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.
- 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 transportation casks have been conducted and copies provided.

- All procedures associated with the transportation of the loaded transportation casks, including the State of Wisconsin DOT-issued HHT permits to move from the ISFSI to the rail transload site are provided.
- Proper documentation is provided to demonstrate the required security plan is in place and has been approved by the USCG for the rail transload site, as site is located along the Fox River. The railroad would also need to be informed that the site has been designated as a "rail secure" facility. The railroads do not approve the plan, but the serving carrier must be informed a plan exists and a contact name must be provided.
- Since the transload site is along a water body with potential easy access to the loaded train, the KPS site will inform the USCG when rail operations will commence, so it will be aware of the activity on the site and possibly evoke a Marine Safety Zone during active operations if required.
- If the transload site has an existing MTSA plan in affect for the plant site, adopt that plan and make necessary changes and submit the revision to the USCG for approval.

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 Tribes, NRC, State and local governments, DOT, USCG, and DOE as applicable. The USCG would need to be notified because the transload site is located immediately on a navigable waterway, at the water's edge, and it should be aware of the transportation activities taking place on site.
- It is recommended that any water served or adjacent facility should have an active safety and security plan in place while campaign activities are taking place, and in compliance with the regulations, the security team must be on the site once the transportation casks begin to arrive.

- The USCG must review and approve the MTSA plan or altered plan if one already exists for the transload site.
- Provide copies of and ensure all required permits to transport SNF are prepared and/or in place.
- Ensure proper notification requirements are being met for the disposal/storage facility.
- Identify scheduled meetings and briefings that would be conducted for all phases of the shipments.

Transport Operations

Truck Transport to the Rail Transload Facility

Once the transportation cask is loaded onto the trailer at the KPS ISFSI, it would be secured by the truck driver and his team. The State of Wisconsin DOT inspection will be ordered and the private and State escorts will arrive. In accordance with the granted state DOT trucking permits, the convoy would then proceed to the rail siding which is approximately 35 miles from the ISFSI. The convoy, including the armed security escorts will only travel on the permitted route during the permitted hours, as identified in the truck permits. The driver would proceed to move into position at the rail track.

Hours of operation will be in accordance with the issued truck permits, which will dictate the number of casks that may travel in one day. For purposes of this report, the assumption is that two casks per day will move from the ISFSI to the rail transload site. Local law enforcement personnel would provide the physical protection of the load during the transport, and private escorts required by state DOT will be provided by the trucking company due to the dimensional aspect of the load.

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

Once the briefings have been completed and approval for shipment obtained, the transportation team would be assembled and staged as directed by the transportation supervisor. The applicable transportation-related paperwork would be given to the driver(s), a communication check would be performed with the transportation team and the Movement Control Center (MCC), and other stakeholders as necessary. Verification would be obtained that the rail transloading site is ready to receive the shipment. The shipment would be released and conducted as directed by the Transportation Supervisor and procedure(s).

In compliance with the issued road permits, the truck convoy will exit the KPS ISFSI gate and proceed along the access road toward WI-42 to travel to Green Bay, WI along the approved DOT route. No stops are anticipated during the short transit.

Continuous shipment tracking would be monitored and communicated by the MCC. This would be achieved by global positioning system (GPS) monitoring equipment (or other similar designated equipment as approved by the regulations). It will be located on the transportation cask truck. The

MCC would maintain continuous communication with the transportation team, including security using redundant radio equipment in compliance with procedures and would monitor the GPS continually to track the shipment progress in real time. A log would be maintained and used by the MCC as required by regulation.

Shipment speed, route, and duration would be monitored and controlled by procedure and managed by the transportation supervisor with support from the MCC.

The over-the-road portion of the shipment would be considered completed once the truck has safely arrived at the rail transload facility and is positioned inside the fenced and secured location as required by regulation. Transportation paperwork for the shipment would be delivered to the management team at the rail transload facility in Green Bay.

Performing the Transload from HHT to the Railcars

The loaded HHT trailer/Goldhofer would meet the crane at the rail transloading track, where the train is already staged. The receiving fixtures would already have been welded to the railcar decks in preparation for loading. This enhances the accuracy of the loading, as 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 confirm with the approved clearance window for the rail shipment.

The truck will park parallel to the crane, which is positioned along the unloading track. The crane will lift the transportation cask and its attached cradle together, move it 180 degrees, and place it onto the positioned railcar. The Goldhofer will return to the KPS ISFSI and the cycle will be repeated until all five casks are delivered to the rail siding. For purposes of this study, a second trailer is planned for the campaign and will be loaded at the KPS ISFSI while the first transportation cask is being unloaded at the transload site.

Performance of a visual inspection of the installed transportation casks, cradle, 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 cradle main beam web-to-flange-welds, the beam webs, plus checking the tie-down structure for any signs of distortion or failure.

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

The crew then proceeds to secure the cradle to the railcar ensuring compliance with the AAR OTR. Specifically, all restraint values would meet the stated requirements of 7.5G x 2G x 2G[67], the requirement from the DOT and what is required for load securement in the transportation cask SAR.

Once the transportation cask is secured to the railcar and internal 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 are on the train (as with some existing Department of Defense shipments) and perform a visual inspection of the train’s safety devices. The appropriate party would issue the electronic bill of lading (BOL) to the serving railroad, the Canadian National Railway.

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

Once the serving railroad, Canadian National Railway, 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 Canadian National Railway train crew at the rail transload facility, the Rail Transload Supervisor will unlock the gate and allow entry of the train crew into the site. This will be a documented and manned release of the loaded train from the transload facility to the Canadian National Railway train crew. The chocks would be removed and the locomotive would attach to the loaded train and pull it from the facility. The Rail Transload Supervisor would unlock the gate and 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 Canadian National Railway train will leave the facility and proceed to the GCUS directly with no other interchanges or stops in the journey for interchange before arrival. An estimated transit schedule would also be provided to the shipper for the train movement. The ability to monitor and trace the train would be limited to need-to-know personnel.

Upon arrival, the Canadian National Railway train crew would document the manned interchange, deliver the loaded train to the designated track and then disengage its locomotive. Advance notification would be provided to the GCUS location to coordinate the manned and documented interchange or placement at the site.

6.1.6 Demobilization

Once the 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 KPS ISFSI and returning it to its proper owner in accordance with rental / lease agreements. This includes returning any leased property to the proper owner in the agreed upon condition in accordance with the lease, which may include leaving added pads, fences, and lighting in place.

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

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

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

The empty VCCs and HSMs would remain onsite for disposition by KPS as potentially contaminated and activated materials. In addition, the ISFSI site, after all removal of all NAC and TN storage systems, would be decommissioned in accordance with NRC and site regulatory requirements.

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

6.2 Resource Requirements / Staffing

At the KPS 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

- Rail Transload Supervisor
- Rail Transload Security Team
- Cask Operations Technicians/Mechanics
- Tractor /VCT Driver and Equipment Operators
- QA/QC Specialist
- Security Personnel

6.3 List of Ancillary Equipment

TABLE 6-4: ADDITIONAL EQUIPMENT FOR KPS SITE TRANSFER

Additional Equipment for KPS Transfer	
Primary Mobile Crane (375-ton)	Required for horizontal lifting of the MP197HB transportation cask and vertical lifting and movement of the MTC, the vertical lifting and movement of the MAGNATRAN cask, the upending and downending of the MAGNATRAN transport cask from and to the intermodal transport cradle/frame located on the HHT or on the ground and subsequently lifted horizontally and loaded onto the railcar and HHT.
Secondary Mobile Crane (15-ton)	Required for lifting ancillary items, such as VCC lid, HSM door, transfer adapters, transport cask lids, transport impact limiters, and personnel barriers.
Man basket/ lift or pre-assembled scaffolding	Capable of accessing the top of the MAGNASTOR TFR when in stack-up position on the VCC or MAGNATRAN cask will be required for removal and re-installation of the VCC lid and MAGNATRAN transport lid bolts, handling of the Transfer Adapters, Transfer Shield Ring, installation and removal of the TSC lift adapter plate, etc. of the TSC lifting slings.
Lifting Rigs	See Section 2.3 for details.
Standard rigging and supplies	See Section 2.3 for details.
Diesel-Powered Air Compressor	See Section 2.3 for details.
Standard tools	These include personal protective equipment (PPE), communications equipment, wrenches, etc.

TABLE 6-5: OFF-SITE HHT TRANSPORT

Off-Site HHT Transport	
2 Goldhofers	Final size to be determined by the truck survey, assuming use of 12 lines for this activity.
1 Truck Cab- Prime Mover	To provide motive force to Goldhofer.
Standard tools	These include PPE, communications equipment, wrenches, etc.

TABLE 6-6: EQUIPMENT FOR THE TRANSLOAD FACILITY

Equipment for the Transload Facility	
Crane: 375-ton mobile crane	Crane would be used to conduct lift operations removing the MAGNATRAN cask package and intermodal transport cradle combination from the trailer and placing it onto the railcar.
Large forklift	Used to move heavy equipment onsite, pick up and relocate heavy objects, and reposition train if required.
Man basket	Used to inspect and measure the loaded railcars 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 required per AAR S-2043.
Buffer cars	Used to provide buffer between loaded overpack cars and all other cars.
Load (cask) 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.

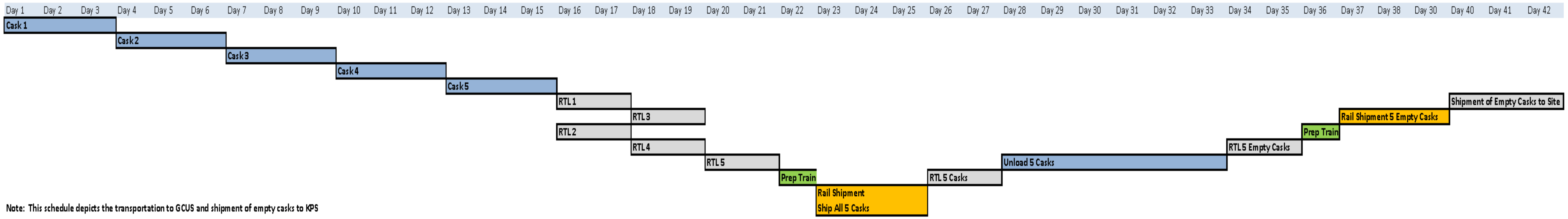
6.4 Sequence of Operations / Schedule

The operations would be sequenced as described in Section 6.1.

For the onsite loading sequence, it is estimated that 3 8-hour days per loading will be required to move the MAGNASTOR VCC, off-load the transport casks, retrieve the canisters from the storage casks into the MTC and NUHOMS transfer trailer, load the TSC/canister into the transport casks, close and prepare the casks for transport (e.g., evacuation, helium backfill, leakage testing), place the loaded casks on the transport vehicle/horizontal transport cradle and release for transport, and move the empty VCC back to the ISFSI pad. Therefore, for a 5-cask train, approximately 3 weeks will be required.

The sequence of operation timeline, **Figure 6-2**, outlines the operations associated with the facility at the KPS site, off-site heavy-haul transportation services, and the off-site railcar loading facility. Note that some operations could be done concurrently (equipment staging and some inspections) to reduce time, but this was not considered in the development of this timeline. Transfer operations at the KPS site would include the transport casks handling operations to transfer the casks and preparation for shipment. The transit times listed in **Figure 6-2** are provisional and may change as route details and operations are better defined. The transfer of the canisters from the storage units to the transport casks is estimated to take approximately 3 8-hour days per cask. Cask loading and transport of the casks from the KPS site to the off-site rail siding, conducting the transload from the HHT to the railcars, and securing the cask/intermodal transport cradles to the railcars and preparation of the train will take approximately 21 days. The total evolution from the initial transfer of a canister from a storage cask to a transport cask to the return of the empty casks to the KPS ISFSI takes approximately 42 days.

FIGURE 6-2: SEQUENCE OF OPERATIONS



Note: This schedule depicts the transportation to GCUS and shipment of empty casks to KPS

Assumptions

1) Only 1 train is used, consisting of 5 cask cars
2) Starting condition: 5 cask at site empty ready to load
3) 2 HHT used to transport the cask from site toRail Transload (RTL) site
4) 7 Day work week / 8 hour work days
5) No concurrent work i.e., only one system handled at a time
6) Rail spur is adjacent to unloading facility (no travel time)
7) 3 days to transfer a canister into a cask
8) 2 days to ship and load the cask onto the rail car
9) 1 day to inspect the rail cars and process shipment paperwork
10) 3 days to ship the loaded casks via rail
11) 2 days to transload the loaded casks off of the rail cars
12) 4 days to unload the canisters from the casks
13) 2 days to transload the empty casks onto the rail cars
14) 3 days to transport the empty casks to Kewaunee
15) No contingency is added

Results

21 days to load the train rail cars
6 days for rail shipment
42 days per 5 cask shipment (round trip)

For the resources estimate, the timeline of the operations can be broken down into:

- 2 round trip shipments of 5 MP197HB packages and 1 one-way shipment of 4 MP197HB packages over a period of 6 weeks each
- 4 round trip shipments of 5 MAGNATRAN packages and 1 one-way shipment of 4 MAGNATRAN packages over a period of 6 weeks each

Table 6-8 estimates the resource requirements needed to support this de-inventory campaign. An additional 8 weeks of planning and preparation is added before the start of the first campaign. The level of detail is the week.

TABLE 6-8: OPERATIONS TIMELINE WITH REQUIRED RESOURCES

	Major steps for a 38 TSC campaign	Resources required [in full-time equivalent (FTE)]*											Estimated Duration (in work weeks)
		OM	COSS	TS	PW	RP	TC	CO	RM	EO	QS	SP	
1	Detailed operations planning, campaign preparation, equipment mobilization, procedure preparation and approval, training program, pre-loading review(s) and dry run(s)	1	2	1	2	2	1	2	6	2	1	3	8 weeks prior to start 1st campaign
2	Onsite transfer of the SNF and GTCC canisters and preparation of 5 packages	1	2	1	1	2	1	2	6	2	1	3	2 weeks per 5-cask campaign
3	Trucking of 5 packages to transload location	0.5			1		2						1 week per 5-cask campaign
4	Shipment to destination by rail	0.5			1		2						1 week per 5-cask campaign
5	Unloading	0.5	1		1	1	2						1 week per 5-cask campaign
6	Return transport of empty casks	0.5			1		2						1 week per 5-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 measure for work with dry cask storage of SNF. Infrastructure requirements that would be required for transitioning from essentially a static, monitoring condition of the storage of SNF to an active worksite that involves handling and loading operations would be considerable. Stranded sites that are no longer staffed with trained and qualified health physics personnel would be dependent upon either loaned labor from the utility, if those resources are still available, and/or contract health physics staff. In addition, portable survey instruments, portable Continuous Air Monitors (CAMs), 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 20 and 10 CFR 72, sufficient controls must be in place to protect the workers and the public from radiation. Therefore, at a minimum, the following requirements must be satisfied prior to commencement of radiological work activities at the site:

- Approved radiological control procedures in place
- A sufficient number of trained and qualified RCTs are mobilized and ready to support operations at the pad (estimated at one supervisor and three RCTs per shift)
- Sufficient quantity of radiation control equipment and consumable supplies on hand to support the planned work activities (PPE, signage for posting, radwaste controls, etc.)
- Qualified RP/ALARA supervision assigned for oversight of radiological work activities
- Personnel dosimetry for monitoring worker doses including Thermoluminescent Dosimeters (TLDs) 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 Plan (QAP) meeting the requirements of 10 CFR 50, Appendix B (within owner-controlled area); 10 CFR 71, Subpart H (as related to transportation); and 10 CFR 72, Subpart G (within the ISFSI site), as applicable to the scope of work. The licensee's QAP is to be used to control activities performed by the licensee (qualified cask user/operator) in accordance with 10 CFR 71.

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

Fabrication of important safety components and support equipment for the NAC MAGNASTOR / MAGNATRAN and AREVA TN NUHOMS and MP197HB Systems would be controlled under the licensee's QAP or by a qualified supplier's QAP that has been approved for this scope of work. Component classification guidance is taken from Regulatory Guide 7.10 [61] and NUREG/CR-6407 [62] 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 KPS campaign organized over 56 calendar weeks is $19.3M. 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. These estimates are based on operations being performed in the current calendar year (2017). This section provides a breakdown of the estimated campaign costs of de-inventorying the KPS 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 set of 5 NAC MAGNATRAN transport casks, 5 pairs of impact limiters, 5 personnel barriers, 5 transport cradles allowing the upending/downending of the casks, etc. 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.
2) A set of 5 MP197HB transport casks, 5 pairs of impact limiters, 5 personnel barriers, 5 transport cradles for loading and unloading a canister into the cask, etc. are provided by the cask vendor. Ancillary equipment to prepare the transport cask for transportation (tooling, lifting yoke, spreader bar, leak test equipment, VDS, etc.) will be supplied by the cask vendor. No estimate is provided here.
3) Cask railcar, escort car, buffer car, 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) 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.
7) No additional onsite fencing and lighting is considered at KPS. Lighting and fencing estimates are provided for the transload location only.
8) A total of 8 iterations of 6 weeks each will be necessary to complete the de-inventory as described in Section 6.4. In addition, another iteration of 8 weeks is added and will happen before the first shipment for campaign readiness, procedure writing, dry run, testing, and training purposes.
9) Pre-loading canisters inspection activities are not included in the cost estimates.
10) Does not account for potential impact of additional specific local regulatory requirements, if applicable, and assumed labor performed by vendor-approved specialists.
11) The workload and the labor resources needed to support the loading operations for each canister are conservatively considered to be the same for the TN and NAC systems as

described in Section 6.4. The transport operations are assumed to be similar for NAC and TN systems.

7.1 Fees and Permits

The estimated permit fee for the trucking from the site to the transload facility is estimated to cost around $3,000 per one-way move. These fees are included in the trucking costs.

In addition to this cost, an estimated fixed cost of $50,000 for the physical road survey would be expected. This would be charged upfront as the road survey would have to happen within a few months prior to the actual moves.

Additional costs for the NRC route approval processing, preparation of the security plan, route survey, and the clearance are to be expected.

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 Operations Management Team would be composed of a Project Manager, Plant Manager/Coordinator supported by a Scheduler, and Transload Operations Manager.

The estimated cost for the Management crew for the 56-week campaign is $1.2M. 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 onsite, the lease of two 375-ton cranes (one at the loading site and one at the transload facility), and operators for 56 weeks at the shipper site for one large forklift, two man baskets, three welding machines, miscellaneous supplies, a telescopic handler and the mobilization/demobilization of the equipment would be approximately $3.3M for the duration of the KPS campaign.

In addition to this equipment, NAC transfer equipment comprising one MAGNASTOR Transfer Cask (MTC2); two Transfer Adapters; Auxiliary Hydraulic System; one Secure-Lift Yoke and Hoist; one VCT; and one Diesel-Powered Air Compressor would be necessary for the loading operation of the NAC systems. The lease cost of the equipment including the mobilization and demobilization is estimated $3.9M.

Additional equipment is also necessary for the transfer of the TN NUHOMS system, including the NUHOMS HSM lid handling system, hydraulic ram and HPU system, transfer trailer, transfer skid, skid positioning system. The lease cost including the mobilization and demobilization costs of this equipment is estimated to be $1.2M.

Two Goldhofers and their tractor/prime mover used to transport the VCC onsite and the loaded transport casks to the transload location or to return the empty casks from the transload facility will be required to support the transport operations. The cost of lease of the trucking system is estimated $4.3M. This cost includes the drivers, the permits, and transportation costs.

No cost for a new building is considered here.

7.4 Site modifications

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

The fencing and the lighting of the transload site is estimated to cost $0.4M.

7.5 In-Transit Security

The in-transit security comprising the security crew is estimated $0.25M for the movement to the Class 1 railroad for the campaign. These costs will be included in the overall security costs for the entire movement to the final destination as it is reasonable to assume the same security crew will be responsible for the security over the entire shipment. The security at the shipping site would be ensured by the crew already in place at the site. The security at the transload facility is included in the cost identified above for the in-transit security cost. The security in transit on the train is not included in this cost estimate.

7.6 Cask Transportation Services to Transload Site

The Cask Transportation Services team would consist of a Transport Coordinator located onsite who would coordinate the transport operations with truck drivers, support the shipper in the preparation of shipping documentation, and marking, labeling, and placarding. He 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).

Two Goldhofer systems would be used to perform the transport operation of one overpack at a time. It is considered here that the tractors will stay onsite for the entire duration of the campaign along with one driver and one technician. The cost of the Goldhofers and prime movers is already included in the costs of the ancillary equipment and is therefore not included here.

The estimated costs for the overpack transportation services are $1.4M for the entire campaign.

7.7 Onsite Operations

The shipping site operations would be composed of the crew listed in Section 6.4. The estimate for the whole crew for the onsite operation is $3.5M for the entire campaign.

7.8 Breakdown of the Costs by Activity

This section provides a breakdown of the estimated $19.3M cost of de-inventorying the KPS site, by activity, and to the extent cost information is currently available.

- Equipment (e.g., transportation casks, railcars, cranes, movers, etc.): >$12.6M (cost of casks and railcars is not included)
- Transportation services and security: $1.7M
- Management and labor: $4.6M
- Infrastructure: $0.4M

7.9 Additional Cost Estimates to Support De-Inventory Activities

Additional costs are 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: cask consist transportation services (loaded and unloaded) costs; emergency response center operation costs; railcar maintenance services costs; and transportation cask maintenance and compliance costs. Estimates for these costs are provided in the following sub-sections; however these costs have several significant conditions associated with them including:

1) The shipment of the consist occurs in the current quarter of the calendar year (3rd quarter of 2017), as rates are temporal.
2) The representative rates apply to Canadian National Railway, which currently has no settlement agreement with the U.S. DOE and is conservative when handling hazardous material shipments.
3) The transportation casks meet the 10 CFR 71 regulatory limits (e.g., thermal, structural, and radiological) at the time of shipment.
4) 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 MAGNATRAN and MP197HB) and are similar to one another.
5) 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.
6) The transportation cask systems and railcars are assumed to be leased to DOE and maintained at vendor operated facilities.
7) 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 KPS ISFSI and the portion of the facility and communication equipment needed to support the shipments from the KPS 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 Cask Consist Transportation Services Costs

For the Canadian National Railway movement of a single rail consist from the Green Bay, WI transload site to the GCUS site, which is a point-to-point distance of approximately 653 railroad miles, costs were developed to be comparable to current market rates for radioactive materials rail shipments and include:

- Freight Costs per Consist: $815,000 to $1,100,000
- Special Train Movement Costs: $122/mile or $79,666/consist

- Current Fuel Surcharge Costs: $0.0480/mile/car or $250.75 (this surcharge adjusts on a monthly basis)
- Total Estimated Costs: $895,000 to $1,180,000/consist (per round trip)

Therefore, the average freight cost of shipping the consist, which is assumed to be made up of 5 cask cars loaded with transportation casks either containing SNF or empty, 2 buffer cars[8], and an escort car, is approximately $1,000,000 (2017). This value includes the shipment of the consist from Green Bay, WI to GCUS and the return trip of the empty transportation casks on a dedicated train for the loaded movement and merchandise train for the empty return and includes the use of two locomotives in both directions. Since the selected route includes no interchanges, no switching charges are included in this estimate. These costs also assume all shipments are made up of the heavier MAGNATRAN transportation casks (MAGNATRAN's ~360,000 lbs vs. MP197HB's ~335,000 lbs).

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 FEMA training would also be useful.

The estimated costs for a crew satisfying these assumptions is between $1.6 and $2.4 million (2017) per year. This number is considered independent of the number of shipments and includes the costs for an office and associated communication equipment.

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

7.9.3 Estimate of Railcar Maintenance Services Costs

To develop an estimate for railcar maintenance services costs, a combination of experience from an existing fleet of railcars used to ship low level waste in the U.S. and activities involving the design and potential building of AAR S-2043 compliant cask and buffer railcars for SNF shipment was utilized. For the purpose of estimating these costs, they are assumed for a single consist, made up of the aforementioned two buffer cars, five casks cars, and one escort car and dedicated to the de-inventory of the KPS 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 are estimated to be approximately $100/month/car.
- Cask car (12 axles) maintenance costs are estimated to be approximately $200/month/car.
- Escort car (4 axles) maintenance costs are estimated to be approximately $250/month/car.
- Costs associated with administering a fleet maintenance program are not included.
- The period of performance is assumed to be 12 months for the 46-week estimated schedule.

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

As noted above, routine maintenance activities for railcars are generally provided by the railroad and a portion is covered in freight rates. Maintenance work beyond routine serving of the cars is estimated to be in the range of $5,000 to $25,000 (2017) per major inspection period for the five cask cars and between $2,000 and $10,000 (2017) for the two buffer cars. This cost estimate covers a single maintenance occurrence, when the car is inspected and major maintenance is performed. Typically, major maintenance can occur every 100,000 miles, annually, or at a five year routine inspection, whichever comes first. Due to the sensitive nature of the composition of the escort car, details on the cost for maintenance services are not readily available, but for estimating purposes a range of $10,000 to $50,000 (2017) per major inspection period should be assumed for an escort car. This cost includes maintenance activities involving the rail portion/undercarriage of this car (e.g., trucks, axles, etc.), but does not include any repairs or upgrades to the electronics/instruments located on the escort car.

Using this data, a range of $17,000 to $85,000 (2017) per major inspection period would cover the maintenance costs for the consist to be used to de-inventory the KPS ISFSI; however the more probable cost is approximately $19,000 (2017) per major inspection period.

7.9.4 Estimate of Transportation Cask Maintenance and Compliance Costs

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

- One single shop is assumed to be used to perform the maintenance for all the transport casks (including those from different cask vendors).
- Costs associated with the transport to or from this shop are not included, as its location has not yet been established (although an economic argument could be made to locate this facility near the receiver site to minimize the transport costs).
- The shop where maintenance activities are to take place must have approval from the State to perform radiological work and dispose of the radioactive wastes potentially generated by the maintenance activities, noting the shop will need to open potentially contaminated transportation casks that may result in the release of some contamination.
- The shop must provide facilities for the storage of transportation casks, potentially for long periods of time.
- The shop must also allow for the training of personnel on cask maintenance operations.
- The shop must provide a covered building to allow maintenance operations to occur under any weather conditions and at any time of the year.
- The shop must be able to receive and store railcars (preferred) and/or HHT and ideally be connected by a rail spur to a major railroad.
- The shop must be equipped with a crane capable of lifting a transportation cask and the associated cradle/skid from a railcar or HHT.
    - Conservatively, the lifting capacity of this crane would need to be approximately 375 tons, although the transportation casks brought to this facility will be empty (i.e., will not include a canister with SNF).
    - From a nuclear safety standpoint, no critical load lift is necessary and hence, the crane does not need to be designed as single failure-proof.
    - The crane hook and height of the crane must be compatible with the lifting of yokes and associated rigging supplied by cask vendors.
- Some details of the transportation cask maintenance program will be different between cask vendors, however the bulk of the maintenance costs are assumed to involve the following larger scale common activities:

  - External decontamination of the casks
  - Internal decontamination of the casks
  - Replacement of sealing gaskets
  - Periodic maintenance and leak testing of the containment boundary
  - Load tests
  - Maintenance of spare parts
  - Maintenance of the leak testing tools
  - Maintenance of cask leak testing equipment
  - Maintenance of the vacuum drying systems
  - Maintenance of lifting and support equipment (yokes, trunnions, skids, etc.)
- Leak testing will be performed according to ANSI N14.5-2014, unless specified otherwise in a Safety Analysis Report, by an American Society for Nondestructive Testing (ASNT) Level II cask operator.
- The maintenance program will be approved by an ASNT Level III reviewer and performed in accordance to the specifications identified in each transportation cask's Safety Analysis Report.
- The single shop will require a radiation protection plan that will be implemented and maintained.
- The size of the facility and the staff are assumed to limit maintenance to only one cask at a time.
- The staff at this single shop will be composed of 2 trained operators, some engineering support, a ½ time ASNT Level II cask operator, and a part time ASNT level III procedure writer/reviewer.

Given these assumptions, the estimated annual transportation cask maintenance costs will range from $2.1 to $2.9 million (2017) per facility, which is assumed to handle only one cask at a time.

8.0 SAFETY AND SECURITY PLAN AND PROCEDURES

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

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

The transportation activities covered by the plan include the shipment, by HHT, of the casks from the KPS ISFSI site to the designated transload site in Green Bay, WI, for final delivery via rail to the hypothetical destination of the GCUS.

The basic statute regulating HAZMAT transportation in the U.S. is 49 U.S.C. 5101 et seq. Section 5101 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 (HMR) in 49 CFR 171-180 and represents the DOT in international organizations. Another organization that will be involved in the transportation of overpacks from the KPS ISFSI site is the USCG. The relevant regulations addressing the security of SNF during transportation include: 49 CFR 172-177; 10 CFR 73.20, 73.37 and 73.72; and 49 CFR 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 (FAA), 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 aforementioned Maritime Transportation Security Act of 2002 (MTSA) is assumed to govern the water-served site, even though the recommended mode of transportation is heavy-haul truck to rail in Green Bay. 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 to both sites. 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 proximity of the site and transload site to navigable waters, additional security precautions should be implemented. In consultation with the USCG, a facility security plan should be developed as described in the MTSA. Likewise, when movement of SNF is occurring on site, the USCG should be notified to monitor and patrol the navigable waters adjacent to the facility to provide a secure maritime area, even if the selected mode of transportation is land-based. In addition to the maritime security measures for the rail-served transload site, the railroad will be notified of the "secure rail access" establishment/status of the site, as required. This means all provisions of the Safety and Security Plan will be adhered to and enforced and effectively, a layered security approach is established to govern the sites for ISFSI transload operation, the HHT-to-rail movement, and the rail transload operations.

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

8.1 Safety and Security Plan Requirements

Security plans are addressed by the Federal HAZMAT Law 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 materials included in 49 CFR 172.800, which includes highway route controlled quantities of radioactive materials, and must address the identified risks including security while the material is en route. The Security Plan, used interchangeably throughout this report with Safety and Security Plan) must also provide protection of the ISFSI facility and transload activities incidental to the transportation, including loading and unloading operations. This document assumes the provisions of the MTSA of 2002 are applicable. No formal determination has yet been made by the USCG or the NRC as to its implementation.

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.
- 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.
- Identification, by job title, of the senior management official responsible for overall development and implementation of the Security Plan.
- Security duties for each position or department responsible for implementing the plan and the process of notifying employees when specific elements of the Security Plan must be implemented.
- A Training Plan for HAZMAT employees in accordance with 49 CFR 172.704 (a)(4) and (a)(5).
- 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 the 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. The risk assessment will address:

- An assessment of transportation security risks for shipments of the specific HAZMAT listed in 49 CFR 172.800 (includes radioactive materials).
- Site-specific or location-specific risks associated with facilities at which the HAZMAT is prepared for transportation, stored, or unloaded incidental to movement (rail transload facility).
- Appropriate measures to address the assessed risks.
- 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 (KPS) 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 Safety and Security Plan:

- The Security Contractor will 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 maintain a high level of confidentiality and security.
- 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 Transfer Installation to be Used

The following should be considered for the selecting and/or utilizing a secure, existing transfer installation:

- 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. Assuming MTSA jurisdiction over the site and transload locations, TWIC identification cards would be mandatory for workers.
- Limit communications to only direct contacts and their direct reports.
- Do not use public email for communications. Use only direct communication by telephone or through a secured website.

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, identify potential bottlenecks, narrow roads, interstate highways, proximity to hospitals, schools, civic centers, shipping channels, and highly populated areas.
    - The assessment should include a 10-mile area 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" [39] and the Enhancing Security of Hazardous Materials Shipments Against Acts of Terrorism or Sabotage [50].
- Existing site security plans (transload locations) will be incorporated into the safety and 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, 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 [50].

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 Development of Security Plan and Protocols for Marine Facilities

The following will be considered in the development of a Security Plan and associated protocols for a marine facility site (KPS and Green Bay transload sites).

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

- Development of a Facility Security Plan (FSP). The FSP identifies procedures and processes for transportation activities on site. The FSP is implemented by a Facility Security Officer (FSO) and submitted to the COTP for the particular Sector in which the site is located. The RSAT will conduct a security assessment up to the entrance of the marine facility. A review of the FSP in effect inside the marine facility will be conducted with the permission of the USCG COTP.
- Coordination with the COTP for development of an Area Maritime Security Plan. This plan identifies procedures for handling the maritime domain surrounding the facility during a transportation activity. Included in the Area Maritime Security Plan would be buffer zones where commercial or pleasures vessels would not be permitted during a transportation activity at the site. If vessels are to be used to transport SNF, the vessels would need a Vessel Security Plan (VSP). The VSP outlines vessel security and identifies the Vessel Security Officer (VSO), who would be delegated the responsibility of implementing the VSP and coordinating with the USCG and the FSO during a transportation activity.

8.10 Railroad Security Requirements

The following are railroad security-related requirements:

- On November 26, 2008, the TSA published new rules regarding the rail transportation of certain HAZMAT, which became effective on December 26, 2008 [51]. The materials subject to these new rules include explosive, TIH, PIH, and highway route controlled quantities of radioactive materials. 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 [51].
    - 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 Safety and 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.

8.11 General Provisions for Protection of In-Transit Road Shipments

General provisions for protection of in-transit road shipments of SNF are found in the following regulations and other documents:

- 10 CFR 73.37 (b)
- 10 CFR 73.37 (c)
- 10 CFR 73.21
- 10 CFR 73.22

- NUREG 0561, Rev 2: Physical Protection of Shipments [48]
- DOE Order 460.2A [63]
- DOE Manual 460.2-1A [68]

Additional provisions include:

- Transportation vehicles must be accompanied by at least two armed escorts.
- Each must carry a minimum of two weapons which:
    - Provide separate and distinct response capabilities.
    - This does not apply to LLEA performing escort duties.

Communications provisions include:

- Escorts must be provided with the means to call for assistance when necessary through:
    - LLEA
    - MCC
- Escorts must be provided with a way to quickly develop new LLEA contacts and obtain new route information when unexpected detours become necessary and provide a way to coordinate the movement of transport and escort vehicles when more than 1 transport vehicle is used in the shipment.

10 CFR 73.37 (c)(3) requires transport and escort vehicles:

- Be equipped with redundant communication abilities that provide for two-way communication among transport vehicle, escorts and MCC, and LLEA at all times.
- Alternate methods of communication should not be subject to the same failure as the primary method of communication.
- Must be able to reach the emergency phone number provided on the approved route.
- Shipments must be continuously and actively monitored by:
    - Telemetric position monitoring system.
    - Alternate system reporting to the MCC.

The MCC shall:

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

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

Requirement for Immobilization of Transport Vehicle:

- Highway transport vehicles 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 this immobility once engaged [52].

Training for Drivers:

- Drivers are required to be familiar with and capable of implementing transport vehicle immobilization, communications, and other security precautions.

8.12 General Provisions for Protection of In-Transit Rail Shipments

General provisions for protection of in-transit rail shipments are found in the following regulations and other documents:

- 10 CFR 73.37 (b)
- 10 CFR 73.37 (d)
- 10 CFR 73.21
- 10 CFR 73.22
- NUREG 0561, Rev 2: Physical Protection of Shipments [48]
- DOE Order 460.2A [63]
- DOE Manual 460.2-1A [68]

In addition, the following are required protection of in-transit rail shipments:

- 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 car/caboose). Most railroads no longer allow the escorts to ride in the locomotive.
- Each armed escort shall be equipped with a minimum of two weapons with separate and distinct responsive capabilities.
- Escorts may be private guards or LLEA, and must be:
    - Trained in accordance with Appendix D, 10 CFR Part 73.
    - Thoroughly familiar with all security requirements.
    - Alert to recognizing situations that might constitute a threat to the safety or security of the shipment.
- A copy of the route overview data must be provided to the escorts.
- Escorts should maintain close cooperation with the train crew to ensure adherence to the shipment schedule and so the crew remains aware of all the security requirements as the shipment progresses.

The following provisions regard communications for rail movement:

- Escorts must be provided with a way to quickly develop new LLEA contacts and obtain new route information when unexpected detours become necessary and provide a way to coordinate the movement of the escorts when more than one transport vehicle is used in the shipment.
- Communication must be redundant.
- Telephone call boxes located along the train tracks generally are not acceptable if the train is forced to make an emergency stop. However, telephone call boxes can be used in short intervals during which cellular and satellite phone service is unavailable.
- If the train's communication system is used, provisions must be made for the escorts to have immediate access to the communications equipment when necessary.
- Shipment route overview should indicate areas where cell, satellite, or other communications may not be effective along the route. For those areas, alternate communications should be planned.
- All equipment must be maintained properly and checked before the shipment begins.
- Licensee must ensure that rail shipments are monitored by licensee, third party, or the railroad MCC.

The MCC personnel shall:

- Provide positive confirmation of the location, status, and control over the shipment.
- Pre-plan procedures for any route diversions or in case of notice of actual, attempted, or suspicious activities.
- Information to be provided includes identification and contact information for appropriate LLEA along the route.
- The Operator in the MCC is required to monitor the shipment to ensure continued integrity while in route to maintain periodic contact with the train or monitoring party at a frequency not to exceed two hours.

8.13 General Provisions for Protection of In-Transit Barge Shipments

General provisions for protection of in-transit barge shipments are found in the following regulations and guidance documents:

- 10 CFR 73.37(b)
- 10 CFR 73.37 (e)
- 10 CFR 73.21
- 10 CFR 73.22
- NUREG 0561, Rev 2: Physical Protection of Shipments of Irradiated Reactor Fuel [48]
- 33 CFR 104
- 33 CFR 105

Because the onsite loading facility from the KPS ISFSI to HHT is located adjacent to the waters of Lake Michigan, the following definitions will apply, even though no transportation on the waterways will occur:

- U.S. waters extend to 3 nautical miles from the U.S. land territory, with the exception of small offshore islands.
- Security between 3 and 12 nautical miles from the coast falls under the responsibility of the USCG.
- If a U.S. port is used for transport, the licensee shall coordinate with both the USCG and local port authorities during a transport (or transload) operation to ensure that all parties are appropriately informed and to ensure the physical protection thereof [52].
- If an established port facility is used, protocols of that MTSA plan will be enforced to protect the shipment from any threat presented from the rail transfer site being located on water or adjacent to the water and provide protection against theft, diversion, or radiologic sabotage while located adjacent or next to the water.

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

- MSTA plan to be developed and implemented on the rail transfer site.
- Property to be fenced.
- Property to be lighted.
- Perimeter and fence line to be surveilled by a closed-circuit camera system.
- All personnel on a water-served site must obtain a TWIC.
- All personnel who are on duty will have the capability to delay or impede such acts as listed for the Safety and Security Plan and can request assistance promptly from LLEA responses forces and USCG.
- All provisions applicable to U.S. ports will apply to a private water-served site, including coordinating with USCG and local port authorities.

No vessels will be docked at the KPS site barge slip and therefore, the escort requirements in 10 CFR 73.37(e) will not apply to the site.

9.0 EMERGENCY RESPONSE AND PREPAREDNESS

The purpose of the 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 [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 [53].

9.1 General Requirements for an Emergency Response Plan

As required by 49 CFR 172.604, the ERP must include the emergency contact telephone number and conform to the following requirements:

- Must be monitored at all times the HAZMAT is in transportation, being stored, loaded, or unloaded.
- 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 papers in a prominent position just after the description.
- May be the number of an agency or organization capable of, and accepting responsibility for, providing the detailed information.

All shippers are registered with CHEMTREC, or a similar company, to provide the above requirements.

At a minimum, the ERP must provide the following information:

- Basic description and technical name of the hazardous material (waybill info).
- Immediate hazard to health.
- Immediate precautions in the event of an accident or incident.
- Immediate methods for handling fires.
- Initial methods for dealing with spills and leaks in the absence of fire.
- 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].

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 hazardous material. The plan is compiled in compliance with 49 CFR 172.600 and other federal, state, and local requirements and regulations and is intended to provide direction by identifying immediate measures to contain the situation and ensure safety and security until the LLEA and emergency response professionals arrive on the scene.

The emergency response procedures apply to persons who offer, accept, transfer, or otherwise handle HAZMAT during transportation. In this case, the procedures will apply to site operations at KPS, onsite HHT transport beginning with all transfer operations conducted at KPS to transfer the overpacks from the ISFSI to the onsite HHT, transport to the rail siding 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 Green Bay to the final destination.

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

Each entity involved in each facet of the transportation operation will develop and provide its own ERP and procedures. The plan will be disseminated to the appropriate employees and the information will become part of the overall ERP for the licensee. Each entity on the project will have separate and individual ERPs, but they will be coordinated for the project to delineate hand-off procedures (interfaces) to clearly define responsibilities for each phase and participant. All shared information concerning safety, security, and emergency response is governed by 10 CFR 71.11.

An example of the index for such a plan and the information to be included is listed below:

Section 1: Purpose & Scope
Section 2: Commitments, Company procedures, 49 CFR
Section 3: References – 40 CFR , 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: 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 KPS Site-Specific Considerations for the Emergency Response Plan

The MUA identified the highest ranked means for transporting the SNF and GTCC LLW from KPS by HHT with transfer to rail to be conducted at a private facility in Green Bay, WI. Since the Green Bay site is also located on a U.S. waterway, it is recommended that MTSA requirements apply in addition to the Rail Secure Area designation. These two provisions will present a layered security approach for the operations involved in the campaign.

The USCG will have the responsibility to review and approve the MTSA plan for operations conducted on any water-served site. This would include activities at the ISFSI and rail transload site as it pertains to safety and security of the sites from the coastline. The respective COTPs from the Ninth USCG District will be involved in the assessment of the plan. This may include a request from the site for the USCG to establish a barrier or security zone around KPS and the Georgia Pacific Plant in Green Bay, while the onsite and rail transloading operations are conducted. The required notification will be given in writing to the serving railroad, Canadian National Railway, stating that the 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 safety and security plan.

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

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

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. Establish best route(s) from the KPS ISFSI to Class I rail line:
    a. Examine the onsite road for the HHT and evaluate the need for improvements to ensure acceptable conditions of transport exist to either the off-site road or onsite barge landing planned to be used to transport the casks from KPS. Consider the extent of the concrete roadway needed to be added/upgraded at the site to handle anticipated transportation activities.
    b. Examine the feasibility to use HHT to reach a rail spur in Green Bay, WI approximately 35 miles from the site by performing a formal survey to determine the condition of the route, the condition of the rail spur, and the potential site(s) for performing the transload activities from HHT to rail and identifying the improvements and modifications potentially needed.
    c. Perform a marine survey of the area in front of the KPS ISFSI and adjacent waterways to determine any improvements and modifications and/or dredging that would be required to facilitate use of a barge to transport the casks from KPS. If dredging in front of the KPS plant is required, an evaluation will be needed to determine requirements for permitting, sampling, disposal, and management of any contamination that may be found. In addition, an assessment of potential landing locations along the beach must be performed to establish if RO/RO operations can occur.
2. The TN 32PT DSCs and the NAC TSCs will need to be evaluated prior to transport to ensure Part 71 requirements are met. At a minimum, this will need to involve a comparison of the fabrication records against the licensing requirements and verification that the canister integrity has been maintained. It is recommended to allocate 2-3 years for this activity, which could involve licensing actions. In general, a complete transportability study consisting of a comparison of each transport cask and its contents in a transport configuration to the Part 71 license application at the time the transport will be performed by the NRC licensee with the support of the transport cask licensees prior to transportation of each canister to be offered for transport.
3. This report should be updated when more is known of the GTCC LLW planned to be removed from the site. The only information today is an estimate that two canisters will be loaded in the 2070 timeframe [2] and that it may be stored in the two empty onsite HSMs. Based on the waste characteristics, the MP197HB cask CoC may need to be revised prior to transport of the GTCC LLW.
4. Establish planned shipment date from the KPS ISFSI and verify:
    a. The CoC for the TN MP197HB package is still valid (expires 8/31/2022).
    b. Obtain a valid CoC for the NAC MAGNATRAN and verify it is still valid. The original application under Docket 71-9356 is currently under review by the NRC.

   c. The contents, as loaded in the TN and NAC canisters are compliant to the applicable CoC requirements (e.g., dose and thermal transport limits are satisfied).
   d. Ability for permitting the transportation activities along the selected route(s).

5. Establish equipment needs for transportation:
   a. Procurement of the five MP197HB and five MAGNATRAN casks, associated impact limiters, cavity spacers (ATLAS), transport cradles, personnel barriers, and vertical lifting yoke and horizontal lift beam. As discussed in Section 2.3, any road or barge transportation activities may not require the complete cradle assembly necessary for rail transportation.
   b. Assemble additional equipment and auxiliaries including establishment of the Transfer Station for MAGNASTOR TSC transfers, MAGNATRAN Lift Yoke, vacuum, leak test and helium backfill system, etc. Limiting schedule delivery date would be for the procurement and delivery of the MAGNATRAN Lift Yoke at 10 months.
   c. Investigate the availability and capacity of the existing NUHOMS transfer equipment, previously used at KPS, to identify what can be reused and what, if any, modifications would be needed due to the additional weight of the MP197HB transportation cask.

6. Establish KPS ISFSI site operations related details:
   a. Establish electrical power requirements for performing operations and verify availability at KPS ISFSI.
   b. Determine the maximum height an MP197HB and MAGNATRAN packages can be lifted without impact limiters. While no lifts of the loaded MP197HB are proposed, this may drive additional requirements for the transfer trailer regarding cask retention. Currently the trailer and HHT designs are not important to safety.
   c. Consult with appropriate regulatory authorities on the applicability of the MTSA and its requirements for KPS ISFSI.

7. Due to the potential significant impacts of the conditions and assumptions identified in Section 7.9 for the estimated costs associated with activities involving the rail shipment of transportation casks from the transload site to the GCUS site (i.e., cask consist transportation services costs, emergency response center operation costs, railcar maintenance services freight costs, and transportation cask maintenance and compliance costs), the development of more precise costs requires resolution to, or clarification of, the identified conditions and assumptions in Section 7.9, as well as consideration of economies of scale and synergies associated with the de-inventory of multiple sites at the same or nearly same time, understanding of equipment (e.g., railcars and casks) ownership impact, and the need for a comprehensive breakdown of activities involved in these costs.

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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.

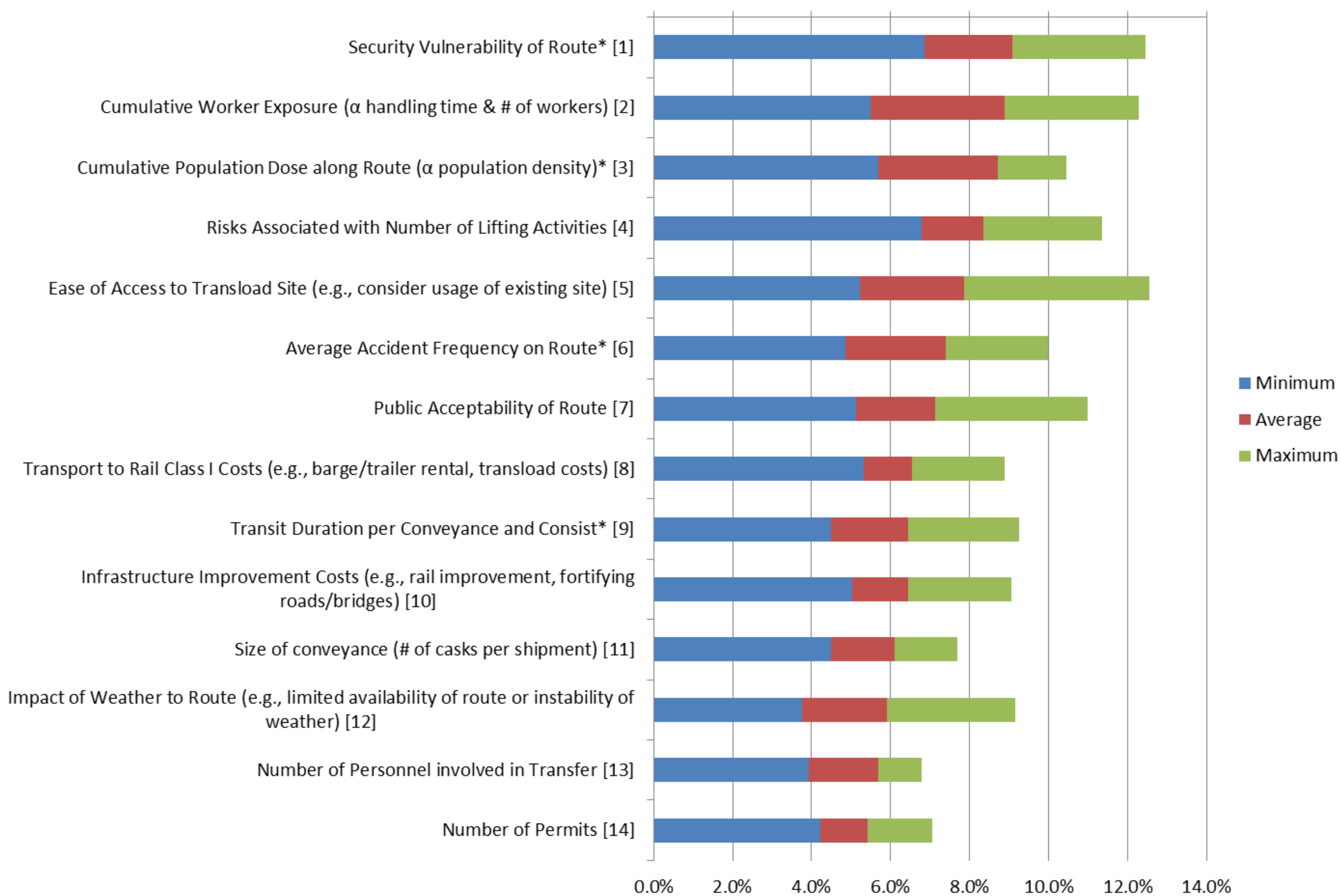
Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Public Acceptability of Route
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Number of Permits
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Number of Personnel involved in Transfer
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Cumulative Worker Exposure (α handling time & # of workers)
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Cumulative Population Dose along Route (α population density)*
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Risks Associated with Number of Lifting Activities
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Average Accident Frequency on Route*
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Transit Duration per Conveyance and Consist*
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Size of conveyance (# of casks per shipment)
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)								Security Vulnerability of Route*
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								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)								Number of Personnel involved in Transfer
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cumulative Worker Exposure (α handling time & # of workers)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cumulative Population Dose along Route (α population density)*
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Risks Associated with Number of Lifting Activities
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Average Accident Frequency on Route*
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Transit Duration per Conveyance and Consist*
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								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)								Size of conveyance (# of casks per shipment)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Security Vulnerability of Route*
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Public Acceptability of Route
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Permits
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Number of Personnel involved in Transfer
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Cumulative Worker Exposure (α handling time & # of workers)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Cumulative Population Dose along Route (α population density)*
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Risks Associated with Number of Lifting Activities
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Average Accident Frequency on Route*
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Transit Duration per Conveyance and Consist*
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Size of conveyance (# of casks per shipment)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)								Security Vulnerability of Route*
Public Acceptability of Route								Number of Permits
Public Acceptability of Route								Number of Personnel involved in Transfer
Public Acceptability of Route								Cumulative Worker Exposure (α handling time & # of workers)
Public Acceptability of Route								Cumulative Population Dose along Route (α population density)*
Public Acceptability of Route								Risks Associated with Number of Lifting Activities
Public Acceptability of Route								Average Accident Frequency on Route*
Public Acceptability of Route								Transit Duration per Conveyance and Consist*
Public Acceptability of Route								Ease of Access to Transload Site (e.g., consider usage of existing site)
Public Acceptability of Route								Size of conveyance (# of casks per shipment)
Public Acceptability of Route								Security Vulnerability of Route*
Number of Permits								Number of Personnel involved in Transfer
Number of Permits								Cumulative Worker Exposure (α handling time & # of workers)
Number of Permits								Cumulative Population Dose along Route (α population density)*
Number of Permits								Risks Associated with Number of Lifting Activities
Number of Permits								Average Accident Frequency on Route*
Number of Permits								Transit Duration per Conveyance and Consist*
Number of Permits								Ease of Access to Transload Site (e.g., consider usage of existing site)
Number of Permits								Size of conveyance (# of casks per shipment)
Number of Permits								Security Vulnerability of Route*

Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Number of Personnel involved in Transfer								Cumulative Worker Exposure (α handling time & # of workers)
Number of Personnel involved in Transfer								Cumulative Population Dose along Route (α population density)*
Number of Personnel involved in Transfer								Risks Associated with Number of Lifting Activities
Number of Personnel involved in Transfer								Average Accident Frequency on Route*
Number of Personnel involved in Transfer								Transit Duration per Conveyance and Consist*
Number of Personnel involved in Transfer								Ease of Access to Transload Site (e.g., consider usage of existing site)
Number of Personnel involved in Transfer								Size of conveyance (# of casks per shipment)
Number of Personnel involved in Transfer								Security Vulnerability of Route*
Cumulative Worker Exposure (α handling time & # of workers)								Cumulative Population Dose along Route (α population density)*
Cumulative Worker Exposure (α handling time & # of workers)								Risks Associated with Number of Lifting Activities
Cumulative Worker Exposure (α handling time & # of workers)								Average Accident Frequency on Route*
Cumulative Worker Exposure (α handling time & # of workers)								Transit Duration per Conveyance and Consist*
Cumulative Worker Exposure (α handling time & # of workers)								Ease of Access to Transload Site (e.g., consider usage of existing site)
Cumulative Worker Exposure (α handling time & # of workers)								Size of conveyance (# of casks per shipment)
Cumulative Worker Exposure (α handling time & # of workers)								Security Vulnerability of Route*
Cumulative Population Dose along Route (α population density)*								Risks Associated with Number of Lifting Activities
Cumulative Population Dose along Route (α population density)*								Average Accident Frequency on Route*
Cumulative Population Dose along Route (α population density)*								Transit Duration per Conveyance and Consist*
Cumulative Population Dose along Route (α population density)*								Ease of Access to Transload Site (e.g., consider usage of existing site)
Cumulative Population Dose along Route (α population density)*								Size of conveyance (# of casks per shipment)
Cumulative Population Dose along Route (α population density)*								Security Vulnerability of Route*
Risks Associated with Number of Lifting Activities								Average Accident Frequency on Route*
Risks Associated with Number of Lifting Activities								Transit Duration per Conveyance and Consist*
Risks Associated with Number of Lifting Activities								Ease of Access to Transload Site (e.g., consider usage of existing site)
Risks Associated with Number of Lifting Activities								Size of conveyance (# of casks per shipment)
Risks Associated with Number of Lifting Activities								Security Vulnerability of Route*
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)
Average Accident Frequency on Route*								Size of conveyance (# of casks per shipment)
Average Accident Frequency on Route*								Security Vulnerability of Route*
Transit Duration per Conveyance and Consist*								Ease of Access to Transload Site (e.g., consider usage of existing site)
Transit Duration per Conveyance and Consist*								Size of conveyance (# of casks per shipment)
Transit Duration per Conveyance and Consist*								Security Vulnerability of Route*
Ease of Access to Transload Site (e.g., consider usage of existing site)								Size of conveyance (# of casks per shipment)
Ease of Access to Transload Site (e.g., consider usage of existing site)								Security Vulnerability of Route*
Size of conveyance (# of casks per shipment)								Security Vulnerability of Route*

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

	Rater																									
	1		2		3		4		5		6		7		8		9		10		11		Average			
Metric	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	Ranks	**Metric**
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	6.32%	9	9.07%	3	6.41%	8	5.04%	12	7.23%	7	5.04%	14	6.50%	8	6.41%	7	5.22%	14	7.33%	5	6.41%	12	6.5%	10	9.0	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	6.32%	9	8.15%	5	6.78%	6	5.59%	11	5.40%	9	6.41%	8	6.32%	9	5.31%	13	5.40%	12	8.88%	4	7.33%	6	6.5%	8	8.4	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Impact of Weather to Route (e.g., limited availability of route or instability of weather)	5.40%	11	5.77%	9	5.04%	13	6.59%	9	3.75%	14	5.86%	9	5.59%	12	5.95%	12	5.40%	12	9.16%	3	6.59%	10	5.9%	12	10.4	Impact of Weather to Route (e.g., limited availability of route or instability of weather)
Public Acceptability of Route	9.07%	2	5.40%	11	5.13%	12	9.25%	3	8.97%	5	5.40%	13	5.40%	13	6.23%	10	5.86%	10	10.99%	2	6.78%	8	7.1%	7	8.1	Public Acceptability of Route
Number of Permits	5.13%	13	5.49%	10	5.40%	10	4.40%	13	4.21%	13	7.05%	7	4.85%	14	5.31%	13	5.86%	10	5.49%	11	6.32%	14	5.4%	14	11.64	Number of Permits
Number of Personnel involved in Transfer	6.78%	8	4.95%	12	6.23%	9	3.94%	14	4.58%	12	5.86%	9	6.59%	7	6.41%	7	6.59%	9	4.12%	14	6.59%	10	5.7%	13	10.1	Number of Personnel involved in Transfer
Cumulative Worker Exposure (α handling time & # of workers)	8.97%	3	10.53%	1	12.27%	1	9.80%	2	10.71%	2	5.59%	12	7.69%	5	9.52%	2	8.97%	2	5.49%	11	8.15%	2	8.9%	2	3.9	Cumulative Worker Exposure (α handling time & # of workers)
Cumulative Population Dose along Route (α population density)*	9.52%	1	10.16%	2	10.44%	3	10.35%	1	10.26%	3	5.68%	11	8.88%	3	9.16%	3	7.97%	4	5.77%	9	7.78%	4	8.7%	3	4.0	Cumulative Population Dose along Route (α population density)*
Risks Associated with Number of Lifting Activities	8.52%	4	7.51%	7	6.96%	5	7.69%	6	9.34%	4	7.88%	4	6.78%	6	9.71%	1	8.33%	3	11.36%	1	7.78%	4	8.3%	4	4.1	Risks Associated with Number of Lifting Activities
Average Accident Frequency on Route*	7.51%	7	7.14%	8	4.85%	14	8.06%	5	5.31%	10	7.23%	6	9.98%	2	9.16%	3	7.14%	5	6.87%	6	8.06%	3	7.4%	6	6.3	Average Accident Frequency on Route*
Transit Duration per Conveyance and Consist*	5.40%	11	4.49%	13	6.50%	7	7.14%	8	6.41%	8	9.25%	2	5.95%	11	6.41%	7	6.87%	7	5.68%	10	6.87%	7	6.5%	9	8.3	Transit Duration per Conveyance and Consist*
Ease of Access to Transload Site (e.g., consider usage of existing site)	8.15%	5	8.70%	4	5.22%	11	7.33%	7	7.42%	6	8.61%	3	8.52%	4	6.96%	6	12.55%	1	6.50%	8	6.41%	12	7.9%	5	6.1	Ease of Access to Transload Site (e.g., consider usage of existing site)
Size of conveyance (# of casks per shipment)	5.13%	13	4.49%	13	7.60%	4	6.23%	10	4.76%	11	7.69%	5	6.23%	10	6.04%	11	6.87%	7	5.49%	11	6.68%	9	6.1%	11	9.5	Size of conveyance (# of casks per shipment)
Security Vulnerability of Route*	7.78%	6	8.15%	5	11.17%	2	8.61%	4	11.63%	1	12.45%	1	10.71%	1	7.42%	5	6.96%	6	6.87%	6	8.24%	1	9.1%	1	3.45	Security Vulnerability of Route*

Purple	Lowest ranked
Red	Highest ranked


Security Vulnerability of Route* [1]
Cumulative Worker Exposure (α handling time & # of workers) [2]
Cumulative Population Dose along Route (α population density)* [3]
Risks Associated with Number of Lifting Activities [4]
Ease of Access to Transload Site (e.g., consider usage of existing site) [5]
Average Accident Frequency on Route* [6]
Public Acceptability of Route [7]
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs) [8]
Transit Duration per Conveyance and Consist* [9]
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges) [10]
Size of conveyance (# of casks per shipment) [11]
Impact of Weather to Route (e.g., limited availability of route or instability of weather) [12]
Number of Personnel involved in Transfer [13]
Number of Permits [14]
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%
14.0%
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
Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP					X			3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP			X					3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP			X					5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP					X			5. Truck to Green Bay, Rail on CN
Impact of Weather to Route (e.g., limited availability of route or instability of weather)	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP						X		3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Public Acceptability of Route	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP							X	3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP							X	4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP							X	5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP							X	3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP							X	4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP							X	5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP			X					5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Number of Permits	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP		X						3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP			X					5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP							X	4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP			X					5. Truck to Green Bay, Rail on CN

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 Personnel involved in Transfer	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP					X			3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP					X			5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Cumulative Worker Exposure (α handling time & # of workers)	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP					X			3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP					X			5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP					X			5. Truck to Green Bay, Rail on CN
Cumulative Population Dose along Route (α population density)*	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP		X						3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP					X			5. Truck to Green Bay, Rail on CN
Risks Associated with Number of Lifting Activities	1. Truck to Port of Kewaunee, Barge and Rail on UP				X				2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP						X		3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Average Accident Frequency on Route*	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP	X							3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP	X							4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP	X							3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP	X							4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Transit Duration per Conveyance and Consist*	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP						X		3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP						X		5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN
Ease of Access to Transload Site (e.g., consider usage of existing site)	1. Truck to Port of Kewaunee, Barge and Rail on UP							X	2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP			X					3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP	X							5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP					X			4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP		X						5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP	X							5. Truck to Green Bay, Rail on CN
Size of conveyance (# of casks per shipment)	1. Truck to Port of Kewaunee, Barge and Rail on UP					X			2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP		X						5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP		X						3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP				X				4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP				X				5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP				X				5. Truck to Green Bay, Rail on CN
Security Vulnerability of Route*	1. Truck to Port of Kewaunee, Barge and Rail on UP						X		2. Barge from site to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					3. Truck to Kohler, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					4. Truck to Milwaukee, Rail on UP
	1. Truck to Port of Kewaunee, Barge and Rail on UP			X					5. Truck to Green Bay, Rail on CN
	2. Barge from site to Milwaukee, Rail on UP		X						3. Truck to Kohler, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	2. Barge from site to Milwaukee, Rail on UP		X						5. Truck to Green Bay, Rail on CN
	3. Truck to Kohler, Rail on UP		X						4. Truck to Milwaukee, Rail on UP
	3. Truck to Kohler, Rail on UP			X					5. Truck to Green Bay, Rail on CN
	4. Truck to Milwaukee, Rail on UP						X		5. Truck to Green Bay, Rail on CN

Attachment D: Route Information from START for Kewaunee

Route	Mode	Distance (mi)	Time (min)	Population	Population Density (per sq mi)	Edu, Hospital, Mass Gathering	Water Crossing	Tribal Lands (sq mi)	Environmental Areas (sq mi)
Truck to Port of Kewaunee, Barge and Rail UP	HHT - Barge - Rail	499	1750	417,893	842	327	35	0	17.55
Barge to Milwaukee, Rail on UP	Barge - Rail	480	1662	412,228	863	318	35	0	17.51
Truck to Kohler, Rail on UP	HHT - Rail	498	966	543,685	1,098	419	47	0	19.1
Truck to Milwaukee, Rail on UP	HHT - Rail	473	821	498,900	1,061	462	46	0	18.1
Truck to Green Bay, Rail on CN	HHT - Rail	653	968	527,801	813	547	54	0	5.52

Route	Water Miles	Truck Miles	Rail to Class 1 Miles	Rail Carriers	Water Accident Rate (per mi per yr)	Truck Accident Rate (per mi per yr)	Rail Accident Rate (per mi per yr)	Cumulative Accident Rate (per mi per yr)	Normalized
Truck to Port of Kewaunee, Barge and Rail UP	119	10	0	UP	0.003	0.11677	0.005	0.0068	13.6%
Barge to Milwaukee, Rail on UP	111	350 ft.	0	UP	0.003	0	0.005	0.0046	9.2%
Truck to Kohler, Rail on UP	0	57	0	UP	0	0.351284182	0.004685267	0.0445	89.6%
Truck to Milwaukee, Rail on UP	0	103	0	UP	0	0.21102902	0.005026191	0.0497	100.0%
Truck to Green Bay, Rail on CN	0	35	0	CN	0	0.347155868	0.004704476	0.0233	46.9%